

UNITED STATES PATENT AND TRADEMARK OFFICE

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BEFORE THE PATENT TRIAL AND APPEAL BOARD

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

Petitioners,

v.

METROM RAIL, LLC,  
Patent Owner.

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Case No. IPR2024-00947  
Patent No. 9,731,738

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**DECLARATION OF FOSTER J. PETERSON**

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I, Foster J. Peterson, declare:

1. I have been retained by counsel for Petitioners Siemens Mobility, Inc., Ground Transportation Systems USA, Inc., and Piper Networks, Inc., to assess claims 1-18 (the “challenged claims”) of U.S. Patent No. 9,731,738 (“the ‘738 Patent”). I am being compensated for my time at my standard rate of \$495.00 per hour, plus actual expenses. My team is being compensated for our time according the Fee & Expense Schedule attached as Appendix A. Our compensation is not dependent in any way upon the outcome of the *inter partes* review of the ‘738 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 a Principal with Engineering Systems Inc. (“ESi”) based in ESi’s Norcross, Georgia office. I have a bachelor’s degree in mechanical engineering from the Georgia Institute of Technology, and more than 28 years of experience in the railroad industry. I have held a variety of positions for heritage railway companies including certified locomotive engineer and conductor, Designated Supervisor of Locomotive Engineers, Director of Safety & Operating Practices, Manager of Training, Rules & Safety, Manager of Operating Practices, Chief Operating Officer,

machinist/mechanic, Engineer, Director Testing and Engineering Applications, and Senior Director Testing and Engineering Applications.

4. During my career, I have operated numerous passenger and freight trains. As a railroad official, I have trained and supervised train and engine service personnel. I have inspected numerous locomotives, freight cars, and passenger cars as both a mechanical and operating employee. I have extensive experience in train and vehicle dynamics simulation, and in field testing of train operations, including on-board and wayside testing.

5. I have investigated and analyzed hundreds of railroad accidents and incidents in my career. These include derailments, train collisions, and train collisions with motor vehicles at highway/rail grade crossings. In many of these derailments and train collisions, operation of the train above the allowable speed limit (overspeed event) and violation of the train's movement authority was a cause of the derailment or collision. Recent examples of overspeed derailments include the Metro-North derailment at Spuyten Duyvil, New York, on December 1, 2013, the Amtrak Train 188 derailment near Philadelphia, Pennsylvania, on May 12, 2015, and the derailment of Amtrak Train 501 near DuPont, Washington, on December 18, 2017. My investigation of the Spuyten Duyvil and Philadelphia derailments both involved a detailed analysis of the signal and train control systems, including train

control methods such as wayside signals, cab signals, Automatic Train Control, and the Advanced Civil Speed Enforcement System.

6. I have extensive experience in the downloading and use of locomotive event and video recorder data and have trained railroad personnel in the downloading and use of this data. I have extensive experience in both train and vehicle dynamics simulation and in field testing of train operations, including on-board and wayside testing. I have developed and implemented railroad operating rules, maintenance of way rules, safety rules, and railroad practices related to the operating, mechanical, and maintenance of way departments, including those related to Roadway Worker Protection (49 CFR Part 214).

7. I have operational experience with the operating rules and practices of Norfolk Southern and CSX. Since 1992, I have been qualified to operate as a locomotive engineer on NS trackage rights (for Tennessee Valley Railroad and East Chattanooga Belt Railroad) in the Chattanooga, Tennessee area and have operated mainline trains in numerous locations throughout the southern part of the NS system. Starting in 2005, I have been qualified to operate on CSX trackage rights (for the Hiwassee River Railroad) in eastern Tennessee and was qualified on the CSX rules to do so. NS and CSX have operated into the Tyner Terminal facility since we established those operations in 2011, and I thus have management oversight over the Class I railroads' operation on our property. I have operated in "Other Than Main

Track” territory and on Main tracks with methods of operation including Track Warrant/Track Authority (with and without signal overlay), and on track signaled in one and both directions.

8. In addition to my qualification on NS operating rules and trackage, I have extensive experience as a consultant to all of the Class I railroads (BNSF, CN, CPKC, CSX, NS, and Union Pacific) since the 1990s and of those railroads’ operating rules and practices and the application thereof. I have similar experience with many passenger and commuter railroad operators, example of which include Amtrak (both on the Northeast Corridor and across the United States), Metro-North Railroad, New Jersey Transit, Metra (Chicago area), and Metrolink (Los Angeles area).

9. Through my railroad and consulting experience, I have had direct experience with methods of operation and train signal control systems ranging from Track Warrant/Track Authority control (with and without signal overlay), ABS systems to include track signaled in one and both directions, cab signals (with and without wayside block signals), Automatic Train Control, and Positive Train Control systems.

10. I am a member of several railroad professional organizations including the International Association of Railway Operating Officers (of which I am a past President), Air Brake Association, the American Railway Engineering and

Maintenance of Way Association, and the American Society of Mechanical Engineers.

## **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 railway vehicles and control 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.

| <b>Exhibit</b> | <b>Description</b>                                                                     |
|----------------|----------------------------------------------------------------------------------------|
| <b>1001</b>    | U.S. Patent No. 9,731,738 (“738 Patent”)                                               |
| <b>1002</b>    | Prosecution History of US Patent No. 9,731,738                                         |
| <b>1005</b>    | U.S. Patent No. 6,957,131 (“Kane”)                                                     |
| <b>1006</b>    | U.S. Patent Publication No. 2006/0151672 (“Heddebaut”)                                 |
| <b>1007</b>    | International Application No. WO 2011/125074 (“Das”)                                   |
| <b>1008</b>    | U.S. Patent No. 5,803,411 (“Ackerman”)                                                 |
| <b>1009</b>    | U.S. Patent No. 5,950,966 (“Hungate”)                                                  |
| <b>1010</b>    | U.S. Patent No. 6,759,948 (“Grisham”)                                                  |
| <b>1011</b>    | U.S. Patent Publication No. 2007/0293153 (“Molisch”)                                   |
| <b>1012</b>    | Time Domain’s Ultra Wideband (UWB) Definition and Advantages, Time Domain (March 2011) |

|             |                                                                                                                                                                                              |
|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>1013</b> | Paul A. Flaherty, "CCS: A Railway Corridor Control System Utilizing UWB Radio Technology," Proceedings of the 2004 ASME/IEEE Joint Rail Conference (2004)                                    |
| <b>1014</b> | IEEE Std 802.15.4™-2011, IEEE Standard for Local and Metropolitan Area Networks: Part 15.4: Low-Rate Wireless Personal Area Networks (Sept. 5, 2011)                                         |
| <b>1016</b> | U.S. Patent Publication No. 2008/0111688 ("Nikitin")                                                                                                                                         |
| <b>1017</b> | U.S. Patent No. 6,133,876 ("Fullerton")                                                                                                                                                      |
| <b>1020</b> | U.S. Patent Publication No. 2006/0009240 ("Katz")                                                                                                                                            |
| <b>1021</b> | European Patent Application No. EP 1 785 744 ("Suzuki")                                                                                                                                      |
| <b>1022</b> | "United States Frequency Allocations: The Radio Spectrum," U.S. Dept. of Com.: Nat'l Telecomm. and Info. Admin. Office of Spectrum Mgmt. (Oct. 2003)                                         |
| <b>1023</b> | U.S. Patent No. 6,631,322 ("Arthur")                                                                                                                                                         |
| <b>1024</b> | U.S. Patent No. 6,338,152 ("Fera")                                                                                                                                                           |
| <b>1025</b> | Automatic Train Control and Advanced Civil Speed Enforcement System; Northeast Corridor Railroads, 63 Fed. Reg. 39343 (July 22, 1998)                                                        |
| <b>1026</b> | 49 C.F.R. § 236.0 (2010)                                                                                                                                                                     |
| <b>1027</b> | George D. Bibel, <i>Train Wreck: The Forensics of Rail Disasters 65-99</i> (The Johns Hopkins Univ. Press ed., 2012)                                                                         |
| <b>1028</b> | <i>Report of the Railroad Safety Advisory Committee to the Federal Railroad Administrator: Implementation of Positive Train Control</i> , Railroad Safety Advisory Committee (Sept. 8, 1999) |
| <b>1029</b> | <i>RFID Working on the Railroad</i> , IEEE Potentials (September/October 2015)                                                                                                               |
| <b>1030</b> | <i>Standard for Automatic Equipment Identification: Standard S-918</i> , AAR Manual of Standard and Recommended Practice Railway Electronics (adopted 1991)                                  |
| <b>1031</b> | Beth Bacheldor, <i>South African Railroad Switches to Passive RFID</i> , RFID Journal (Jan. 26, 2007)                                                                                        |
| <b>1032</b> | U.S. Patent No. 8,200,380 ("Ghaly")                                                                                                                                                          |

|             |                                                                                                                     |
|-------------|---------------------------------------------------------------------------------------------------------------------|
| <b>1033</b> | General Code of Operational Rules (GCOR) (6th ed. 2010)                                                             |
| <b>1034</b> | Northeastern Operating Rule Advisory Committee (NORAC) (10th ed. 2011)                                              |
| <b>1035</b> | 42 Fed. Reg. 5065 (Jan. 27, 1977) (to be codified at 49 C.F.R. § 218.35)                                            |
| <b>1036</b> | Federal Railroad Administration, “Type Approval – Advanced Civil Speed Enforcement System (ACSES) II (May 27, 2010) |

### III. MY UNDERSTANDING OF PATENT LAW

12. In developing my opinions, I discussed various relevant legal principles with Siemens’ 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 ‘738 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 developing 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 ’738 Patent is September 3, 2013.

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 in view of 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 ’738 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; and
- 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.

22. I further understand that there must be some teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill to modify a prior art reference or to combine prior art reference teachings to arrive at the claimed invention, and this teaching, suggestion or motivation may come from a prior art reference or from the knowledge or common sense of a POSITA.

#### **IV. QUALIFICATIONS OF A POSITA**

23. I have been informed and understand that for purposes of assessing whether a single prior art reference discloses every element of a patent claim (thus

“anticipating” the claim) and/or whether one or more prior art references would have rendered the claim obvious, the patent and the prior art references must be assessed from the perspective of a person of ordinary skill in the “art” (*i.e.*, the field of technology) 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 ’738 Patent involves a train control system “for enforcing observance to rail signals, for enforcing rail speed limits, for controlling and enforcing rail vehicle separation on railroad lines, or for temporary speed restriction enforcement for railway workers or degraded rail conditions, for example, on light rail lines.” EX1001, 6:53-58.

25. I have been asked to provide my opinions as to the state of the art in this field by 2013. I use this timeframe because the face of the ’738 Patent indicates an earliest claimed priority date of a September 3, 2013 filing date of a provisional application. *Id.*, (60). For purposes of my opinion, 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 ’738 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 2013 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 POSITA at the time of the alleged invention would have been familiar with rail vehicle safety and/or collision warning/avoidance systems. Such a POSITA would have had, at minimum, a background in rail operations, signaling, and train/rail vehicle control systems, including at least a bachelor's degree in mechanical or electrical engineering or a related field, and would have had at least two years of experience with rail operations, signaling, and train/rail vehicle control systems such as collision-avoidance systems. Extensive experience and technical training may substitute for educational requirements, while advanced education such as an MS or PhD in a relevant discipline might substitute for experience. This person would have been capable of understanding and applying the teachings of the '738 Patent and the prior art references discussed in this declaration.

28. By 2013, I held a B.S. in Mechanical Engineering, and I had 18+ years of full-time experience in the railroad industry, including with operations, signaling, and train/rail vehicle control systems such as collision-avoidance systems. Therefore, I was a person of more than ordinary skill in the art during the relevant timeframe. Additionally, I have 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 POSITA, as set forth above.

## **V. TECHNOLOGY BACKGROUND AND OVERVIEW OF THE '738 PATENT**

29. In Section V, I provide an overview of the relevant technology to which the '738 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 '738 Patent relates to rail vehicle control systems for rail line vehicles within a railway network. In Sections V.A.1 and V.A.2, I discuss conventional train control systems that were well-known in the art prior to September 2013.

31. As discussed in more detail in Section V.B, the '738 Patent also relates to the use of wireless communications to facilitate train control systems. The primary wireless communication technology that the patent uses in its exemplary embodiments is ultra-wideband (or UWB for short) radio technology. In Section

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

32. The '738 Patent also relates to the use of radio-frequency identification (RFID) to store and receive information about the vehicle, which I discuss in Section V.A.4.

### **1. Vehicle-Mounted and Railside Systems**

33. Railroads have operated, since well before the claimed priority date, on the fundamental principal that on main tracks, only one train may operate on a given line segment at a time, lest the trains collide. All trains have operated on main tracks under a specified "movement authority." *See, e.g.,* EX1009, 1:5-2:35; EX1032, 2:34-39. When a train has not had "exclusive" occupancy of a segment of the main track, it has only operated at a speed that allows the train to stop within half the range of vision, commonly called "Restricted Speed." *See* EX1035, 5065. When a train has had exclusive occupancy of the track, it has been able to operate at speeds up to the maximum allowable speed for passenger or freight trains (as appropriate) and has not been required to be prepared to stop within any particular range of vision. *See id.* Since 1977, trains operating at Restricted Speed have been limited by the Federal Railroad Administration (FRA) to a maximum speed up to 20 mph, with

visual range and conditions dictating operating speeds to be less than or equal to this value. *Id.*

34. Shortly before and at the time of the claimed priority date, the granting of exclusive track occupancy would be as simple as “mandatory directives” issued in written form or transmitted by a dispatcher or control operator to a train, copied by the train operator, and repeated back to the dispatcher or control station. These written authorities were often called a “Track Warrant,” or a “Form D.” EX1033, 14-1; EX1034, 151. The train operator was required to comply with the limits of these authorities, both in terms of the track to be occupied, and in terms of restrictions to speed or train operation, but there was no way for the dispatcher or control station to independently monitor train movements. In these simple, authority-only based methods of operation, train speeds were limited to 49 mph for freight trains and 59 mph for passenger trains. *See* EX1026, 668.

35. To provide further protection of trains and control their movement authority, signaling systems were used before the claimed priority date. Signal systems, generally, allowed the dispatcher/control operator to monitor train position on the various line segments and to control train movement via these signals. *See, e.g.,* EX1028, 19. Automatic Block Signal systems were first developed in the 1800s in the United States. EX1027, 69. Automatic Block Signals (ABS) provided protection between these control points and, in some cases, between intermediate

points between control points. *See id.* The track between two signals is called a “block.” The ABS signals provided information about the condition (i.e., whether the track had integrity) and occupancy of the block(s) ahead of that signal (i.e., whether there was a train or other equipment in the block or blocks ahead). *See id.*, 69-70. An Automatic Block Signal system allowed trains with exclusive track occupancy to operate at speeds greater than 50 mph (freight) or 60 mph (passenger) but not greater than 79 mph. *See* EX1026, 669.

36. Traditional wayside block signaling systems have been positioned along the track at various locations and typically had lights that were mounted on poles to indicate various conditions. *See, e.g.*, EX1034, 76-91. These lights included color lights, position lights, or color position lights. *Id.* The train operator was required to observe the signals from the train and make operational inputs to comply with the signal instructions related to speed and to movement authority. *See, e.g.*, EX1005, 3:29-56, Fig. 2; EX1028, 19.

37. In some systems before the claimed priority date, there was a display/input device on the train that engineers/trainmen use to receive additional information in the vehicle operating compartment related to that of the wayside signals. EX1028, 19. This is called, generally, a Cab Signal System (CSS) where an in-cab display provides indication of control point and ABS signals to the operator. The FRA allowed operation of trains at speeds of 80 mph and above when using a

CSS. *See* EX1026, 669. Cab signals overlaid on wayside signals still require the train operator to comply with the signal indications without the ability to enforce compliance by the operator. *See, e.g.*, EX1005, 3:29-56, Fig. 2; EX1028, 19.

38. Several systems have been used before the claimed priority date to enforce train operator compliance with movement authority restrictions and/or speed restrictions. For example, an Automatic Train Stop (ATS) system was developed in the early 1920s to force trains to a stop on various routes, and it was mandated by the Interstate Commerce Commission (ICC). EX1027, 92. Automatic Train Control (ATC) was developed in 1951 by the Pennsylvania Railroad and required crews to respond to cab signals with braking automatically applied if crews did not respond in a 6-8 second period to a warning light and whistle. *Id.*, 96. ATC has been in place on numerous railroads and was still in routine use at the time of the '738 Patent application in 2013. ATC enforced compliance with signal indications and their related restrictions to movement authority and/or speed. *See id.*, 96-97.

## **2. Communications Between Vehicles and Collision Avoidance**

39. In a September 1999 Report, the Railroad Safety Advisory Committee to the Federal Railroad Administrator discussed Positive Train Separation (PTS) systems involving radio frequency (RF) communications. EX1028, 23-24. The FRA report also discussed Burlington Northern's (BN, predecessor of BNSF Railway) Advanced Railroad Electronic System (ARES) developed in the 1980s-

1990s, where vehicles could communicate health information to each other. *Id.*, 22-23.

40. Additionally, TrainGuard™ was conceived in a BN safety committee in 1993 as “a means to make train crew members aware of other trains in their vicinity in non-signaled territory.” *Id.*, 28. Every 15 seconds, the mobile communications package broadcasted the locomotive identification number, location, speed, direction, and stopping distance. *Id.* The Railroad Safety Advisory Committee Report explained:

Data transmitted from the controlling locomotive of another train [was] displayed in graphics and text showing the train’s identification, distance, speed, direction, stopping distance and age of the last radio communication received. The locomotive engineer [was] required to acknowledge alerts announcing the proximity of a new train, impending overspeed conditions and alerts indicating the threat of nearby trains. The OBC initiate[d] an automatic brake application if an alert [was] not acknowledged, the train [was] overspeed or the stopping distance to another train [was] about to be violated.

*Id.*

41. Systems like TrainGuard™, as well as the Incremental Train Control System (ITCS, initiated in 1995) and the Communications-Based Train Management System (CBTM) were designed to incorporate continuous stop distance calculations onto trains, with ITCS in particular enforcing grade-crossing

protection measures if the gates do not activate properly. *Id.*, 24-25, 28-29. CBTM prevented collisions between trains at speeds above 8 mph, calculated braking distances, and enforced worker protection limits. *Id.*, 29.

### **3. Ultra-Wideband (“UWB”) Technology – Ranging and Communications**

42. Prior to the earliest claimed priority date, UWB technology was already known in the art. For example, a patent application published in 2007 explained that:

UWB or digital pulse wireless communication 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. UWB radio signals not only can carry a huge amount of data over a short distance at very low power, e.g., less than 0.5 milliwatts, but have the ability to carry signals through doors and other obstacles that tend to reflect signals having more limited bandwidths and a higher power.

EX1011, [0003]. At that time, there were at least three common applications for UWB:

In radar applications, the UWB signal penetrates nearby surfaces but is reflected by surfaces that are farther away, allowing objects to be detected behind walls or other coverings. In data transmission applications, digital pulses allow a very low powered and relatively low cost signal to carry information at very high data rates over a short range. In location awareness applications, ultra wideband digital pulses allow accurate ranging estimate between different devices.

*Id.*, [0005]. By 2007, standards had already been created for UWB systems, including by IEEE. *See generally* EX1014; EX1011, [0009] (“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.”).

43. UWB systems transmit 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:

Ultra Wideband (UWB) is a short duration, pulsed RF technology that achieves the highest possible bandwidth at the lowest possible center frequency. The technology can be used for communications, radar, and ranging/location applications.

In contrast with spread spectrum radio technologies that achieve a few 100s of kilohertz (kHz) to 10s of megahertz (MHz) of bandwidth, UWB signals are spread over a few gigahertz (GHz), achieving relative bandwidths of 25-100%.

UWB systems achieve this bandwidth by transmitting an impulse-like waveform. Such waveforms are inherently broadband. In fact, Fourier analysis teaches us that an ideal impulse (i.e., a waveform of a given amplitude and infinitesimally short duration) would provide infinite bandwidth. As a result, transmissions are quite unlike traditional RF modulated sine waves. Instead they resemble a train of pulses. An example of an individual UWB pulse is shown in **Figure 1**.

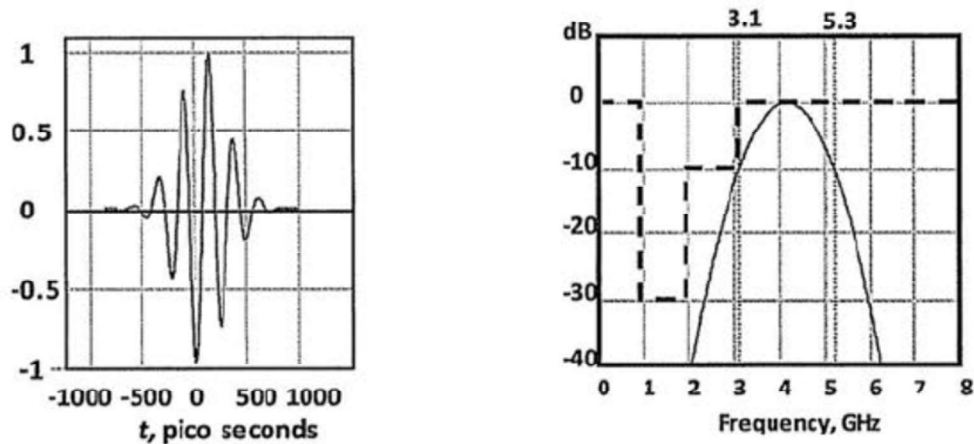


**Fig. 1: UWB waveform shown in time domain (at left) and frequency domain (at right)**

EX1012, 3.

44. For UWB ranging applications, the prior art taught multiple methods, including based on the time it takes for a wireless signal to travel from one radio unit to the other (“time of flight”):

UWB two-way ranging is performed by two transceivers. Conventionally, a range packet is sent from a device A to a device B. Upon receipt of the range packet at the device B, the range packet is returned to device A. Measuring the length of time required for this roundtrip can reveal the distance between the two transceivers.

For example, a transmitter can send a signal to a receiver at  $t_1$ . The receiver, as soon as possible, returns a reply signal to the transmitter. The transmitter measures the time of arrival (TOA) of the reply signal at time  $t_2$ . An estimate of the distance between the transmitter and the receiver is the time for the signal to make the round trip divided by two and multiplying by the speed of light is, i.e.:

$$D = \frac{|t_1 - t_2|}{2} c.$$

EX1011, [0007]-[0008]. Two prior art references discussed below, Heddebaut and Grisham, disclose use of this ranging method. EX1006, [0054]-[0055]; EX1010, 14:56-62, 24:18-24. Other prior art also disclosed use of this method:

To determine the position of the second transceiver, a first sequence of pulses are transmitted from the first transceiver. The first sequence of pulses are then received at the second transceiver and the second transceiver is then synchronized with the first sequence of pulses. Then, a second sequence of pulses are transmitted from the second transceiver. The first transceiver receives the second sequence of pulses and the first transceiver is synchronized with the second sequence of pulses. A delayed first reference signal is generated in response to the synchronization with the second sequence of pulses. Then, a time difference between the delayed first reference signal and the first reference signal is measured. The time difference indicates a total time of flight of the first and second sequence of pulses.

Then, the distance between the first and the second transceiver is determined from the time difference.

EX1017, 2:31-46; *see also* EX1020, [0006] (measuring “the Time of Arrival (TOA) of a signal emitted by the roaming wireless device”); EX1011, [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”);

EX1012, 11 (“The technique is based upon the transmission of a packet of pulses from a requesting P400 to a responding P400 and the subsequent transmission of a packet from responder to the receiver. At a high level, the first packet is used to measure the arrival time and the second packet provides a time reference for determining the transmit time.”).

45. Additionally, UWB devices can determine range with a single device by measuring round trip time from a reflected pulse. EX1021, [0009] (“Moreover, according to the present invention, it is possible to obtain the direction and distance from location information overlapped with the radar wave from other vehicles, and to identify, regardless of clutter, the position even from the radar waves other than the reflection wave of a radar wave which the own vehicle transmitted.”). Further, the change in distance over time (typically a very short period of time such that straight line motion can be assumed) can be used to estimate the velocity of vehicle (by dividing the change distance by the interval of time). *See, e.g.*, EX1013, 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.”).

46. UWB-based technology also has several benefits over other common wireless technologies. First, because of the wide-bandwidth / short-pulse duration of UWB signals, they are naturally resistant to multipath effects:

One of the main reasons for selecting a UWB ranging or communications system over a narrow band system is that a UWB system is able to resolve multipath thereby enabling operation in highly cluttered environments. UWB systems can resolve multipath because their transmitted RF pulse has a bandwidth of almost 2 GHz, giving individual pulses a physical length of about 6 inches. Because the pulses are physically small, a UWB system can separate, or resolve, multipath reflections from a main signal by focusing on the first arriving pulse.

EX1012, 5; *see also* EX1011, [0009] (“One type of an UWB system is an impulse radio (IR). IR uses extremely short duration pulses to generate signal waveforms, and allows fine time resolution of channel multipath characteristics, which is important in identifying the line of sight signal for precision ranging.”).

47. 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:

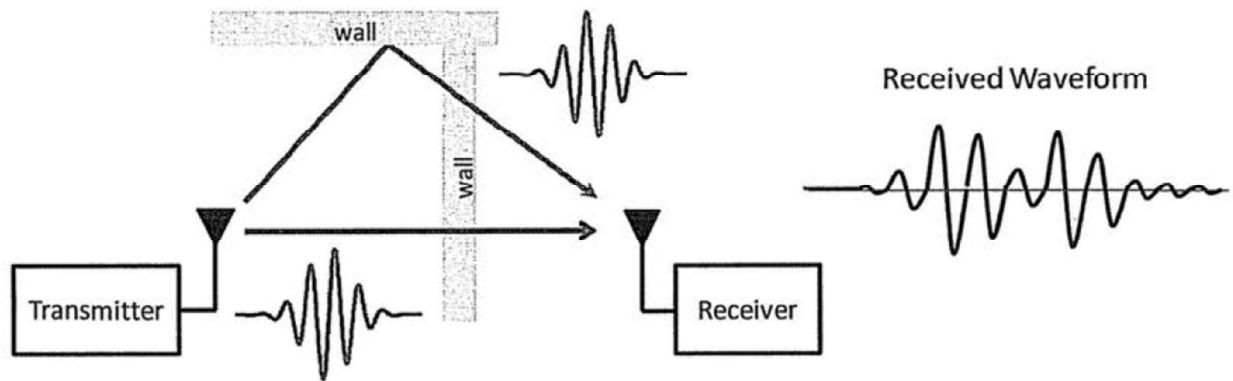


**Fig. 2: UWB transmitter and receiver, with transmitted signal (blue), reflected signal (red), and composite received waveform (black)**

EX1012, 6. The indirect path is longer than the direct path and does not accurately reflect the distance between the radios. “[N]arrowband systems are unable to resolve multipath because their effective pulse lengths are simply too long, in essence overlapping direct and reflected long pulses to the extent that they cannot be effectively differentiated.” *Id.* UWB systems resolve multipath:

This is an example of why a short duration pulse is the best tool for determining range and also makes the best radar. The waveform is small relative to the targets (walls, furniture, people, appliances) it might encounter. It is small relative to the mutual separation distances of the targets. It is small relative to the separation distance being measured. Because of these factors, one can use the leading edge to precisely measure range and one can implement radars to distinguish between targets.

*Id.*, 7.

48. As another advantage, UWB-based ranging provides high resolution for precise distance measurements. *Id.*, 4 (“These advantages are due to UWB short pulses (large bandwidths): . . . The ability to range accurately in the presence of multipath . . .”). Because UWB signals are short and thus easily distinguishable in time, the arrival time of a UWB signal is easy to identify precisely. *Id.*, 7.

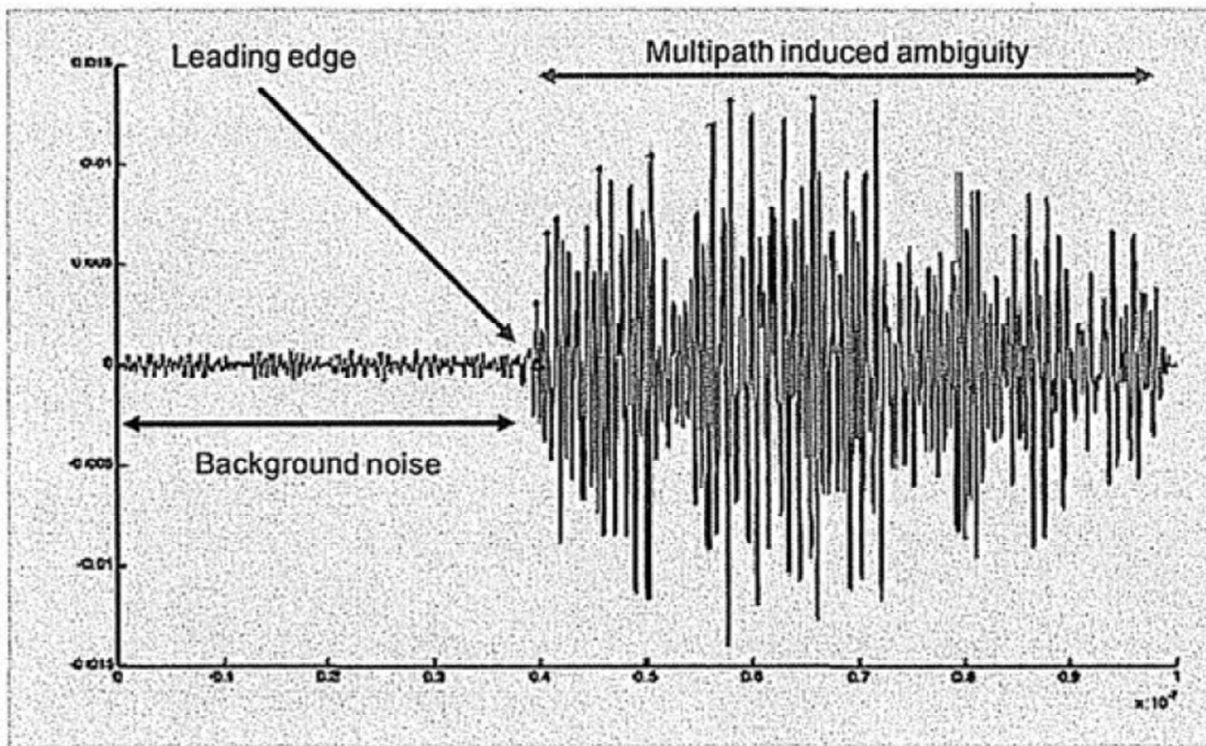


**Fig. 3: Received signal in moderate multipath environment**

In the case shown in **Figure 3**, it is relatively easy to determine the moment when the first pulse arrives at the receiver. That point is marked with a small triangle. Time Domain refers to this point as the “Leading Edge.”

One should note that its exact location is still a bit ambiguous, but that this ambiguity is limited to less than a single RF cycle or about 6” of

range. With a bit of integration and advanced algorithms, this range measurement ambiguity can be reduced to less than a few inches. With signal processing efforts and a cooperative environment the ambiguity could, in principle, be reduced to less than 2mm.

*Id.*, 6-7.

49. As still another advantage, UWB-based ranging would be combined with UWB-based data communications functionality to use the same UWB signals for both ranging and (non-ranging) data communications. *Id.*, 13 (The UWB “pulse can be simultaneously used for data, measurement of range, and operation as a radar.”). 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. *Id.*, 8-9, 13.

50. Yet another benefit of UWB-based technology is that it requires low operating power, making UWB efficient and unlikely to interfere with coexisting RF systems. *Id.*, 5; *see also* EX1011, [0003]-[0005]. “For example, a typical UWB system transmits at power levels of only 50 microWatts (uW). A ‘high power’ unit will achieve at most 10mW.” EX1012, 5.

#### **4. RFID Systems in Trains**

51. The North American and global railroad industry developed and used technologies for tracking rail assets such as freight cars, locomotives and intermodal

trailers/containers well before the priority date. The industry first attempted to track railcars in the 1960's using color-coded labels or barcodes on the sides of equipment in a system called Automatic Car Identification (ACI). EX1029, 22. This method did not work well because the tags would get dirty or damaged, preventing accurate reading by wayside scanners. *Id.* In 1990, after four years of testing, the Association of American Railroads (AAR) adopted an RFID system called Automatic Equipment Identification (AEI) developed by Amtech (later part of TransCore that used a proprietary communication protocol). *Id.*, 24. AAR Standard S-918 called for two AEI/RFID tags per railcar, one per side, and approximately 3 million tags were delivered by 1994. *See* EX1029, 24, EX1030, K-101.

52. The RFID technology in AEI tags can be read by AEI readers at high rates of speed. EX1030, K-88. This technology has been adapted for use in many applications and has spread throughout the transportation world from its genesis in the United States. For example, Spoornet, a South African provider of rail freight services and the region's largest rail operator, in 2007, installed TransCore AEI tags on its fleet of approximately 80,000 rail cars on a more than 14,000-mile system. EX1031, 1. TransCore reported in 2007 that it had installed more than 6.5 million tags and 20,000 readers throughout the world's rail and intermodal freight industry. *Id.*, 2.

53. RFID transponders also played a significant role in Amtrak's Advanced Civil Speed Enforcement System (ACSES and later ACSES II). ACSES relied upon transponders affixed to the railroad track structure to provide key data to the onboard systems. EX1025, 39345. ACSES built upon the original Block Signal and CSS, was an overlay to the ATC system, and was first required in 1998 by the FRA on the Amtrak's Northeast Corridor (NEC) between Washington, D.C. and Boston, Massachusetts. *See id.*, 39343. For ACSES, the FRA explained:

Each permanent transponder set will contain encoded information about speed restrictions ahead, including: (i) The distance to the beginning of the speed restriction; (ii) The target speed; (iii) The type of speed restriction; (iv) The average grade between the location where the speed reduction must begin and the location where the reduced speed must be reached; (v) The distance to the next permanent transponder set location; and (vi) Necessary sync and check bytes to allow for message verification.

*Id.*, 39345.

54. For the updated ACSES II system, the FRA included passive transponders in the list of Main System Components:

## **1.2 Main System Components**

ACSES II comprised of the following components designed, built, operated, and maintained to the specifications in Section 2 of this Schedule of Approval:

1.2.1 Onboard Computer (OBC) with vital Main Board (SW Rev. 7) and associated locomotive hardware interface units, including ACSES/ATC Display Unit (ADU) (SW Rev. 2).

1.2.2 Passive (fixed message) Transponders (Rev. B) at wayside locations and Onboard Transponder Reader comprised of Scanner Antenna (Rev. C ), Process Speed Board (Rev. B-4), Television Compatibility (CTV) box (Rev. A), and Central Unit 20 Board UC20 (Rev. A).

1.2.3 Encoder comprised of Vital Central Sequencing Unit (UCS) (SW Rev. 1.2.3) and non-vital Radio Transmission Module (TRM) Board (SW Rev. 1.2.5).

1.2.4 Safety Temporary Speed Restriction (TSR) Server (STS)/2oo3 platform [2 out of 3 platform] (Rev. 2.0) with Safety TSR Server Application Software (SW Rev. 6.3.5).

1.2.5 Network Server (SW Rev. 3.1).

1.2.6 Data Radio system using ATCS (Spec. 200) communication protocol at 900 MHz frequency that includes Base Communication Package (BCP) (SW Rev. 4.55) at the interlocking locations, Mobile Communication Package (MCP) onboard (Rev. C), and Wayside Communications Controller (WCC) (SW Rev. 5.1) at a central location.

1.2.7 Databases installed in transponders and encoders, and Fixed Database used by Safety TSR server (databases are to be site-specific).

EX1036, 2.

### **B. An Overview of the '738 Patent**

55. The '738 Patent discloses a system for “vehicle management [that] includes a control signal interface subsystem and a vehicle-mounted subsystem” where the “subsystems communicate with each other through the UWB components.” EX1001, Abstract.

56. The patent suggests that a significant factor in rail collisions is vehicle operators failing to respond properly to signals. “For example, vehicle operators

may fail to notice a control point signal due to visibility issues, equipment errors, operator maladies, or negligence. In such a situation, rail vehicles may continue to travel along a track not safe for travel, potentially resulting in disastrous collisions and/or accidents.” *Id.*, 1:34-39.

57. The patent also identifies supposed limitations of prior art collision avoidance systems:

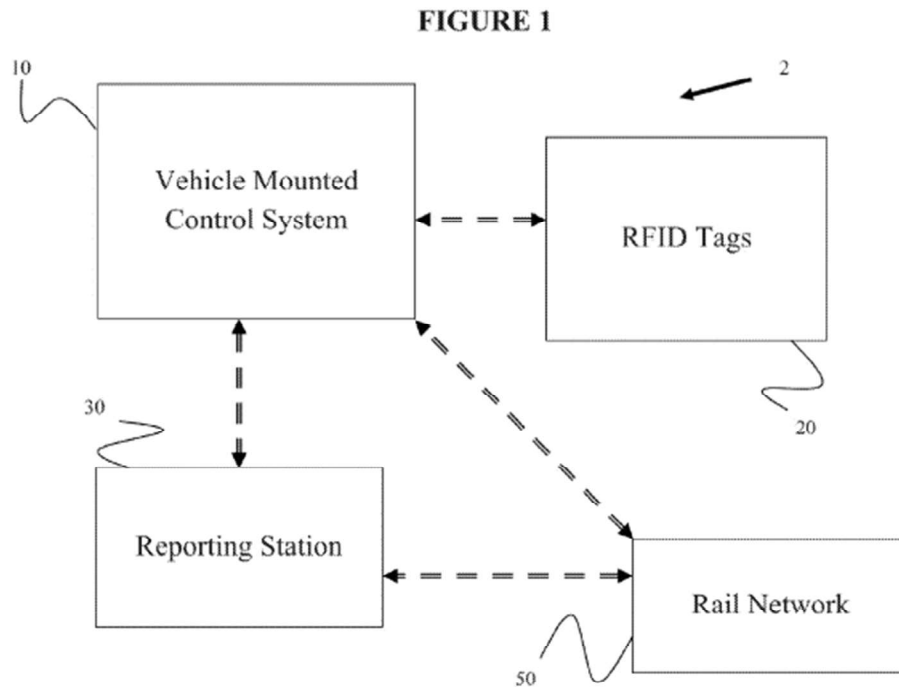
However, present methods and systems for controlling and enforcing rail vehicle separation can be insufficient, particularly under certain circumstances. For example, in subterranean tunnels, or subways, rail vehicles may not have a clear view of the sky, and therefore, may not be traceable by GPS methods. It can therefore be difficult for the operator of such a rail vehicle, to know the location, speed, and position of the rail vehicle relative to other vehicles on the train track with the accuracy necessary to operate safely and efficiently. Moreover, it can be difficult for a rail vehicle control system to properly enforce separation among rail vehicles on a railroad track if the precise location of each rail vehicle is not accurately known. For example, PTC can “dead-reckon” using the odometer in non-GPS areas, but there may be degradation in accuracy. This degradation may be acute in commuter rail applications where train spacing is less than with freight rail.

*Id.*, 1:57-2:6.

58. The ’738 Patent suggests that many of these limitations can be overcome using a combination of known technologies, including UWB and RFID.

“The present technology utilizes a variety of functionalities and technologies to monitor, control, and enforce separation between rail vehicles on a rail track. For example, in some embodiments, the present technology combines ranging technology such as ultra-wideband ("UWB") ranging, RFID tags and detectors, an ad hoc wireless network between vehicles and control signal control portions, and a wireless or wired data collection system.” *Id.*, 8:8-15.

59. Figure 1 of the '738 Patent depicts an exemplary train control system that includes a vehicle mounted control system. “The rail control system 2 can include a vehicle mounted control system (“VMCS”) 10, which can be, for example, mounted or installed on a rail vehicle such as a train or subway car. In some instances, there may be more than one VMCS 10 mounted on a single vehicle (such as an articulated vehicle, where wiring between control systems is problematic or expensive). In some embodiments, the system 2 can comprise multiple VMCSs 10, mounted on several rail vehicles. The VMCSs 10 mounted on various rail vehicles can be configured to communicate with one another in order to determine the speed of the vehicles, and the relative distance between the vehicles, for example.” *Id.*, 10:54-65.



*Id.*, Fig. 1.

60. In this system, these VMCS can also communicate with a control signal interface subsystem (CSIS) to alert vehicle operators if, for example, the speed of the vehicle needs to be reduced. “For example, in some embodiments of the present technology, signal and/or reporting stations located along a railroad track can be equipped with collision avoidance systems, transponder sensor modules, UWB systems, and/or other ranging technology or radio network signaling devices. In this manner, the rail vehicles can communicate with the signal control points to alert the vehicle operators when the rail vehicle is approaching a signal control point, and the signal that the station is currently indicating. For example, the present technology can warn the vehicle operator that the rail vehicle is approaching a signal control

point indicating a "stop" signal, and that the operator should begin to reduce the speed of the vehicle.” *Id.*, 8:45-57.

61. The VMCS and CSIS can be configured to determine separation distance between a VMCS and CSIS, or between two VMCSs. “The control electronics module 1010 may determine or recognize the presence of peers detected by the data radio 1003. The data radio 1003 may also serve to transfer data to and from other peers. The data network may be a spread-spectrum network and may employ frequency hopping. Such techniques may improve signal quality and robustness of the network. The data network may share speed and location of the vehicle with the other peers. This may facilitate determining a proper separation distance between the peers (be they other VMCSs or signal control subsystems).” *Id.*, 27:1-11; *see also id.*, 26:60-67.

62. Once the separation distance is determined, the VMCS then determines a behavior rule for the vehicle, such as stop time duration or speed. “The VMCS 1000 may employ alerts and/or automatic braking events to promote compliance with rules. A rule may have one or multiple components. Such rules may be associated with control signal states. Different control signal states may include red, yellow, green, double red, or double yellow. Each control signal state may have an associated set of behaviors required for vehicles observing such a state. A red signal may mean the following: stop the vehicle; remain stopped for a period of time (e.g.,

one minute); and proceed after stopping at a restricted speed (e.g., 10 miles per hour or less until the next signal). A yellow signal may mean proceed with caution and be prepared to stop at the next signal. A green signal may mean proceed at an authorized speed. A double red (or red over red) may mean stop and stay only until an authorized person hand flags the vehicle past the signal. A double yellow (or yellow over yellow) may mean stop and then proceed at a restricted speed with caution (because, for example, a station ahead is occupied by a train).” *Id.*, 30:39-56.

63. The VMCS observes the vehicle’s operation to evaluate compliance with the rule. “The VMCS 1000 may promote compliance with such signals by monitoring a vehicle's behavior as compared to a rule. If one or more components of a rule are violated, then the VMCS 1000 may cause an alert and/or braking event. For example, if a signal is red, then a rule may include the following components: (1) come to a safe stop before reaching the signal; (2) wait for one minute; and (3) proceed after stopping at a speed of 10 miles per hour or less. The VMCS 1000 enforces compliance with each one of these components.” *Id.*, 31:6-15.

64. The VMCS can also enforce compliance with the rules. “As discussed above, the VMCS 1000 can enforce compliance of the first component of coming to a safe stop before reaching the signal. Then, the VMCS 1000 can ensure that the vehicle remains stopped for one minute (other intervals can also be chosen). If the vehicle begins moving prior to the expiration of the one minute timer, then the

VMCS 1000 can cause an alert and/or automatic braking event. After stopping for one minute, the VMCS 1000 can then cause an alert and/or automatic braking event if the vehicle does not comply with the third component of the rule-proceeding at a reduced speed of 10 miles per hour or less. Thus, the VMCS 1000 can monitor and enforce complex vehicle behavior for rules that require safe stopping, stopping duration, or reduced vehicle speed. Rules may also involve maintaining safe separation distances from other vehicles. For example, a rule may adjust a safe separation distance.” *Id.*, 31:15-31.

65. A useful technology for the radios is UWB. “UWB may provide a wide bandwidth distance measurement signal that can be used to measure distance, for example, within inches. UWB may be resistant to multipath distortions. Narrow-band time-of-flight distance measurement systems may suffer from multipath distortion. UWB may be compatible with varying operating environments including ones with buildings and walls (which cause reflections), curved tunnels, and underground.” *Id.*, 27:29-36.

66. Utilizing UWB radio communications also allows the VMCS and CSIS to communicate other data, including at least one of a unique ID associated with the VMCS, a signal indication, a track number, a track direction, speed, and direction of travel. “In addition to determining range information, the UWB network may be used to communicate data, such as: the VMCS’s unique ID, a signal indication, a

track number, a track direction, the vehicle speed, the vehicle direction of travel, or GPS information (position information and/or GPS clock value).” *Id.*, 27:37-42.

67. Using UWB, the VMCS and CSIS can determine the distance between multiple rail vehicles. The separation distance may be measured using “time of flight.” “By measuring how long it takes a wave/pulse or a signal to travel (for example by reflecting and/or bouncing, or a precisely timed response) between two transceivers, the distance between the transponder sensor modules can be accurately determined. That is, the present technology can detect the distance between two rail vehicles and/or the distance between a rail vehicle and signal/reporting station based on the time it takes a signal to travel between the transponder sensor modules. This technique may be referred to as ‘time of flight.’” *Id.*, 14:44-54.

68. If a separation criterion is violated, the system may generate a warning signal. “[T]he warning system 140 can be operable to initiate a warning signal when the distance between the rail vehicle and a proximate rail vehicle is within a predetermined limit. For example, the predetermined limit can be a value that ensures that the rail vehicle can safely be brought to a complete stop without colliding with the proximate vehicle. The predetermined limit can vary depending on the rail conditions, the weather conditions, and the speed of the rail vehicle and the proximate rail vehicle, for example.” *Id.*, 17:12-21.

69. Alternatively, the system may trigger an auto-braking system. “In some embodiments, the collision avoidance system 100 may use auto-braking system 130 and the warning system 140 together. For example, when the vehicle passes a red signal without stopping, the collision avoidance system 100 can alert the vehicle operator using the warning system 140, log the event description, timestamp, signal state, measured distance to the signal, and the vehicle operating conditions when the alarm was sounded. The collision avoidance system 100 can be configured such that the warning signal can be quieted if the vehicle operator presses a confirmation button, but to sound a periodic alert until vehicle is stopped or the signal is no longer red. If the vehicle doesn't begin braking within a predetermined distance or time (e.g., 50 feet or two seconds of passing the signal control point 40), the collision avoidance system 100 use the auto-braking system 130 to slow or bring the vehicle to a halt.” *Id.*, 17:42-57.

70. Also, the train control system includes an RFID subsystem that scans RFID tags outside the vehicle, to retrieve information that can be used to determine the distance between the VMCS and CSIS. “The rail control system 2 can also include one or more RFID tags 20 mounted at locations along a railroad track. For example, the RFID tags 20 can be mounted on the railroad rails or the ties of the railroad. In some embodiments, the RFID tags 20 can be mounted in other locations, for example, on the wall of a tunnel, on the ground, or on poles or stakes located

along the railroad track. In this manner, the VMCS (which may include an RFID reader) can read the RFID tags 20 located along the railroad track to obtain information about the location, operating track, track speed limit, and/or speed of the vehicle.” *Id.*, 11:38-48.

71. The RFID subsystem enables the VMCS to determine the distance of a vehicle by continuously monitoring the speed of the vehicle. “For example, given a known RFID tag location, the distance of a vehicle can be determined by continuously tracking the speed of the vehicle after passing the RFID tag location.” *Id.*, 30:4-7; *see also id.*, 4:3-32, 15:44-53, 28:4-21, 29:56-30:7.

72. Lastly, the train control system includes an access point external to the vehicle where the VMCS can send stored data regarding prior behavior of the vehicle. “The VMCS 1000 may also communicate with an access point (e.g., via the data radio 1003 and/or ranging radio(s) 1004). Data logs including vehicle incidents (e.g., alarm generating incidents) and speed-limit compliance may be stored in the control electronics module 1010. This information can be communicated with the access point and then forwarded to a centralized network (e.g., a rail network). The access point may also communicate data to the VMCS 1000. Such data may include, for example, track conditions, weather, and/or an updated RFID tag database (which may include location, work zone status, speed limit, etc.). In addition to communicating this information wirelessly, it may be

communicated with an access point via a physical connector (for example, connected to an access port on the VMCS 1000).” *Id.*, 31:32-46; *see also id.*, 25:22-26.

### **C. Overview of the Prior Art**

#### **1. U.S. Patent No. 6,957,131 (“Kane”) (EX1005)**

73. Kane is titled “Positive Signal Comparator and Method” and was published October 18, 2005. I was told to assume Kane qualifies as prior art. It was not cited or considered during prosecution.

74. Kane describes a train control system and method for preventing train accidents that comprises a wayside signaling device 190 (which includes a control signal interface subsystem) and a controller 110 that connects to several components of a train, such as engineer/trainman “pendants” 120/130 (which are essentially a man-machine interface controller on the train), a transceiver 140, a positioning system 150, a database 160, a tachometer 170, and a brake interface 180 (collectively, a vehicle-mounted subsystem) that communicate with each other regarding a signal indication, determine a rule for behavior of a train (such as a target speed or train behavior associated with a “medium approach medium” signal indication), and observe operation of the train to evaluate compliance with the rule. EX1005, 3:23-7:51. Figures 1 and 3 below depict a block diagram of the disclosed train control system and a flow chart illustrating operation of the system, respectively. In Figure 1, signal device 190 is located on the wayside (next to the

tracks), while the remaining components are located on a train. *Id.*, 3:23-5:24. In

Figure 3, flowchart 300 shows operation of the system 100. *Id.*, 5:25-7:51.

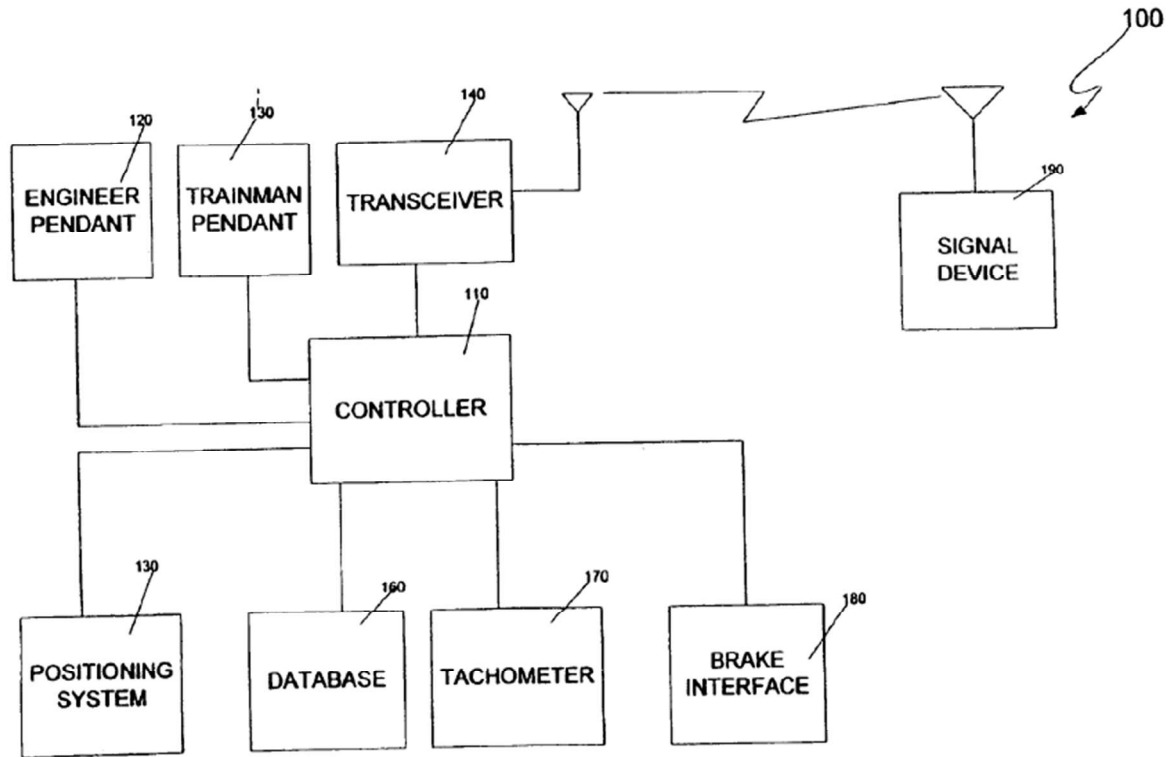


Figure 1

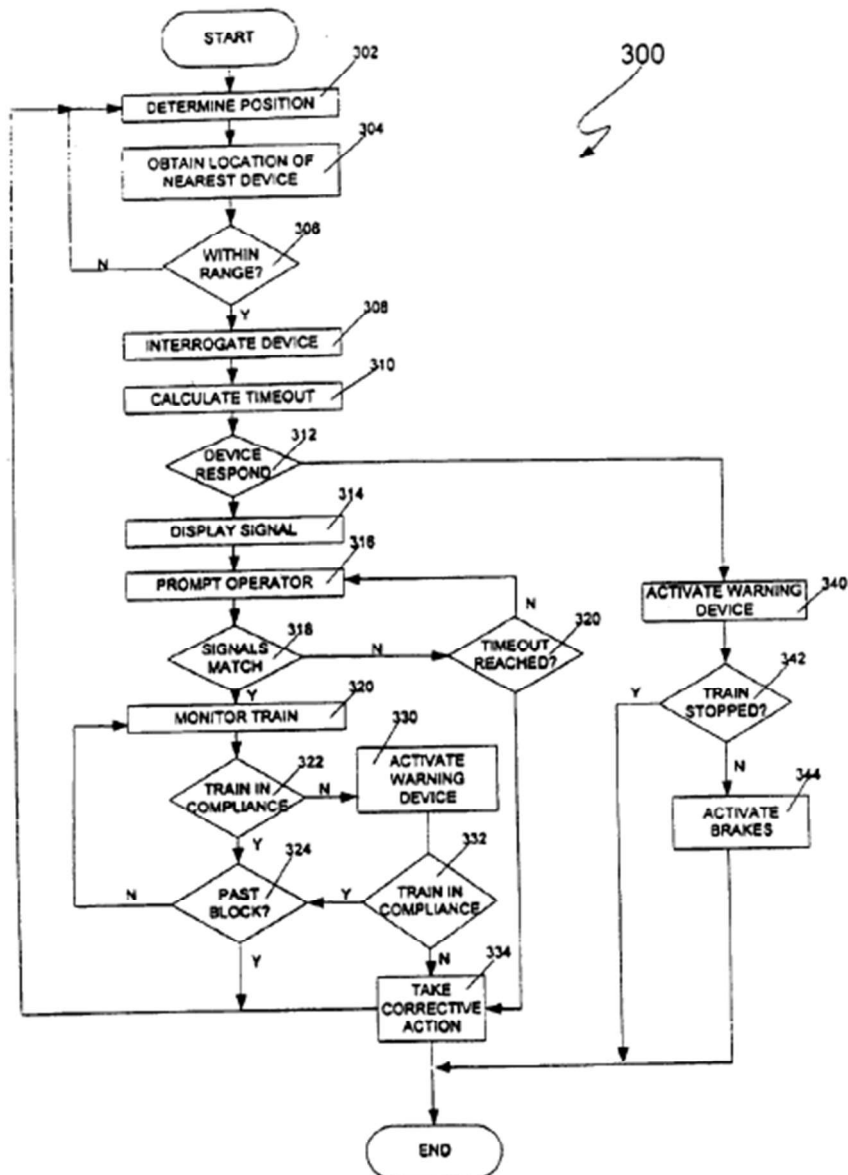
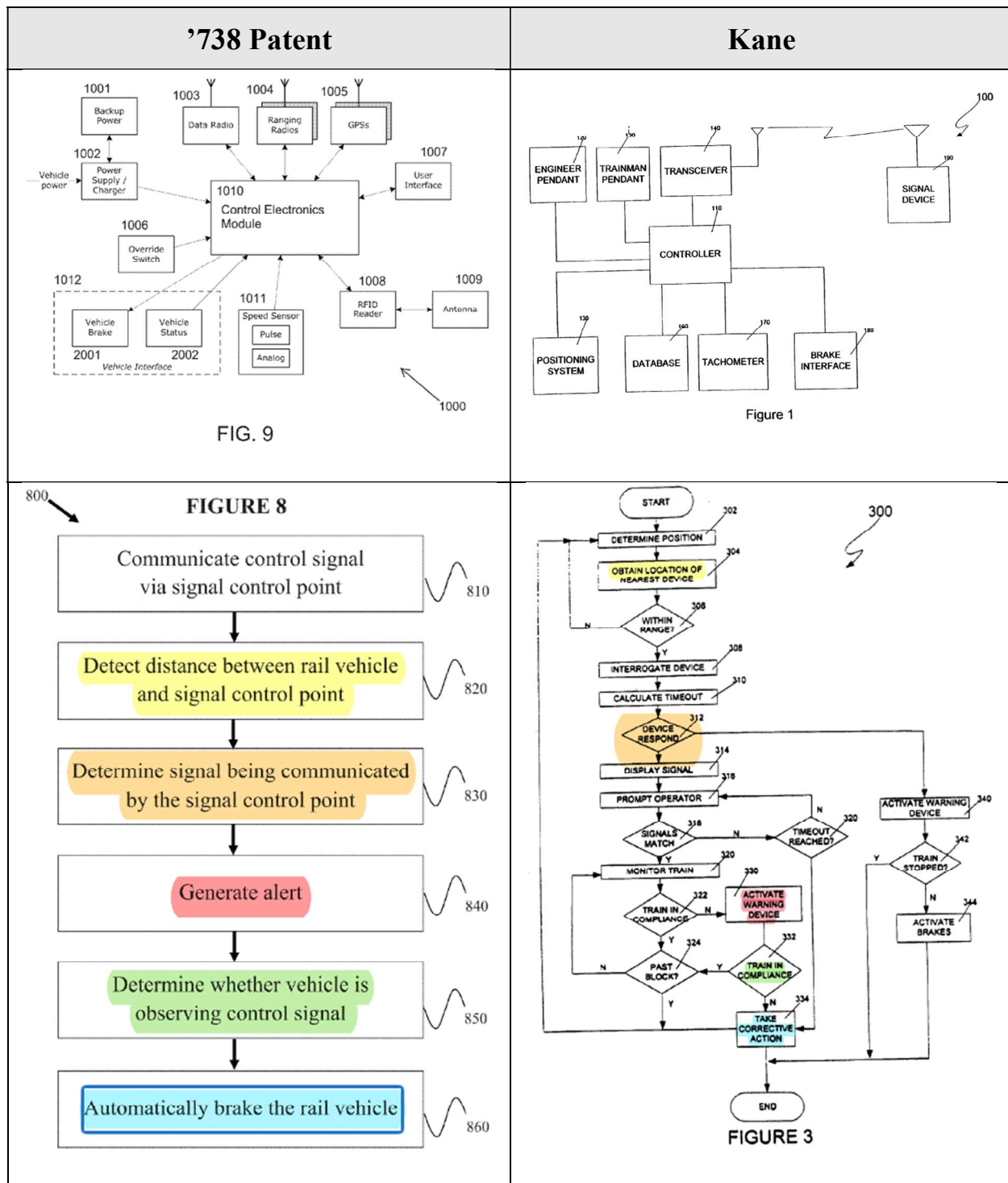


FIGURE 3

*Id.*, Figs. 1, 3.

75. As is evident from a comparison of their respective figures, the system described in Kane is quite similar to the system described in the '738 Patent.



76. For instance, as shown in Figure 9 in the '738 Patent and Figure 1 in Kane, both systems include a controller (or control electronics module) connected to several components of a train to create “a vehicle-mounted subsystem.” EX1001,

Fig. 9; EX1005, Fig. 1. The vehicle-mounted subsystems in both the '738 Patent and Kane receive information corresponding to the control signal status, determine a rule for vehicle behavior based on the control signal status, and observe the vehicle's compliance with that rule. *Infra*, ¶¶ 105-17. Additionally, as shown in Figure 8 in the '738 Patent and Figure 3 in Kane, both systems in operation include distance detection between a rail vehicle and a wayside device (yellow), signal determination (orange), alarm generation (red), observation of vehicle behavior (green), and corrective vehicle control (blue). EX1001, Fig. 8; EX1005, Fig. 3.

## **2. U.S. Patent Publication No. 2006/0151672 (“Heddebaut”) (EX1006)**

77. Heddebaut is titled “Device and Method for Positioning and Controlling Railway Vehicles with Ultra-Large Bandwidth” and was published July 13, 2006. I was told to assume Heddebaut qualifies as prior art. It was cited in an IDS but not cited by the examiner during prosecution.

78. Heddebaut describes a train control system and method for preventing train accidents that utilizes UWB radio communications between a fixed station and a railway vehicle to enable distance measurement using “time of flight” techniques. EX1006, [0007]-[0014]. The train control system also “enables direct communication between vehicles.” *Id.*, [0007]. Figure 1 of Heddebaut, reproduced below, is a schematic representation of the fixed stations and railway vehicles.

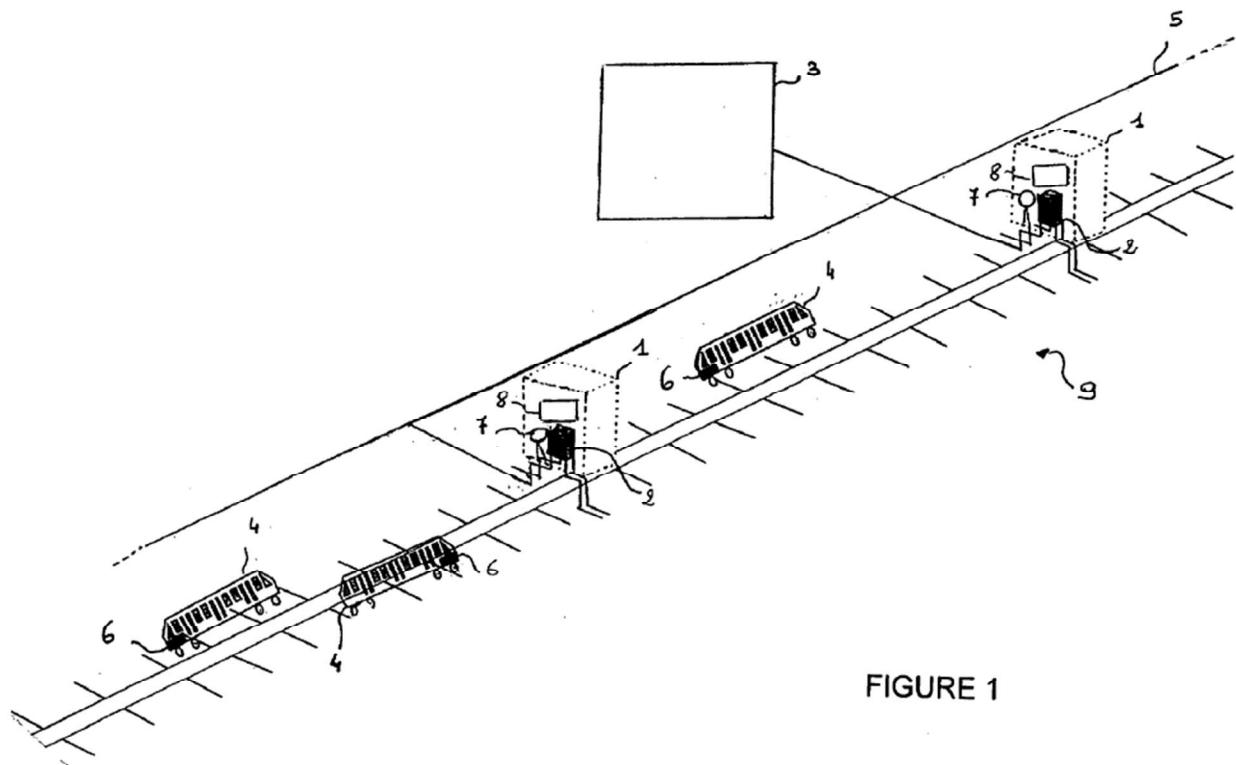


FIGURE 1

*Id.*, Fig. 1

**3. International Publication No. WO 2011/125074 (“Das”) (EX1007)**

79. Das is titled “Obstruction Independent Persistent Signalling System” and was published October 13, 2011. I was told to assume Das qualifies as prior art. It was not cited or considered during prosecution.

80. Das describes “a railway signalling system used to control and manage the railway traffic.” EX1007, Abstract. Das also describes radio frequency transponders installed on trains, fixed “station transponders” installed on tracks, and “signal towers” located at a station. *Id.*, 7:6-10, 22-25, 8:14-24. Das further explains

that these transponders broadcast data including “recommended speed for the train moving past the station [and] stop durations if any.” *Id.*, 8:18-24.

#### **4. U.S. Patent No. 5,803,411 (“Ackerman”) (EX1008)**

81. Ackerman is titled “Method and Apparatus for Initializing an Automated Train Control System” and was published September 8, 1998. I was told to assume Ackerman qualifies as prior art. It was not cited or considered during prosecution.

82. Ackerman describes automatic train control systems implemented by an “onboard computer 24.” EX1008, 4:14-22. Ackerman’s onboard computer 24 “automatically tracks the train location” and, in certain implementations, “provide[s] train protection and/or train speed control.” *Id.* Ackerman’s system uses a “train reader” to “read or receive signals” from track-based “tags,” which provide the train with their “exact location” and, in turn, allow for “the train’s location [to] be pinpointed by the onboard computer.” *Id.*, 4:62-5:22.

#### **5. U.S. Patent No. 5,950,966 (“Hungate”) (EX1009)**

83. Hungate is titled “Distributed Positive Train Control System,” and published September 14, 1999. I was told to assume Hungate qualifies as prior art. It was not cited or considered during prosecution.

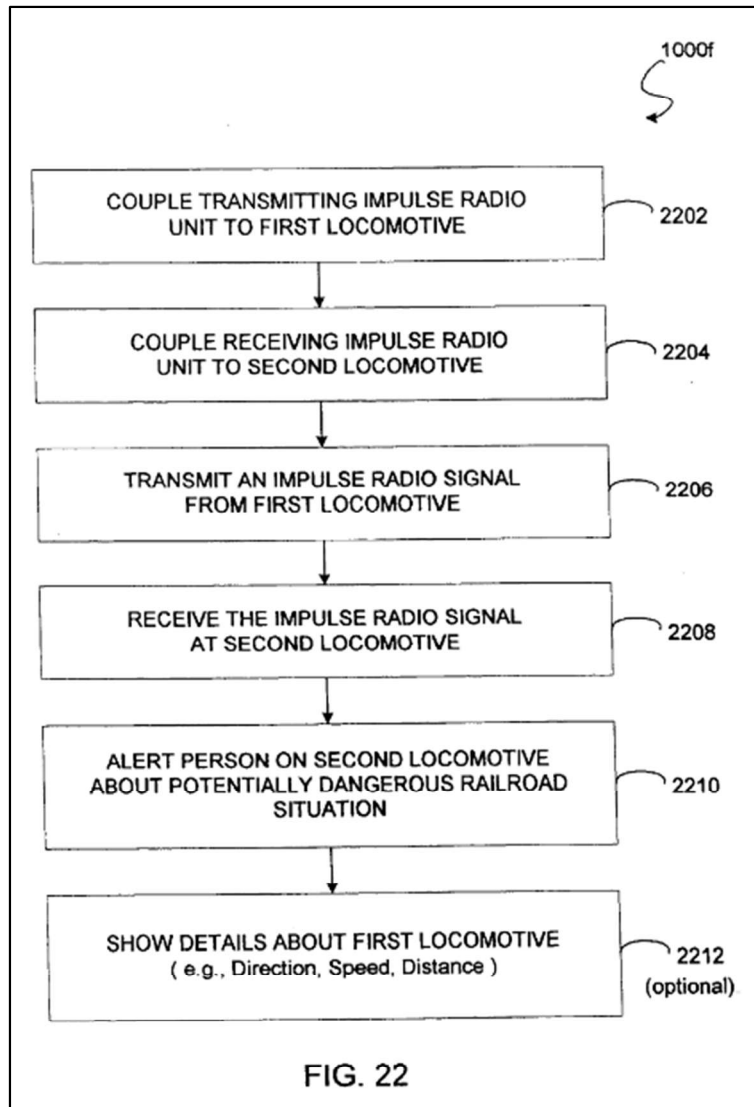
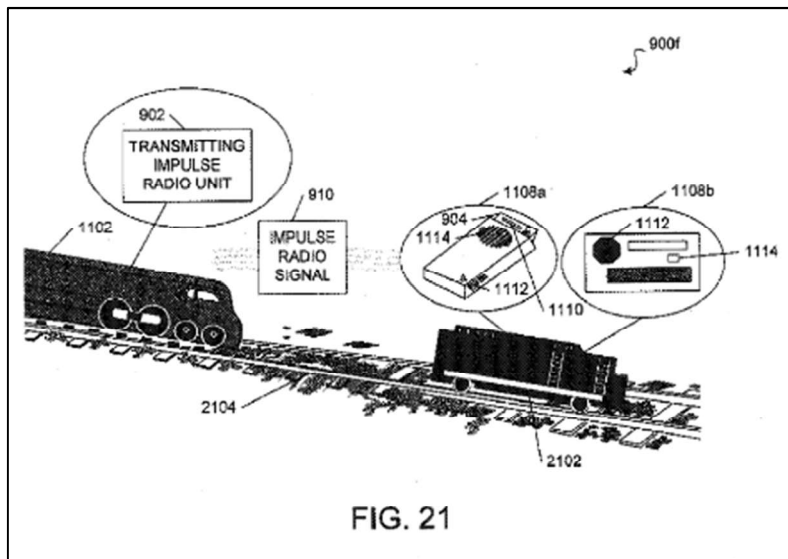
84. Hungate generally discloses “a distributed system and method for controlling train movement in a track network.” EX1009, 1:5-6. More specifically,

Hungate discloses “wayside controllers receive signals from individual trains, including position information which can be derived from a navigation system. The wayside controllers interface with a central train control network and coordinate local train movement.” *Id.*, 1:62-66. Hungate discloses that block release reports and train position reports, which include the track portions a train has completed, its prior positions and speed, and the distance it has travelled are transmitted from a train to wayside controllers. *Id.*, 4:55-5:6; *see also id.* 3:10-19.

## **6. U.S. Patent No. 6,759,948 (“Grisham”) (EX1010)**

85. 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. I understand that a related Grisham reference was listed in an IDS but was not cited by the examiner during prosecution.

86. Grisham describes a railroad collision avoidance system and method that includes direct train-to-train communications using UWB technology (impulse radios) to determine the distance between trains using “time of flight” techniques. EX1010, 23:33-24:29, Figs. 21-22. Figures 21 and 22 of Grisham, respectively show the impulse radio units on two rail line vehicles in communication with one another, and the steps involved in such communication for alerting the vehicle operator about potentially dangerous situations. *Id.*



*Id.*, Figs. 21-22.

## **VI. CLAIM INTERPRETATION**

87. I understand that determining whether a claimed invention is novel and non-obvious requires comparing the claim to the prior art. 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.

88. For the reasons I discuss in Sections VII.A to VII.G, 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.

## **VII. THE CHALLENGED CLAIMS ARE UNPATENTABLE IN LIGHT OF THE PRIOR ART IDENTIFIED IN THE PETITION**

89. I have been asked to provide my opinion concerning whether claims 1-18 of the '738 Patent are patentable over the prior art. For the reasons explained below, it is my opinion that each of claims 1-18 would have been obvious to a POSITA in view of the prior art discussed below, and therefore are unpatentable.

### **A. Ground 1A – Claims 1-2, 6-8, and 13-15 Are Obvious in View of Kane and Heddebaut**

90. It is my opinion that claims 1-2, 6-8, and 13-15 would have been obvious to a POSITA at the time of the claimed invention in view of the combination of Kane and Heddebaut.

## 1. Claim 1

91. It is my opinion that claim 1 would have been obvious to a POSITA at the time of the purported invention in view of the combination of Kane and Heddebaut.

92. The preamble of claim 1 [1-Pre] recites: **“A system for evaluating vehicle operation compliance, wherein the system comprises.”** 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 Kane.

93. Kane teaches a “positive signal comparator system” that monitors the train’s compliance with a signal from a wayside signaling device 190. EX1005, claims 1 and 31. This is a system for evaluating vehicle operation compliance. “If the wayside signaling device 190 responds at step 312, the received signal is displayed in some embodiments on the engineer's pendant 120, and in yet other embodiments on the trainman's pendant 130 at step 314. The controller 110 then prompts the engineer (and, in some embodiments, the trainman) to enter a matching signal.” *Id.*, 5:59-64.

94. Kane then states:

“If a correct matching signal is received from the engineer's pendant 120 (and, in some embodiments, the trainman's pendant 130) at step 318, *the controller then monitors the train's compliance with the signal*

*at step 320. If the train is in compliance at step 322, but is not yet past the end of the block corresponding to the signaling device 190 at step 324, step 322 is repeated until the train is past the end of the block at step 324, at which point steps 310 et seq. are repeated.”*

*Id.*, 6:4-12 (emphasis added).

95. For example, if the train is not in compliance, Kane discloses that “the controller activates a warning device at step 330. The warning device may be a pendant 120 (130) in preferred embodiments, but also may be a horn, whistle, or other device (not shown in Fig. 1) rather than addition to the pendant 120 in other embodiments.” *Id.*, 6:13-18. The train can then be brought into compliance by the operator or, if the train is not brought into compliance, “corrective action is taken at step 334. The types of corrective action can include applying a penalty braking algorithm, which will stop the train; notifying a dispatcher (in embodiments that provide for communication between the system 100 and a dispatcher); and slowing the train down to a predetermined safe speed to allow the engineer to visually verify that it is safe to proceed.” *Id.*, 6:20-25.

96. Claim element [1A] recites: **“a control signal interface subsystem.”** It is my opinion that Kane teaches the claimed control signal interface subsystem as used in the ’738 Patent.

97. Kane discloses a wayside signaling device 190, which is a device that sits next to the tracks and communicates control signals to approaching railway

vehicles. *See id.*, 1:10-24, 4:15-31, 5:59-6:12, Figs. 1, 3, claims 1 and 31. “Traditional wayside signaling systems comprise one or more colored signal lights that are mounted on poles alongside a train track at various locations such as near the beginning of a block of track or near grade crossings, sidings, switches, etc.” *Id.*, 1:11-15.

98. Kane teaches:

In embodiments of the invention in which the signal from the wayside signal device 190 is displayed to the engineer/operator, the signal may be displayed in a “pop-up” window in the window 210. In other embodiments, the signal may only be displayed next to the distance to signal field 214 as discussed above. In other embodiments, no visual indication of the signal device 190 is provided on the pendants 120, 130. Rather, in such embodiments, the engineer/operator relies on a visual indication on the signal device 190 such as colored lights.

*Id.*, 4:15-24. The wayside signaling device 190 in Kane transmits a “response signal,” which is the same type of signal that the ’738 Patent refers to as a “control signal.” *Compare* EX1001, 23:11-25:12, 29:25-31:5 and EX1005, Abstract, 1:66-2:12.

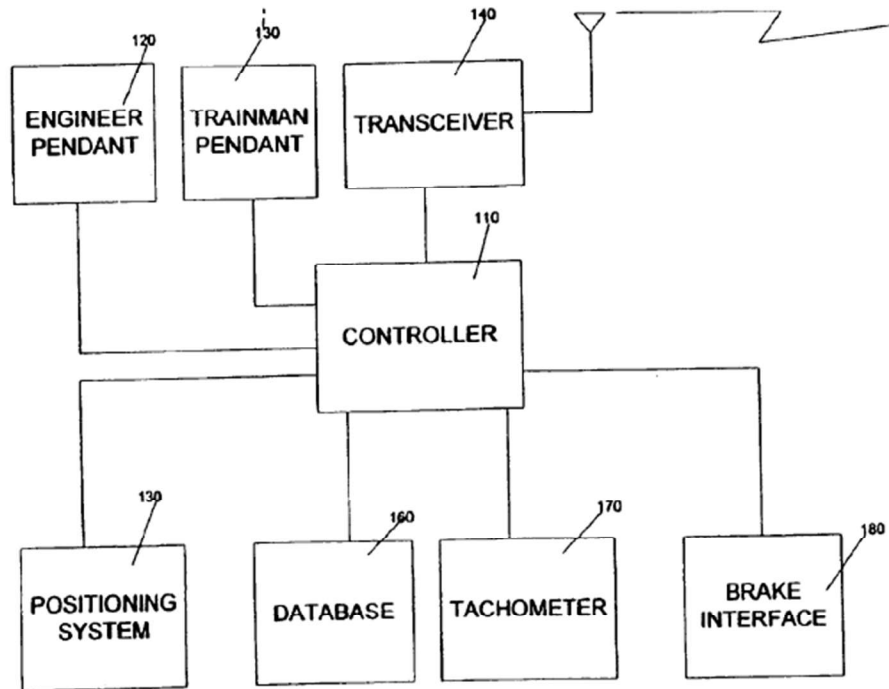
99. Wayside signal device 190 includes a subsystem that interfaces with railway vehicles to transmit control signals to those vehicles (“a control signal interface subsystem”) because wayside signal device 190 generates control signals

that are transmitted wirelessly to railway vehicles, in addition to transmitting those signals visually via colored lights or more complex signals.

100. Claim element [1B] recites: **“a vehicle-mounted subsystem configured to.”** It is my opinion that Kane teaches the claimed vehicle-mounted subsystem as used in the '738 Patent.

101. Kane states that “[a] positive signal comparator system 100 is illustrated in Fig. 1. The system 100 includes a controller 110. The controller 110 may be a conventional microprocessor or may be implemented using discrete components. The controller 110 is responsible for implementing the logical operations discussed in detail below.” EX1005, 3:23-28.

102. Kane discloses that controller 110 connects to several components of a train, such as pendants 120/130, a transceiver 140, a positioning system 150, a database 160, a tachometer 170, and a brake interface 180, as seen below in FIG 1.



*Id.*, Fig. 1; *see also id.*, 3:24-5:24.

103. Kane teaches that “a transceiver 140 is also connected to the controller 110. The transceiver 140 is capable of communicating with wayside signal devices 190.” *Id.*, 4:25-27. The communication between the transceiver and the wayside signal devices “is wireless in preferred embodiments.” *Id.*, 4:28.

104. Kane teaches that the transceiver is “located on a train.” *Id.*, 1:66-2:12. Kane also teaches that the controller is “located on a train.” *Id.*, claim 1 and 31. Thus, Kane discloses that all of these connected components (110, 120, 130, 140, 150, 160, 170, 180) comprise a vehicle-mounted subsystem on a train.

105. Claim element [1C] recites: “**communicate with the control signal interface subsystem to receive information corresponding to a status of a**

**control signal.”** It is my opinion that Kane teaches that the vehicle-mounted subsystem communicates with the control signal interface subsystem to receive information regarding the status of a control signal as claimed in the ’738 Patent.

106. Kane discloses that “the controller 110 causes the transceiver 140 to transmit an interrogation message” to a wayside signaling device 190. *Id.*, 5:37-39. Kane also discloses other means for communicating between the transceiver 140 and the wayside signaling device 190. *Id.*, Abstract, 2:1-4, 4:15-31, 5:59-6:4, Fig. 3, claims 1 and 31. Kane states: “If the wayside signaling device 190 responds at step 312, the received signal is displayed in some embodiments on the engineer's pendant 120, and in yet other embodiments on the trainman's pendant 130 at step 314.” *Id.*, 5:59-62. The received signal conveys the “status” of the wayside signaling device (the “signal indication”) to the onboard controller, such as “medium approach medium” or a signal representing the combination of lights that are being visually displayed. *Id.*, 3:45-4:24.

107. Kane further teaches that once a response signal is received, “[t]he controller 110 then prompts the engineer (and, in some embodiments, the trainman) to enter a matching signal at step 316.” *Id.*, 5:62-64. “The buttons 231-242 are used by the engineer/operator (and, in embodiments with two pendants, the trainman) to

acknowledge a signal from a wayside signaling device. *Id.*, 3:45-47.

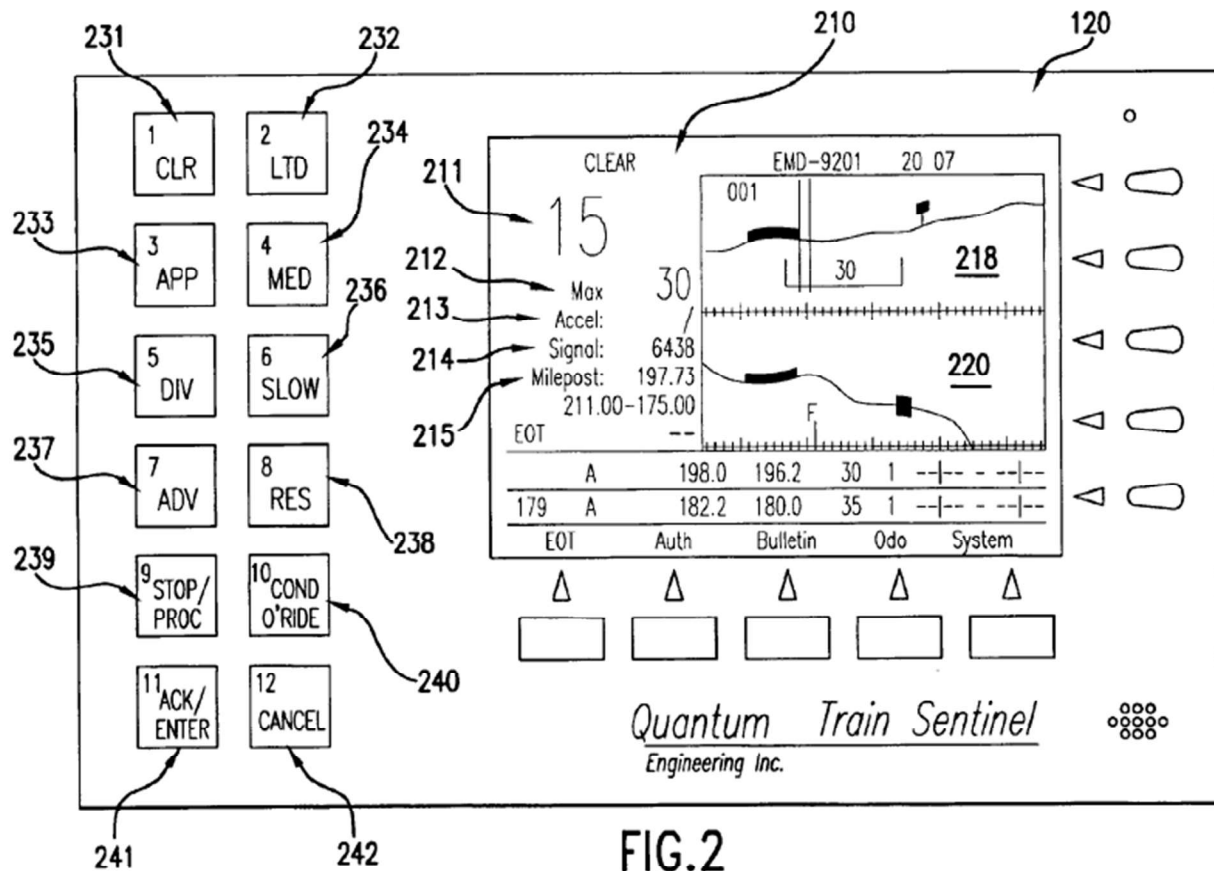


FIG. 2

*Id.*, Fig. 2; see also *id.*, 3:29-56, 5:62-64.

108. Kane teaches that both the buttons 231-240 and response signals from the wayside signaling device 190 correspond to “various signals defined in the GCOR (General Code of Operational Rules) and various other signaling systems used in the United States.” *Id.*, 3:39-42. More particularly:

For example, if a “medium approach medium” signal were received from the wayside signal device (which means that the train is allowed to travel at medium speed through turnouts, crossovers sidings and over power operated switches, then proceed, approaching the next signal at

a speed not exceeding the medium speed), the engineer/operator would depress the MED button 234, the APP button 233, and the MED button 234 in that order to verify that the signal has been correctly received and understood by the engineer/operator.

*Id.*, 3:46-56.

109. Therefore, Kane's controller 110 and transceiver 140 (part of its "vehicle-mounted subsystem") communicate with the wayside signaling device 190 (which includes a "control signal interface subsystem") via an interrogation signal and receives a response signal from the wayside signaling device 190 conveying the status of the control signal (*e.g.*, medium speed, approach, slow).

110. Claim element [1D] recites: **"determine a rule for behavior of a vehicle according to the information corresponding to the status of the control signal."** It is my opinion that Kane teaches that the vehicle-mounted subsystem determines a behavior rule for a rail vehicle in response to information regarding the status of the control signal, as claimed in the '738 Patent.

111. Kane states "If a correct matching signal is received from the engineer's pendant 120 (and, in some embodiments, the trainman's pendant 130) at step 318, the controller then monitors the train's compliance with the signal at step 320." *Id.*, 6:4-8.

112. Kane states:

As discussed above, compliance with the signal from the wayside signaling device 190 is monitored at step 322. An example of non-compliance is if the speed of the train exceeds the “target” speed for a given signal by a prescribed speed over the target speed and the train is not decelerating, at a target deceleration amount (e.g., 1 mph/min). In some embodiments, if an initial determination of non-compliance is made, a response timer will be set and automatic braking will occur upon timeout of the response timer unless (1) the speed of the train is reduced to less than 5 mph above the “target speed”; (2) the train is decelerating at an acceptable rate; or (3) the speed of the train is brought below the “target speed”.

*Id.*, 6:55-67. In this example, the behavior rule is a speed limit for the train (i.e., the “‘target’ speed”) corresponding to the status of the signal received from the wayside signaling device 190. Speed instructions coming from a wayside signals were known in the art. EX1032, 2:40-47.

113. For example, as discussed above for element [1C], the response signal received from the wayside signaling device 190 can indicate “a ‘medium approach medium’ signal.” In monitoring compliance with the status of that signal, the controller 110 determined a behavior rule for the train corresponding to the status of that signal—“the train is allowed to travel at medium speed through turnouts, crossovers sidings and over power operated switches, then proceed, approaching the next signal at a speed not exceeding the medium speed.” Kane suggests that the controller 110 is programmed to determine other behavior rules for the status of

other signals (e.g., slow or advance). *See* EX1005, Abstract, 2:6-12, 2:41-43, 6:4-25, 7:45-51, Fig. 3, claims 1-7, 9, 31, and 39-40.

114. Claim element [1E] recites: **“observe operation of the vehicle to evaluate compliance with the rule; wherein.”** It is my opinion that Kane teaches that the vehicle-mounted subsystem observes the operation of the rail vehicle to ensure it is compliant with a behavior rule for a rail vehicle, as claimed in the '738 Patent.

115. Kane states “If a correct matching signal is received from the engineer's pendant 120 (and, in some embodiments, the trainman's pendant 130) at step 318, the controller then monitors the train's compliance with the signal at step 320.” *Id.*, 6:4-8.

116. Kane states:

As discussed above, compliance with the signal from the wayside signaling device 190 is monitored at step 322. An example of non-compliance is if the speed of the train exceeds the “target” speed for a given signal by a prescribed speed over the target speed and the train is not decelerating, at a target deceleration amount (e.g., 1 mph/min). In some embodiments, if an initial determination of non-compliance is made, a response timer will be set and automatic braking will occur upon timeout of the response timer unless (1) the speed of the train is reduced to less than 5 mph above the “target speed”; (2) the train is decelerating at an acceptable rate; or (3) the speed of the train is brought below the “target speed”.

*Id.*, 6:55-67. In this example, controller 110 monitors the compliance of the train's actual speed with the behavior rule: a speed limit for the train (i.e., the “target speed”) corresponding to the status of the signal received from the wayside signaling device 190.

117. For example, as discussed above for element [1D], the controller 110 determined a behavior rule for the train corresponding to “a ‘medium approach medium’ signal.” The controller 110 then monitors operation of the train for compliance with that rule. *Id.*, 3:46-56. Kane teaches that the controller 110 is programmed so that when it receives the “medium approach medium” signal (or slow or advance), the onboard controller automatically begins to monitor the train's behavior to ensure compliance with the status of the signal. *See id.*, Abstract, 2:6-12, 41-43, 6:4-25, 7:45-51, Fig. 3, claims 1-7, 9, 31, and 39-40.

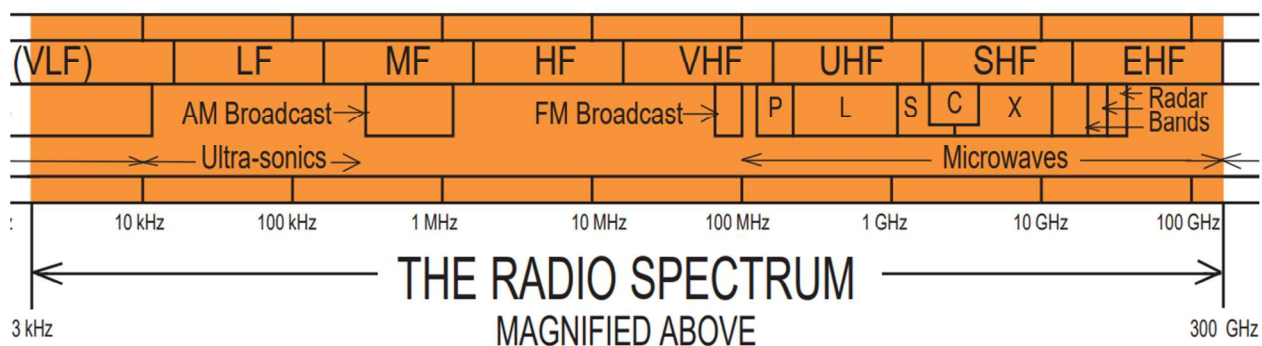
118. Claim element [1F] recites: **“the control signal interface subsystem comprises an ultra-wideband (UWB) communications component.”** It is my opinion that Kane in view of Heddebaut rendered it obvious to a POSITA at the time of the alleged invention to implement Kane's control signal interface with UWB communications components.

119. Kane discloses “a plurality of wayside signal devices, each of the wayside signal devices including a radio frequency transceiver, each of the radio frequency transceivers being configured to transmit at a same frequency, each of the

wayside signal devices being configured to transmit an identification number along with a wayside signal in response to an interrogation signal.” *Id.*, claim 34. Kane also discloses: “At prescribed railroad locations, a low power transmitter can be employed to automatically update the database 160 (which may or may not be accomplished using transceiver 140). Additionally, an existing RF infrastructure of the rail system could be employed to update all locomotives with new data.” *Id.*, 7:25-30.

120. As discussed with respect to element [1A], the wayside signaling device 190 includes “a control signal interface subsystem” as claimed. *Supra*, ¶¶ 96-99. A POSITA would have understood that the radio frequency components were part of this subsystem. Therefore, the wayside signaling device 190 uses “radio frequency” communications, but Kane does not specify or otherwise limit which frequencies/modulation techniques are or could be used.

121. A POSITA in the 2013 timeframe would have understood that “radio frequency” communications are electromagnetic signals having frequencies from 3 kHz to 300 GHz:



EX1022. UWB communications, which have frequencies in the range of 3.1 to 10.6 GHz, are thus radio frequency communications. EX1014, 194.

122. A POSITA would have understood that Kane taught using any type of “radio frequency” communications components (transceivers or transmitters/receivers) known in the art to be suitable for communication between a train and a wayside signaling device, and that would include UWB communications. Indeed, by September 2013, it was well-known that UWB radio transmissions were used for communication between a wayside device and a railway vehicle in the manner claimed in the '738 Patent. EX1006, Abstract, [0024], [0041], [0045], Fig. 1; EX1010, 4:19-25; 19:14-19.

123. For example, like Kane, Heddebaut discloses “a device and method for positioning and controlling railway vehicles.” EX1006, Abstract. “The device includes fixed stations 1 comprising first transmission-reception means 2 of signals,”

as illustrated in Figure 1.

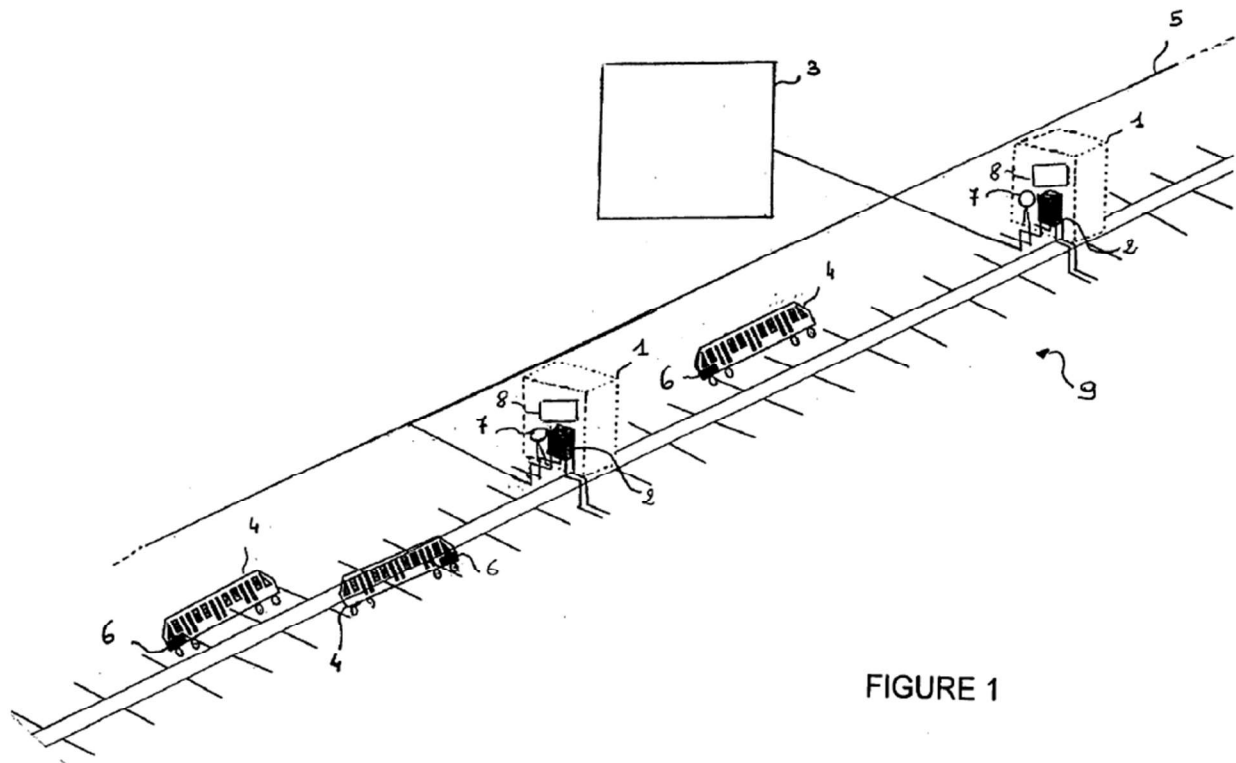


FIGURE 1

*Id.*, [0041], Fig. 1; *see also id.*, [0008], [0010], [0024], [0026], [0057], claim 1.

Thus, like Kane, Heddebaut discloses that a wayside device includes “a control signal interface subsystem” as claimed, on its fixed station 1.

124. Also, in Heddebaut, “[t]he signals transmitted by the first and second transmission-reception means of signals 2, 6 contain a specific identifier of the transmitter and at least one message.” *Id.*, [0044]. “These single identifiers per rail vehicle 4 and fixed station 1 modulate a pulse string according to an ultra wide band technique.” *Id.*, [0045]. Therefore, Heddebaut discloses that a control signal interface subsystem on fixed station 1 (the first transmission-reception means 2)

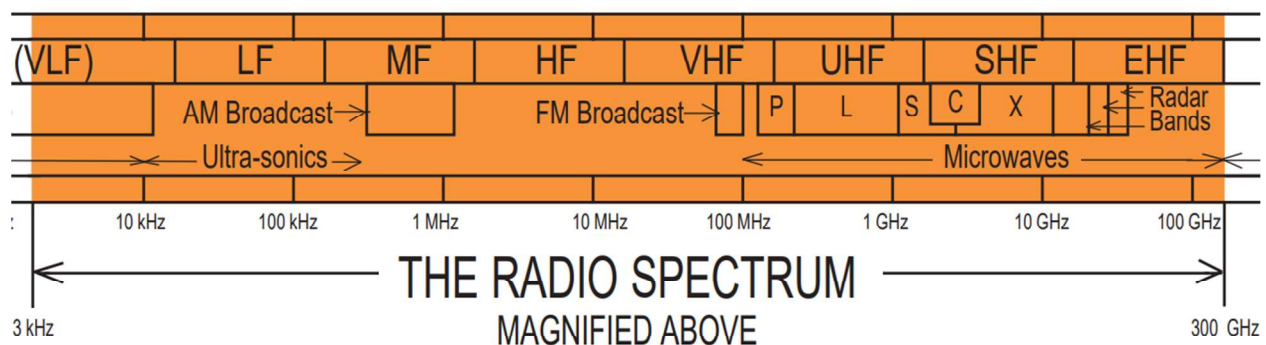
includes a UWB communications component. Heddebaut shows that UWB was a known communications technology well-suited to be used for Kane's "radio frequency" communication between a train and a wayside device.

125. Claim element [1G] recites: **"the vehicle-mounted subsystem comprises an ultra-wideband (UWB) communications component."** It is my opinion that Kane in view of Heddebaut rendered it obvious to a POSITA at the time of the alleged invention to implement Kane's vehicle-mounted subsystems with UWB communications components.

126. Kane discloses, in claim 31, "a receiver connected to the controller for receiving a wayside signal from a wayside signal device," which is located on a train. *Id.*, claim 31. In claim 32, Kane discloses "a transmitter connected to the controller for transmitting an interrogation signal to a wayside signal device under the control of the controller." *Id.*, claim 32. In claim 33, Kane discloses "[t]he system of claim 32, wherein the transmitter and receiver are radio frequency devices." *Id.*, claim 33. Kane also discloses: "At prescribed railroad locations, a low power transmitter can be employed to automatically update the database 160 (which may or may not be accomplished using transceiver 140). Additionally, an existing RF infrastructure of the rail system could be employed to update all locomotives with new data." *Id.*, 7:25-30.

127. As discussed with respect to element [1B], all of the connected components (the controller, receiver, and transmitter) together are “a vehicle-mounted subsystem” as claimed. *Supra*, ¶¶ 100-04. Therefore, the transmitter/receiver uses “radio frequency” communications, but Kane does not specify or otherwise limit which frequencies are or could be used.

128. A POSITA in the 2013 timeframe would have understood that “radio frequency” communications are electromagnetic signals having frequencies from 3 kHz to 300 GHz:



EX1022. UWB communications, which have frequencies in the range of 3.1 to 10.6 GHz, are thus radio frequency communications. EX1014, 194.

129. A POSITA would have understood that Kane taught using any type of “radio frequency” communications components (transceivers or transmitters/receivers) known in the art for communication between a train and a wayside signaling device, and that would include UWB communications. Indeed, by September 2013, it was well-known that UWB radio transmissions were well-suited to be used for communication between a wayside device and a railway vehicle

in the manner claimed in the '738 Patent. EX1006, Abstract, [0024], [0041], [0045], Fig. 1; EX1010, 4:19-25; 19:14-19.

130. For example, like Kane, Heddebaut discloses “a device and method for positioning and controlling railway vehicles.” EX1006, Abstract. “Each rail vehicle 4 comprises second transmission reception means 6 of signals.” *Id.*, [0044]. Thus, like Kane, Heddebaut discloses “a vehicle-mounted subsystem” as claimed.

131. Also, in Heddebaut, “[t]he signals transmitted by the first and second transmission-reception means of signals 2, 6 contain a specific identifier of the transmitter and at least one message.” *Id.*, [0044]. “These single identifiers per rail vehicle 4 and fixed station 1 modulate a pulse string according to an ultra wide band technique.” *Id.*, [0045]. Therefore, Heddebaut teaches a vehicle-mounted subsystem on a rail vehicle 4 (second transmission reception means 6) that includes a UWB communications component. Heddebaut shows that UWB was a known communications technology well-suited to be used as Kane’s “radio frequency” communication between a train and a wayside device.

132. Claim element [1H] recites: **“the vehicle-mounted subsystem and the control signal interface subsystem are further configured to communicate UWB signals carrying data pertinent to evaluating vehicle operation compliance, the data comprising at least one of: a unique ID associated with the vehicle-mounted subsystem, a signal indication, a track number, a track**

**direction, speed, and direction of travel.”** It is my opinion that Kane in view of Heddebaut teach or render obvious the use of UWB communications components within Kane’s control signal interface and vehicle-mounted subsystems that are configured to transmit the particular content required by element [1H].

133. As discussed with respect to elements [1F] and [1G] above, Kane and Heddebaut teach UWB signals communicated by “the vehicle-mounted subsystem” and “the control signal interface subsystem.” With respect to the content of those UWB signals, Kane teaches communication between the subsystems that includes transmission of an interrogation message from the train to the wayside signal device, and transmission of a response signal from the wayside signal device back to the train that conveys at least a signal indication (status) of the wayside signal device. EX1005, 7:25-30, claims 31-34. For example, the response signal may include data representing a “medium approach medium” signal indication, as discussed with reference to elements [1C] and [1D]. A POSITA would have understood that a “medium approach medium” signal requires that the approaching train proceed at medium speed until the entire train clears all switches, and then approach the next signal at medium speed. That data is “pertinent to evaluating vehicle operation compliance” because it establishes the speed limit against which the subsequent operation of the train is evaluated. EX1005, 3:29-56, 6:4-25, 6:55-60, Fig. 2. Therefore, Kane teaches radio-frequency signals carrying data pertinent to

evaluating vehicle operation compliance, including at least two of the particular types of content specified in the claim (i.e., a signal indication and a track speed).

134. Additionally, Heddebaut's UWB signals "contain a specific identifier of the transmitter and at least one message," the identifier being "a specific code and a specific identity which are ascribed to a transmitter." EX1006, [0044]-[0045].

135. Heddebaut states the following:

***Each rail vehicle 4 and each fixed station 1 include processing means 8 for determining the identifier and at least said message of each signal received.*** Thus, since the transmitter of each fixed station 1 or of each rail vehicle is ascribed a specific code and since the first and second transmission-reception means 2, 6 contain in a storage memory the identifiers of the different transmission-reception ultra wide band means of the network, each ultra wide band receiver, fixed or mobile, may play the part, locally, of these different identifiers and attempt at decoding by correlation the signals from the first transmission-reception means 2 of the fixed stations 1 (stations) or from the second transmission-reception means 6 coming from the rail vehicles 4, such as radioelectric range trains. Each transmission-reception means 2, 6 has therefore:

One or several processing lanes locked onto the codes of the fixed stations 1 (stations) and rail vehicles 4 (trains) in radio range. ***They collect the operating data transmitted (identity, speeds, positions, state of the trains and stations . . . ).***

*Id.*, [0048]-[0049] (emphasis added). The identifier shows which device sent the UWB signal, so the identifier for the second transmission-reception means 6 is “a unique ID associated with the vehicle-mounted subsystem.”

136. Therefore, Heddebaut teaches that the first and second transmission-reception means 2 and 6 communicate UWB signals that include data pertinent to evaluating vehicle operation compliance including at least an identifier and a message regarding the identity, speeds, positions, state of the trains and stations. Thus, as discussed above for element [1F], Heddebaut demonstrates that UWB was a known communications technology well-suited for Kane’s “radio frequency” communication between a train and wayside device.

137. Both Kane and Heddebaut teach train control systems that rely, at least in part, on communications between trains and wayside devices. *Supra*, ¶¶ 106-36. Also, both Kane and Heddebaut disclose communicating radio signals between “a control signal interface subsystem” and “a vehicle-mounted subsystem” that include data comprising at least one of: a unique ID associated with the vehicle-mounted subsystem (Heddebaut’s identifier), a signal indication (the information included in

Kane's response signal (*e.g.*, "medium approach medium") and Heddebaut's state of station), and speed (Kane's speed (including medium speed and target speed) and Heddebaut's speed). *Supra*, ¶¶ 133-36. The difference between Kane and Heddebaut is that Kane broadly discloses that the signals are "radio frequency" signals, without limiting them to any particular frequency or frequency band, while Heddebaut specifically discloses using UWB radio signals. *Supra*, ¶¶ 122, 124, 129. UWB technology "is a wireless [radio] technology for transmitting large amounts of data over a wide spectrum of frequency bands with very low power and for a short distance." EX1011, [0003]. Kane already explained that "a low power transmitter" can be used with its vehicle mounted subsystem. EX1005, 7:25-28. UWB is well-suited for the communications that Kane discloses because the interrogation/response signals are used in addition to what the operator would ordinarily see visually, so Kane is contemplating relatively short distances.

138. Heddebaut itself explains why a POSITA implementing Kane's train control system would have been motivated to use UWB for communication between the trains and wayside devices:

All the current driving systems in operation use sinewave signals based upon narrow band or spectrum-spreading technologies. Items of radio equipment are hence preferably installed far and between in station.

However, when considering the propagation of sinewave radioelectric signals through a tunnel, at low frequency, *i.e.* just a few hundred MHz,

these signals are attenuated very rapidly. Attenuation may reach values of the order of 30 to 40 dB per 100 m at 100 MHz through a road tunnel. Such physical characteristic renders thereof the use thereof incompatible with the ranges between stations currently contemplated in modern urban guided transport (of the order of one kilometre).

The purpose of the present invention is hence to provide a device and a method for positioning and controlling rail vehicles with ultra wide frequency bands simple in their design and in their operating mode, with very high transfer rate of data and economical, limiting the risks of interferences with other wireless communication systems, thereby enabling rail vehicle-ground telecommunication with a radioelectric coverage, in particular in tunnel, close to 100% and highly available, very reliable odometry of the rail vehicle and a perception of the front environment of said vehicle for the detection of obstacles and hence reinforced safety of the passengers. Such system also enables direct communication between vehicles, which proved necessary in certain operating modes.

EX1006, [0005]-[0007]. Therefore, Heddebaut explains (and a POSITA would have known) that traditional wireless communications are not ideal for underground transportation, particularly tunnels, and that UWB not only performs better, but it is simple in design and operating mode and limits the risk of interference with other wireless communications. *Id.*

139. In particular, a POSITA would have been motivated to implement communication via UWB signals into Kane's vehicle-mounted and control signal

interface subsystems. Kane and Heddebaut both disclose train control systems that would be expected to operate in various environments (including tunnels, see EX1006, [0005]-[0007]), and Heddebaut demonstrates that UWB was a known communication technology well-suited for Kane's "radio frequency" communication between a train and a wayside device. *Supra*, ¶¶ 124, 131. Also, it would have been obvious for a POSITA to try UWB as the specific radio frequency for the same reasons. There are a finite number of radio frequency types that had been identified by the priority date, and a POSITA would have had a reasonable expectation of success implementing UWB as the radio frequency used for communication between a train and a wayside device.

140. Prior art discloses:

UWB or digital pulse wireless communication 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. UWB radio signals not only can carry a huge amount of data over a short distance at very low power, e.g., less than 0.5 milliwatts, but have the ability to carry signals through doors and other obstacles that tend to reflect signals having more limited bandwidths and a higher power.

UWB signals are transmitted as digital pulses that are timed very precisely on a carrier signal across a very wide spectrum of frequencies. A transmitter and a receiver are synchronized to send and receive pulses with an accuracy of trillionths of a second. On any particular frequency, the UWB signal has less

power than normal and anticipated background noise. Theoretically, interference with conventional radio signals is negligible.

UWB communication has three main types of application. In radar applications, the UWB signal penetrates nearby surfaces but is reflected by surfaces that are farther away, allowing objects to be detected behind walls or other coverings. In data transmission applications, digital pulses allow a very low powered and relatively low cost signal to carry information at very high data rates over a short range. In location awareness applications, ultra wideband digital pulses allow accurate ranging estimate between different devices.

EX1011, [0003]-[0005]. These benefits of UWB would have motivated a POSITA to implement Heddebaut's UWB communications in Kane's train control system at the time of the purported invention of the '738 Patent.

141. One way UWB systems achieve high-bandwidth is by transmitting impulse-like waveforms, which have a short time profile and wide frequency profile, unlike traditional RF modulated sine waves that have a long time profile and narrow frequency profile:

Ultra Wideband (UWB) is a short duration, pulsed RF technology that achieves the highest possible bandwidth at the lowest possible center frequency. The technology can be used for communications, radar, and ranging/location applications.

In contrast with spread spectrum radio technologies that achieve a few 100s of kilohertz (kHz) to 10s of megahertz (MHz) of bandwidth, UWB

signals are spread over a few gigahertz (GHz), achieving relative bandwidths of 25-100%.

UWB systems achieve this bandwidth by transmitting an impulse-like waveform. Such waveforms are inherently broadband. In fact, Fourier analysis teaches us that an ideal impulse (i.e., a waveform of a given amplitude and infinitesimally short duration) would provide infinite bandwidth. As a result, transmissions are quite unlike traditional RF modulated sine waves. Instead they resemble a train of pulses.

EX1012, 3 (footnote omitted). These benefits of UWB would have motivated a POSITA to implement Heddebaut's UWB communications in Kane's train control system at the time of the purported invention of the '738 Patent.

142. UWB-based technology also has several benefits over other common wireless technology. First, because of their wide-bandwidth / short-pulse duration, UWB signals are naturally resistant to multipath effects:

One of the main reasons for selecting a UWB ranging or communications system over a narrow band system is that a UWB system is able to resolve multipath thereby enabling operation in highly cluttered environments. UWB systems can resolve multipath because their transmitted RF pulse has a bandwidth of almost 2 GHz, giving individual pulses a physical length of about 6 inches. Because the pulses are physically small, a UWB system can separate, or resolve, multipath reflections from a main signal by focusing on the first arriving pulse.

EX1012,, 5; *see also* EX1011, [0009] (“One type of an UWB system is an impulse radio (IR). IR uses extremely short duration pulses to generate signal waveforms, and allows fine time resolution of channel multipath characteristics, which is important in identifying the line of sight signal for precision ranging.”). As another advantage, UWB-based ranging provides high resolution for precise distance measurements. EX1012,, 4 (“These advantages are due to UWB short pulses (large bandwidths): . . . The ability to range accurately in the presence of multipath . . .”). As still another advantage, UWB-based ranging can be combined with UWB-based data communication functionality to use the same UWB signals for both ranging and (non-ranging) data communication. *Id.*, 13 (The UWB “pulse can be *simultaneously* used for data, measurement of range, and operation as a radar.”) (footnote omitted). Yet another benefit of UWB technology is that it requires low operating power, making UWB efficient and unlikely to interfere with coexisting RF systems. EX1012, 5; *see also* EX1011, [0003]-[0005]. These additional benefits of UWB would have motivated a POSITA to implement Heddebaut’s UWB communications in Kane’s train control system at the time of the purported invention of the ’738 Patent.

143. A POSITA reasonably would have expected to succeed using UWB with train control and collision-avoidance systems like the one disclosed in Kane because such systems were already known in the art.

The purpose of the present invention is hence to provide a device and a method for positioning and controlling rail vehicles with ultra wide frequency bands simple in their design and in their operating mode, with very high transfer rate of data and economical, limiting the risks of interferences with other wireless communication systems, thereby enabling rail vehicle-ground telecommunication with a radioelectric coverage, in particular in tunnel, close to 100% and highly available, very reliable odometry of the rail vehicle and a perception of the front environment of said vehicle for the detection of obstacles and hence reinforced safety of the passengers.

EX1006, [0007]; EX1010, 11:33-37 (“FIG. 5A illustrates the result of a narrow band sinusoidal interference signal 502 overlaying an impulse radio signal 504. At the impulse radio receiver, the input to the cross correlation would include the narrow band signal 502 and the received ultrawide-band impulse radio signal 504.”); EX1013, 1-4 (Title: “CCS: A Railway Corridor Control System Utilizing Ultra Wideband Radio Technology”). Moreover, a POSITA would have had a reasonable expectation of success for this combination because both Kane and Heddebaut teach train control systems by communicating between trains and wayside devices via radio signals between “a control signal interface subsystem” and “a vehicle-mounted subsystem” that include data comprising at least one of a signal indication and speed. *Supra*, ¶¶ 133-36.

144. It is my opinion that claim 1 would have been obvious to a POSITA in September of 2013 in view of the combination of Kane and Heddebaut. As discussed above, the limitations of claim 1 are disclosed in Kane and Heddebaut and a POSITA would have been motivated to implement Heddebaut's UWB communication in Kane's train control system at the time of the purported invention of the '738 Patent.

## **2. Claim 2**

145. Claim 2 recites: **"The system of claim 1, wherein the rule corresponds to the status of the control signal being at least one of red, double red, yellow, or double yellow."** It is my opinion that claim 2 would have been obvious to a POSITA at the time of the purported invention in view of the combination of Kane and Heddebaut.

146. As discussed above with respect to elements [1A] and [1C], Kane discloses a wayside signaling device 190 that generates signals with "a visual indication on the signal device 190 such as colored lights." EX1005, 4:15-24. The standard meaning of various such "visual indications" are "defined in the GCOR (General Code of Operational Rules) and various other signaling system used in the United States." *Id.*, 3:29-44. A POSITA in 2013 would have been very familiar with such wayside signaling devices.

147. GCOR and the Northeastern Operating Rule Advisory Committee (NORAC) rules are consensus books of operating rules that have been adopted by

over 350 railroads (as of 2011, in total) in the United States. *See generally* EX1033, EX1034. The operating rules and related instructions of a railroad define signals used by the railroad to govern train movement. In particular, GCOR and NORAC outline the use of specific colors, such as red, yellow, and green to indicate how a train should adjust its operational behavior, including its speed, based on certain track and block conditions. EX1033, 5-3 to 5-7; EX1034, 76-91. EX1033, 5-3 to 5-7; EX1034, 76-91. In the most basic terms, a green signal is called a “Clear” signal and indicates that the train may “[p]roceed not exceeding Normal Speed.” EX1034, 80-81. A yellow signal is called an “Approach” signal and indicates that the train may “[p]roceed prepared to stop at the next signal. Trains exceeding Medium Speed must begin reduction to Medium Speed as soon as the engine passes the Approach signal.” *Id.*, 86-87. A red signal is a “Stop” signal and indicates that the train needs to stop before passing the signal. *Id.*, 90-91. Further combinations and positions of these lights can create many different signal aspects. *Id.*, 76-91. As such, a POSITA would have understood that the visual indications displayed by the wayside signal devices in Kane would be a variety of colors, including red and yellow, because they are signals defined in the various operating rules used across the industry.

148. As discussed with respect to element [1D] above, Kane discloses determining a rule for behavior of the train based on the signal from wayside signaling device 190 (such as a speed restriction). Therefore, Kane discloses a

train's behavior rule that corresponds to a red, double red, yellow, or double yellow control signal. A POSITA would have been motivated to combine Kane and Heddebaut for the same reasons discussed above with reference to claim 1, Section VII.A.1.

### 3. Claim 6

149. Claim 6 depends from claim 1 and imposes several additional limitations on the vehicle-mounted subsystem. It is my opinion that claim 6 would have been obvious to a POSITA at the time of the purported invention in view of the combination of Kane and Heddebaut.

150. Claim element [6A] recites: **“The system of claim 1, wherein the vehicle-mounted subsystem is configured to: interface with a braking system of the vehicle.”** As discussed above with respect to element [1B], Kane expressly discloses “a vehicle-mounted subsystem,” including controller 110, that interfaces with the train's braking system through brake interface 180: “a brake interface 180 connected to the controller 110 allows the controller 110 to activate and control the train brakes when necessary to slow and/or stop the train. Brake interfaces are well known in the art and will not be discussed in further detail herein.” EX1005, 5:20-24; *see also id.*, Abstract, 1:66-2:12, 6:18-25, 6:30-32, 6:55-67, claims 2, 39-40. Therefore, Kane discloses a vehicle-mounted subsystem configured to interface with a train's braking system.

151. Claim element [6B] recites: **“communicate with the UWB communications component of the control signal interface subsystem via the UWB communications component of the vehicle-mounted subsystem.”** As discussed with respect to elements [1F] and [1G] above, Kane discloses that the UWB communications components of “the vehicle-mounted subsystem” and “the control signal interface subsystem” communicate via “radio frequency” signals. A POSITA would have understood that UWB, a type of radio frequency, was particularly well-suited for the system described in Kane. *Supra*, ¶¶ 122, 129. Additionally, as discussed with respect to elements [1F] and [1G] above, Heddebaut discloses that “the control signal interface subsystem” (the first transmission-reception means 2) and “the vehicle-mounted subsystem” (the second transmission-reception means 6) communicate via UWB signals from their UWB communications components. *Supra*, ¶¶ 123-24, 130-31. A POSITA would have been motivated to combine Kane and Heddebaut for the same reasons discussed above with reference to claim 1, Section VII.A.1.

152. Claim element [6C] recites: **“determine a distance between the vehicle-mounted subsystem and the control signal interface subsystem based on a time-of-flight of at least one communication between the UWB communications component of the control signal interface subsystem and the UWB communications component of the vehicle-mounted subsystem.”**

Heddebaut discloses that “[a]ll the rail vehicles 4 may calculate their distances to the downstream and upstream fixed stations where they are situated locally.” EX1006, [0054]. Heddebaut also discloses that calculating the distance relative to a fixed reference upstream and/or downstream is based on the time-of-flight for UWB communications between the rail vehicles and the fixed stations:

Measuring 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. While considering again the order of magnitude of the duration of an ultra wide band elementary pulse, of the order of the nanosecond regardless of the wave shape employed, this duration corresponds to a distance travelled through the air of approximately 30 cm. A distance resolution equal to a fraction of this length may be obtained by processing the signal. This leads to a distance resolution of the order of several centimetres, which is compatible notably with the target shooting objective for an accurate stoppage before a landing gate of a rail vehicle 4. The ultra wide band technology also enables to reach, notably by deriving from this distance, an <<(actual speed measurement of the rail vehicle)>>, realised without detriment to the cinematic capacities of the vehicles (no un-braked axle . . . ) and highly performing, including for low speeds (zero speed detection-vehicle stoppage).

*Id.*, [0055]. Therefore, Heddebaut discloses that the UWB communications components of “the control signal interface subsystem” (the first transmission-reception means 2 on fixed station 1) and “the vehicle-mounted subsystem” (the second transmission-reception means 6 on rail vehicle 4) use the time-of-flight of UWB signals to determine the distance between the subsystems.

153. A POSITA would have been motivated to use the known technique of UWB ranging disclosed in Heddebaut to augment the “positioning system 150” for the train control system disclosed in Kane. Kane and Heddebaut both disclose train control systems, and a POSITA would have understood that UWB ranging would improve Kane in the same way that it improves Heddebaut, such as by providing more accurate positioning information in environments where the GPS positioning disclosed in Kane may not work, such as in a tunnel. *See id.*, [0005]-[0007], [0055]. By 2007, IEEE had established a UWB standard 802.15.4.a: “To meet the need for improved and private location awareness in UWB, an IEEE 802.15.4a Task Group (TG) has been established to develop a UWB-based physical (PHY) layer standard with a precision ranging capability.” EX1011, [0009]; *see generally* EX1014. As discussed above, UWB-based technology has several benefits over other common wireless technology, including resistance to multipath effects, high resolution for precise distance measurements, combined ranging and communication functionalities, and low operating power. *Supra*, ¶ 142.

154. Kane also discloses:

“In addition to the positioning system 150, a tachometer 170 is also connected to the controller 110. The tachometer 170 measures the axle rotation, from which the speed of the train can be derived if the wheel size is known. In the event that the positioning system 150 becomes unavailable, the system 100 can operate by estimating distance traveled from the rotation of the axle or motor. However, wheel slippage and changes in wheel size over time can effect the accuracy of such a system.”

EX1005, 5:6-14. Therefore, Kane explains that its GPS positioning system is supplemented by the tachometer, but the tachometer may not be accurate. Because of this, a POSITA would have been motivated to supplement the accuracy of the GPS system with complementary technologies, such as the UWB ranging of Heddebaut.

155. One of the most common positioning systems by the earliest-alleged priority date for the '738 Patent was GPS, and a POSITA would have known that GPS systems pair well with UWB systems because of their complementary feature sets. *See e.g.*, EX1021, [0004]-[0009], [0013]-[0050], [0063]; EX1023, 4:66-5:5. For example, GPS allows positioning at larger distances between trains and provides heading and other information useful to train-safety systems, and UWB allows positioning to occur in locations where GPS signals may not reach a train, such as a tunnel. *See e.g., id.* One UWB ranging system that is used for a train control system

is described in Heddebaut. EX1006, [0054]-[0055]. Kane describes a system that is effective at larger distances, and Heddebaut describes a UWB system which is effective at small distances and in tunnels. *Compare* EX1005, 4:32-60 *with* EX1006, [0054]-[0055]. Given the catastrophic consequences of collisions between rail vehicles, a POSITA would have been motivated to include redundant positioning systems to guard against system failures. *See e.g.*, EX1005, 5:6-14; EX1021, [0007]-[0009], [0013]; EX1023, 4:66-5:5.

156. Both UWB and GPS provide positioning data, so it would have been readily apparent to a POSITA how to implement UWB into “the vehicle-mounted subsystem” and “the control signal interface subsystem” from Kane. A GPS system determines coordinates for the train, providing the train’s actual position, and by comparing the GPS coordinates to the coordinates of a wayside device, a controller determines the train’s relative position to the wayside device. *See* EX1005, 4:32-60. A UWB system determines the train’s relative position to the wayside device, and by comparing the train’s relative position to the known location of the wayside device in a map database, a controller determines the train’s actual position. *See* EX1006, [0054]-[0055]; EX1005, 4:61-5:5. If the UWB range is decreasing over time, that shows that the train is approaching the wayside device; if the UWB range is increasing over time, that shows that the train is moving away from the wayside device.

#### 4. Claim 7

157. Claim 7 recites: **“The system of claim 1, wherein the vehicle-mounted subsystem is further configured to generate an alert if a distance between the vehicle-mounted subsystem and the control signal interface subsystem is less than a threshold.”** It is my opinion that claim 7 would have been obvious to a POSITA at the time of the purported invention in view of the combination of Kane and Heddebaut.

158. The system described in Kane is configured to generate an alert if, for example, a signal indication from an upcoming wayside signal device is not received, or an operator does not appropriately acknowledge a received signal indication, before a timeout expires. EX1005, 5:40-6:28. The timeout is measured from the time the controller 110 causes an interrogation message to be sent to the upcoming wayside signal device:

The controller then determines at step 310 a timeout within which a signal must be received from the device 190 and a matching signal must be received from the engineers pendant 120, and, in some embodiments, from the train man's pendant 130. The timeout is chosen such that, at the expiration of the timeout, there will be sufficient distance and time in which to stop the train in the event of a problem (e.g., the device does not respond or the signal entered by engineer and/or trainman does not match the signal received from the device). The timeout is dynamically determined in some embodiments using factors such as the speed and weight of the train, the distance between

the train and the upcoming signaling device 190, the grade of the upcoming section of track, the distribution of weight on the train, and/or the characteristics of the braking system on the train using equations which are well known in the art. In other embodiments, the timeout is a fixed period based upon a worst-case assumption about the distance required.

*Id.*, 5:40-57.

159. The timeout is based on, among other things, “the distance between the train and the upcoming signaling device 190,” so a POSITA would have understood that when the timeout expires, the train would be a certain distance from the wayside signaling device 190 based on “equations which are well known in the art.” *See id.*, 5:50-56. Therefore, a POSITA would have known that the timeout corresponds to a distance threshold. Indeed, Kane’s timeout is an improvement over a fixed distance threshold because it’s determining how long it will take the train to stop in view of several factors, not just relying on a preset distance threshold.

160. Kane further teaches “[i]f the device 190 fails to respond within the timeout period at step 312, the controller activates a warning device at step 340.” *Id.*, 6:26-28. “The warning device may be a pendant 120 (130) in preferred embodiments, but also may be a horn, whistle, or other device (not shown in Fig. 1) rather than addition to the pendant 120 in other embodiments.” *Id.*, 6:14-18; *see also id.*, Abstract, 1:66-2:12, 2:33-43, 5:40-57, 6:13-25, claims 6-7, 37-38. Therefore,

Kane teaches controller 110 generating an alert (e.g., horn, whistle, etc.) if the distance between “the vehicle-mounted subsystem” and “the control signal interface subsystem” is less than a threshold distance required to stop the train before it passes the signal (e.g., in case the signal indicates “stop”). A POSITA would have been motivated to combine Kane and Heddebaut for the same reasons discussed above with reference to claim 1, Section VII.A.1.

## **5. Claim 8**

161. Claim 8 recites: **“The system of claim 1, wherein the vehicle-mounted subsystem is further configured to cause a braking system of the vehicle to activate if a distance between the vehicle-mounted subsystem and the control signal interface subsystem is less than a threshold.”** It is my opinion that claim 8 would have been obvious to a POSITA at the time of the purported invention in view of the combination of Kane and Heddebaut.

162. As discussed for claim 7 above, Kane teaches controller 110 generating an alert if, for example, a response has not been received from the wayside signal device or the operator has not correctly acknowledged the signal before a timeout expires, which corresponds to a distance threshold. EX1005, 5:40-6:28.

163. Alternatively, Kane teaches controller 110 triggering the braking system if a timeout expires, which corresponds to the distance between “the vehicle-

mounted subsystem” and “the control signal interface subsystem” being less than that threshold distance (*see supra* ¶¶ 158-60):

If the device 190 fails to respond within the timeout period at step 312, the controller activates a warning device at step 340. The controller determines whether the train is stopped (or, in other embodiments, has slowed down to a safe speed) at step 342. If the train has not been stopped (or slowed down) at step 342, ***the brakes are activated at step 344***. The process then ends. At this point, some embodiments of the system require authorization from a dispatcher in order to start the train moving again. Other embodiments require the engineer/operator to perform a start up procedure. Yet other embodiments simply require a full stop before further movement is allowed.

EX1005, 6:26-37 (emphasis added). Therefore, Kane teaches causing controller 110 to activate the braking system if the distance between “the vehicle-mounted subsystem” and “the control signal interface subsystem” is less than a threshold distance required to stop the train before it passes the signal. A POSITA would have been motivated to combine Kane and Heddebaut for the same reasons discussed above with reference to claim 1, Section VII.A.1.

## 6. Claim 13

164. Claim 13 depends from claim 1 and imposes several additional limitations. It is my opinion that claim 13 would have been obvious to a POSITA at the time of the purported invention in view of the combination of Kane and Heddebaut.

165. Claim element [13A] recites: **“The system of claim 1, further comprising: a second vehicle-mounted subsystem including a UWB communications component, wherein the second vehicle-mounted subsystem is configured to be mounted on another vehicle.”** As discussed for claim 1 above, Kane and Heddebaut render obvious using the UWB communications component of “the vehicle-mounted subsystem” to communicate via UWB signals. *See* Section VII.A.1. Kane generally discusses a vehicle-mounted subsystem in the context of a single train, but a POSITA also would have understood Kane as disclosing a system that would be implemented on multiple trains within a railway system.

166. Heddebaut further discloses that a UWB communications component (included in “a second transmission-reception means 6”) should be provided for **“each** rail vehicle” in the train control environment, clearly indicating the presence of multiple vehicle-mounted subsystems. *See, e.g.*, EX1006, [0010] (“each rail vehicle comprises second transmission-reception means”), [0017] (“each rail vehicle includes on the one hand, means for determining the position and the direction of

said vehicle”), [0026] (“each rail vehicle comprises second transmission-reception means of signals”), [0044] (“Each rail vehicle 4 comprises second transmission-reception means 6 of signals.”), [0048] (“Each rail vehicle 4 and each fixed station 1 include processing means 8 for determining the identifier and at least said message of each signal received.”), [0057] (“Each rail vehicle 4 comprises second transmission-reception means of signals 6.”) (emphasis added).

167. Therefore, Heddebaut discloses at least a second vehicle-mounted subsystem including a UWB communications component, wherein the second vehicle-mounted subsystem is configured to be mounted on another vehicle, as claimed.

168. Claim element [13B] recites: **“wherein the vehicle-mounted subsystem is configured to: communicate with the UWB communications component of the control signal interface subsystem via the UWB communications component of the vehicle-mounted subsystem.”** For the same reasons as discussed above with respect to element [6B], it is my opinion that claim element [13B] would have been obvious to a POSITA at the time of the purported invention in view of the combination of Kane and Heddebaut. *Supra*, ¶ 151.

169. Claim element [13C] recites: **“communicate with the UWB communications component of the second vehicle-mounted subsystem via the UWB communications component of the vehicle-mounted subsystem.”**

Heddebaut discloses that the inclusion of a UWB communications component in “a “second transmission-reception means 6” on “each” vehicle “enables direct communication between vehicles[.]” EX1006, [0007] (“Such system also enables direct communication between vehicles, which proved necessary in certain operating modes.”), [0057] (“Each rail vehicle 4 comprises second transmission-reception means of signals 6.”), [0062] (“Thanks to the direct communication between vehicles, such calculation may also take place on-board trains without resorting to fixed technical means, on the ground.”).

170. Heddebaut further discloses using the direct train-to-train communication to determine the speed and position of other vehicles:

All the rail vehicles 4 may calculate their distances to the downstream and upstream fixed stations where they are situated locally. The vehicles 4 may also acquire pieces of information regarding the identity, the speed and the position relative to the other vehicles 4 in the vicinity.

*Id.*, [0054].

171. A POSITA would have understood Heddebaut as disclosing UWB communications components communicating with each other on first and second vehicle-mounted subsystems, as claimed.

172. Claim element [13D] recites: **“determine a distance between the vehicle-mounted subsystem and the control signal interface subsystem based on**

**a time-of-flight of at least one communication between the UWB communications component of the control signal interface subsystem and the UWB communications component of the vehicle-mounted subsystem.”** For the same reasons as discussed above with respect to element [6C], it is my opinion that claim element [13D] would have been obvious to a POSITA at the time of the purported invention in view of the combination of Kane and Heddebaut. *Supra*, ¶ 152.

173. Claim element [13E] recites: **“determine a distance between the vehicle-mounted subsystem and the second vehicle-mounted subsystem based on a time-of-flight of at least one communication between the UWB communications component of the second vehicle-mounted subsystem and the UWB communications component of the vehicle-mounted subsystem.”** Heddebaut discloses using the train-to-train UWB communications to determine a distance between trains. Specifically, Heddebaut discloses that each vehicle-mounted subsystem is configured to “calculate [its] speed relative to the fixed stations 1 or rail vehicles 4 with which the ultra wide band communication is established.” EX1006, [0050]; *see also id.* [0054] (“The vehicles 4 may also acquire pieces of information regarding the identity, the speed and the position relative to the other vehicles 4 in the vicinity.”).

174. A POSITA would have understood that one way for a vehicle-mounted subsystem to calculate its speed relative to other rail vehicles would be to calculate its distance to those other vehicles and measure the change in distance over time. *See id.*, [0055]. Indeed, a POSITA would have viewed this as one of the more common and straightforward techniques for determining relative speed between two moving vehicles. A POSITA also would have understood that such a distance calculation would be “based on the flight time of signals,” the same ranging technique Heddebaut discloses for determining the distance between the rail vehicles and the fixed stations (*see* element [6C]) and the only ranging technique that Heddebaut discloses. *Id.*

175. Heddebaut’s disclosure of train-to-train distance determinations is further supported by discussion of an “automatic driving system” for “keeping [a] distance D between each vehicle.” *Id.*, [0060]-[0061]. Regarding the safety distance calculation, Heddebaut discloses:

The length D of the elementary mesh may also be variable with time and it is then a so-called deformable moving block mode. The length D of the elementary mesh is determined in real time from the signals transmitted by each rail vehicle 4, said length being at least equal to the safety distance  $D_{\min}$  between each vehicle, the central station 3 sending rail operation control orders to each rail vehicle 4 for keeping said distance D between each vehicle. In this second operating mode, the railway line is not limited any longer in immovable blocks, but a central

control station 3 receives the speed and position information from each of the rail vehicles 4 on the line. It calculates permanently safety interval before each of the trains enabling said trains to stop in safety mode if needed. According to the cinematic capacities of the trains (speed, braking capacities, adhesion), this distance evolves rapidly. These pieces of information are refreshed permanently on the basis of the speeds and positions transmitted periodically by all the trains. The ground system calculates and sends in return, to each of the trains of the line, valid speed and itinerary authorisations for a limited time period (a few hundred milliseconds). This operating mode enables in theory to process a maximum of trains on the line and hence to optimise the transport resource.

*Id.*, [0061].

176. Heddebaut discloses a “central control station” tracking and maintaining these distances between vehicles. Heddebaut also teaches, however, that “[t]hanks to the direct communication between vehicles, such calculation may also take place on-board trains without resorting to fixed technical means, on the ground.” *Id.*, [0062].

177. A POSITA would have understood that the obvious way for a vehicle-mounted subsystem to maintain a separation distance between vehicles would be to determine the distance between vehicles and take actions needed to maintain a proper separation distance. Further, a POSITA would have understood that if this is to be done “without resorting to fixed technical means, on the ground,” such distance

determinations would be based on time of flight calculations for UWB communications, as that is the ranging technique that Heddebaut expressly discloses. *Id.*, [0055], [0062].

178. As such, it is my opinion that Heddebaut discloses a vehicle-mounted subsystem with a UWB communications component configured to communicate with the UWB communications component of the second vehicle-mounted subsystem via UWB communications and configured to determine a distance between the subsystems based on a time-of-flight of the UWB communications, as claimed.

179. In my opinion, a POSITA would have been motivated to install Kane's vehicle-mounted subsystem in each rail vehicle, as Heddebaut discloses. When designing and implementing a train control system like the one disclosed in Kane, it would almost always be the case that the system would be designed to work for the majority—if not all—of the trains in the rail network. It would be counterintuitive, in fact, to have many different train control systems operating in the same rail network because it would increase the chance of miscommunication or inconsistency between the systems and their instructions to trains.

180. Increasing the number of systems in operation reduces this risk. For example, if there is a train control system on each train operating in the network, the system has better knowledge of where each train is located, how fast each train is

moving, the movement authority for each train, and other factors related to train movement. *Id.*, [0061]. Thus, the system is better able to ensure that the trains in the network will not collide and will maintain a safe separation distance.

181. Because it is highly desirable to design a train control system that controls multiple trains in the network, it is likewise highly desirable to install the necessary train control equipment on multiple trains. In the context of the Kane and Heddebaut disclosures, it therefore follows that it would have been highly desirable to install train control equipment (e.g., vehicle-mounted subsystems) on multiple trains in the system.

182. In addition to installing this equipment on multiple trains, a POSITA would have been motivated to use this equipment to communicate between the rail vehicles on which it was installed. While it is possible to implement a train control system where each train independently communicates only with a centralized controller that, in turn, sends control information to each individual train, a POSITA would have recognized that such a system would be improved by enabling direct train-to-train communication.

183. For instance, a POSITA would have understood that direct communication between trains would be faster and with fewer points of possible failure than communicating via an intermediate wayside device or central office. The speed of communication is an important consideration in train control systems

because the important variables like speed, location, and distance are constantly changing and it is important for the trains in the system to have the most current information about other trains. *See id.*

184. Additionally, even in train control systems that primarily operate using centralized and/or wayside control, a POSITA would have understood that having the ability to directly communicate between trains would improve the safety of the system by providing a redundant fallback communication mechanism. Thus, in the event that the centralized and/or wayside controller were to fail, trains would be able to communicate directly with one another to track the location of nearby trains and maintain safe separation.

185. Additionally, with train control equipment installed on multiple vehicles in the rail system and with communication between the vehicles, a POSITA would have been motivated to use the UWB ranging capability to determine a distance between the vehicles. As discussed above in connection with Claim 6, a POSITA would have used Heddebaut's train-to-wayside ranging to supplement the positioning systems contemplated by Kane (*e.g.*, GPS), which have limitations relative to UWB ranging. *See* Section VII.A.3.

186. Furthermore, a POSITA would have understood that with UWB equipment installed on multiple trains and at the wayside, it would be possible—and beneficial—to perform such UWB ranging to determine both train-to-wayside and

train-to-train distances. In particular, a POSITA would have recognized that in train control systems like Kane's and Heddebaut's, it is beneficial to know not only the absolute location of each vehicle but also the location of the vehicles relative to one another. *See* EX1006, [0054]-[0055]; EX1005, 4:61-5:5. While the latter can be derived from the former, a POSITA would have recognized that it would be faster and more accurate to measure that variable directly. Measuring the variable directly would also provide an additional layer of protection in the event that the other location-determination systems were to fail.

187. Indeed, Heddebaut specifically teaches using its UWB ranging system to determine—and maintain—a “safety distance” between vehicles. Heddebaut discloses determining this distance on each vehicle, teaching that the separation distance “calculation may [] take place on-board trains without resorting to fixed technical means, on the ground.” *Id.*, [0057]-[0062].

## **7. Claim 14**

188. Claim 14 depends from claim 13 and imposes several additional limitations on the vehicle-mounted subsystem. It is my opinion that claim 14 would have been obvious to a POSITA at the time of the purported invention in view of the combination of Kane and Heddebaut.

189. Claim element [14A] recites: **“The system of claim 13, wherein the vehicle-mounted subsystem is further configured to: generate an alert if the**

**distance between the vehicle-mounted subsystem and the control signal interface subsystem is less than a first threshold.”** For the same reasons as discussed above with respect to claim 7, it is my opinion that claim element [14A] would have been obvious to a POSITA at the time of the purported invention in view of the combination of Kane and Heddebaut. *See* Section VII.A.4.

190. Claim element [14B] recites: **“generate an alert if the distance between the vehicle-mounted subsystem and the second vehicle-mounted subsystem is less than a second threshold.”** Kane discloses generating an alert. For example, Kane discloses generating an alert if a signal indication from an upcoming wayside signal device is not received, or an operator does not appropriately acknowledge a received signal indication, before a timeout expires, which corresponds to a distance threshold between the vehicle and the wayside device. EX1005, 5:40-6:28.

191. Heddebaut discloses using its train control system to calculate “safety distance” between vehicles and to “keep[] said distance D between each vehicle.” EX1006, [0061]. The “safety distance” between vehicles is the second threshold, different from the first threshold, which is the distance between a vehicle and a wayside device.

192. Heddebaut further discloses that using “direct communication between vehicles” enables this “calculation” to “take place on-board trains.” *Id.*, [0062].

193. It would have been obvious to a POSITA to expand Kane’s “warning device” to not only generate alerts before the train reaches a first threshold distance from the wayside signal device but also to generate similar alerts if the train is not in compliance with a required separation distance (i.e., “safety distance”) between trains as taught by Heddebaut. A POSITA would have understood that trains must be “prepared to stop within one-half the range of vision . . . unless the main track is known to be clear.” EX1035, 5065.

194. Further, a POSITA would have understood that the “safety distance” measurement would provide, among other things, a more robust collision avoidance capability. For example, the first threshold would prevent trains from missing signals from wayside devices or from entering segments of track that the train should not yet enter. And the second threshold would prevent trains from colliding, independent of any signals from wayside devices. It is my opinion that the first and second threshold are each addressing different aspects of the collision avoidance problem, and it would have been beneficial for a POSITA to combine the two from Kane and Heddebaut.

## **8. Claim 15**

195. Claim 15 depends from claim 13 and imposes several additional limitations on the vehicle-mounted subsystem. It is my opinion that claim 15 would

have been obvious to a POSITA at the time of the purported invention in view of the combination of Kane and Heddebaut.

196. Claim [15A] recites: **“The system of claim 13, wherein the vehicle-mounted subsystem is further configured to: cause a braking system of the vehicle to activate if the distance between the vehicle-mounted subsystem and the control signal interface subsystem is less than a first threshold.”** For the same reasons discussed above with respect to claim 8, it is my opinion that claim element [15A] would have been obvious to a POSITA at the time of the purported invention in view of the combination of Kane and Heddebaut. *See* Section VII.A.5.

197. Claim element [15B] recites: **“cause the braking system of the vehicle to activate if the distance between the vehicle-mounted subsystem and the second vehicle-mounted subsystem is less than a second threshold.”** Kane discloses taking corrective actions. For example, activating the brakes if a signal indication from an upcoming wayside signal device is not received, or an operator does not appropriately acknowledge a received signal indication, before a timeout expires, which corresponds to a distance threshold between a vehicle and a wayside device. EX1005, 5:40-6:37; *see also id.*, Abstract, 1:66-2:12, 2:33-43, 5:40-57, claims 2, 39-40.

198. Although Kane does not expressly disclose that its signal compliance functionality includes enforcing separation distances between trains, that is a

common purpose for the signals presented by wayside signaling devices. Additionally, Heddebaut discloses using its train control system to calculate “safety distance” between vehicles and to “keep[] said distance D between each vehicle.” EX1006, [0061]. The “safety distance” between vehicles is the second threshold, different from the first threshold, which is the distance between a vehicle and a wayside device. Heddebaut further discloses that using “direct communication between vehicles” enables this “calculation” to “take place on-board trains.” *Id.*, [0062].

199. It would have been obvious to a POSITA to expand Kane’s automatic braking to not only stop the train before it reaches a first threshold distance from the wayside signal device but also to similarly stop the train before it reaches a second threshold from another train as taught by Heddebaut. A POSITA would have understood that trains must be “prepared to stop within one-half the range of vision . . . unless the main track is known to be clear.” EX1035, 5065.

200. Further, a POSITA would have understood that the “safety distance” measurement would provide, among other things, a more robust collision avoidance capability. The first threshold would reduce the risk of a train traveling through a signal without complying with the signal indication (e.g., entering a segment of track despite a “STOP” signal). The second threshold would prevent trains from colliding, independent of any signals from wayside devices. It is my opinion that, because the

first and second threshold are each addressing different aspects of the collision avoidance problem, a POSITA would have been motivated to combine Kane and Heddebaut to get the benefits of both.

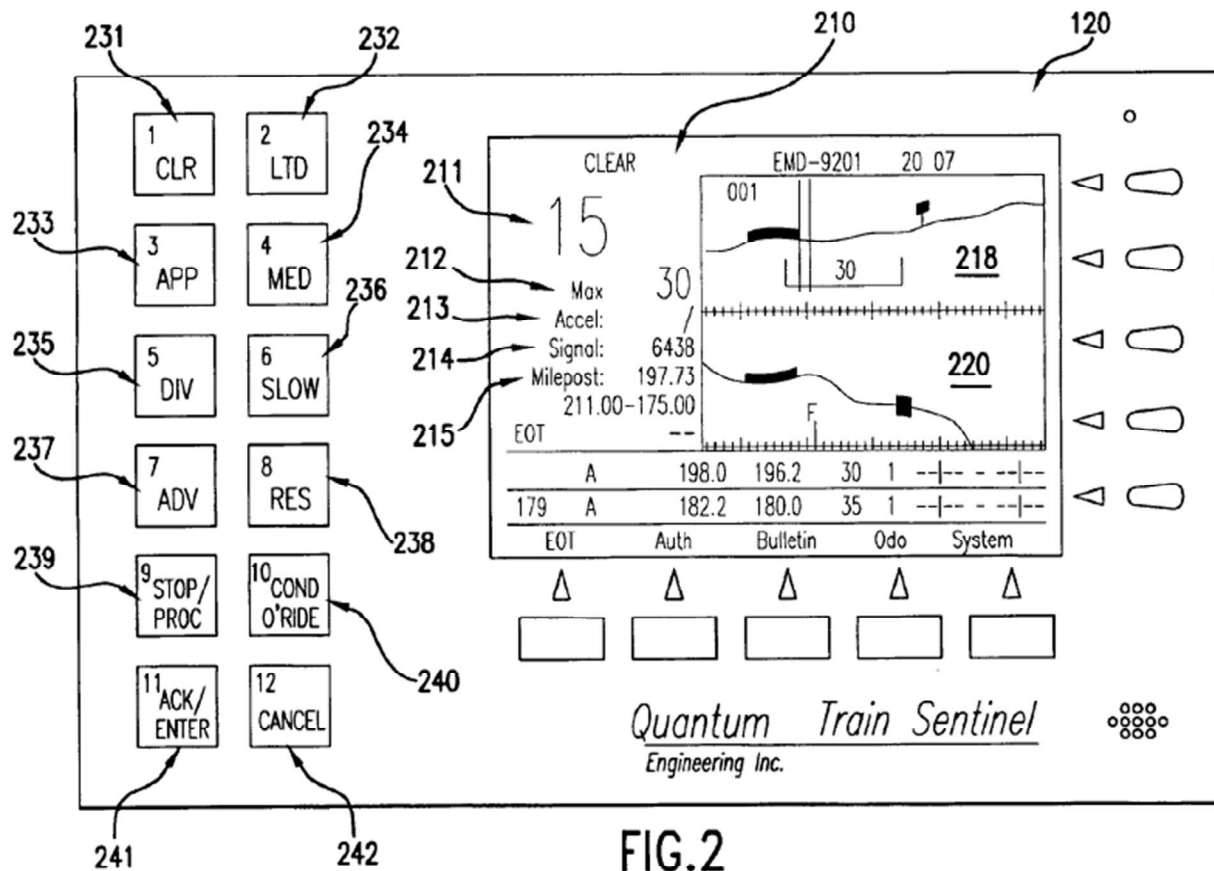
**B. Ground 1B – Claims 3-5 Are Obvious in View of Kane, Heddebaut, and Das**

201. It is my opinion that claims 3-5 would have been obvious to a POSITA at the time of the claimed invention in view of the combination of Kane, Heddebaut, and Das.

**1. Claim 3**

202. Claim 3 recites: **“The system of claim 1, wherein the rule specifies a stop-time duration for the vehicle.”** It is my opinion that claim 3 would have been obvious to a POSITA at the time of the purported invention in view of the combination of Kane, Heddebaut, and Das.

203. As discussed above with respect to claim 1, Kane discloses establishing and enforcing behavior rules based on the signal indication (status) of the wayside signal device. One of the signal indications is “STOP”:



EX1005, Fig. 2, 3:29-56. A POSITA would have understood that the behavior rule corresponding to this signal indication is for the train to stop and stay until it receives authorization to move.

204. Das discloses: “In another embodiment of the proposed invention the said Radio Frequency Transponders installed on the train are in communication with the said control unit installed on the train; the said transponders have unique identity number specific to each train; and the said transponders are installed on front and rear dash boards; or top or side of the engine and guard cabin; or as per the requirements.” EX1007, 7:6-10.

205. Das further states:

In still another embodiment of the proposed invention the signal towers located at station comprise radio frequency transponders having unique location Identity number and visible signalling means like signal lights, Light Emitting Diodes and other such devices known in the art; and wherein, each of the said transponders on signal towers continuously broadcast data on a predetermined interval. The said broadcast data includes, but not limited to, its identity, signal data i.e. go (green) or stop (red), data like which train this signal is for (as decided by the control computer at the station depending on the pre known schedules), recommended speed for the train moving past the station, stop durations if any, when did the last train left the same track and platform in the station and at what time so that the driver gets all this info on a screen before train reaches the station.

*Id.*, 8:14-24. Therefore, Das discloses another signal indication (a stop duration) that corresponds to a behavior rule for a train and is conveyed by a wayside device to a train. A POSITA would have understood that the behavior rule corresponding to this signal indication is for the train to stop for the amount of time identified as the stop duration.

206. Kane, Heddebaut, and Das all teach train control systems that rely on communications between trains and wayside devices. EX1005, 5:37-39, 4:15-31, 5:59-6:4, Fig. 3; EX1006, [0041], [0044]-[0045], [0048]-[0049]; EX1007, 7:6-10, 8:14-24. Also, Kane and Das disclose establishing and enforcing behavior rules for

a train in response to signal indications conveyed by a wayside device to a train. For example, Kane discloses a “STOP” signal indication and a corresponding behavior rule for the train to stop and stay until it receives authorization to move, while Das discloses a stop duration (i.e., stopping for a predetermined period of time) as a signal indication that prompts a behavior rule. EX1005, Fig. 2, 3:29-56, 6:36-37; EX1007, 8:14-24. These were two common signal types at the time of the purported invention. EX1032, 5:47-6:9 (describing “stop” and “stop and proceed” signals). Thus, a POSITA would have been motivated to add the handling of stop duration signals shown in Das to the handling of other types of signals as disclosed in Kane and Heddebaut to promote enhanced safety and improved efficiency for railroad operations for Kane and Heddebaut in the same way that it improves it for Das: e.g., “A further object of this invention is to provide a system to completely overcome the situation of delay arrival or departure of trains during the fog, smog or haze.” EX1007, 4:3-4. The rail industry is heavily schedule dependent, and a fundamental goal is to keep the trains moving as fast and as close to one another as can be accomplished safely. If a train control system only tells a train to stop, then it will remain stopped until it receives another instruction: an instruction to proceed. A stop duration, however, efficiently tells the train to stop and when to proceed again through a single instruction.

207. A POSITA would have been motivated to add accommodation for stop duration signals in a train control system combining the features of Kane and Heddebaut as discussed above, because stop duration rules were known in the art and not substantially different than handling a STOP signal in Kane. For example, NORAC Signal Rule 291 is entitled “Stop and Proceed” where the train is required to “Stop, then proceed at Restricted Speed until the entire train has cleared all interlocking and spring switches (if signal is an interlocking or CP signal) . . . .” EX1034, 90-91. A POSITA would have known that “Stop and Proceed” includes a stop duration. Moreover, a POSITA would have had a reasonable expectation of success for this combination because Kane, Heddebaut, and Das teach train control systems that rely on communicating between trains and wayside devices. EX1005, 5:37-39, 4:15-31, 5:59-6:4, Fig. 3; EX1006, [0041], [0044]-[0045], [0048]-[0049]; EX1007, 7:6-10, 8:14-24. All of these systems teach rules for stopping a train. EX1005, 6:26-32; EX1006, [0060]-[0061]; EX1007, 8:14-24. Das simply adds a stop duration as another well-known signal indication that is enforced. EX1007, 8:14-24.

## 2. Claim 4

208. Claim 4 recites: “**The system of claim 3, wherein the rule specifies a speed for the vehicle.**” It is my opinion that claim 4 would have been obvious to a

POSITA at the time of the purported invention in view of the combination of Kane, Heddebaut, and Das.

209. As discussed above with respect to element [1D], Kane discloses determining a target speed behavior rule for the train corresponding to a signal received from the wayside signaling device 190. *Supra*, ¶¶ 111-13. A POSITA would have been motivated to combine Kane, Heddebaut, and Das for the same reasons discussed above with reference to claim 3, Section VII.B.1.

### 3. Claim 5

210. Claim 5 recites: **“The system of claim 4, wherein the rule specifies a maximum speed for the vehicle after an expiration of the stop-time.”** It is my opinion that claim 5 would have been obvious to a POSITA at the time of the purported invention in view of the combination of Kane, Heddebaut, and Das.

211. As discussed above with respect to element [1D], Kane discloses determining a target speed behavior rule for a train corresponding to a signal received from the wayside signaling device 190. *Supra*, ¶¶ 111-13.

212. As discussed above for claim 3, Section VII.B.1, Das discloses a stop duration as a signal indication that prompts a behavior rule for a train. Kane discloses specifying a maximum speed of 15 mph after a stop signal, so a POSITA would have understood that the same would apply for a stop duration signal. *See* EX1005, 6:50-54 (“In the event that speed is reduced to a ‘stop’ and then increased

to greater than 15 mph without any intervening button operation, the system will ‘force’ an acknowledgment to further check the system and the crew’s actions.”). The only difference between the stop and stop duration signals is whether the train stays stopped for a specified time or has to wait for authorization to proceed. Therefore, Kane, Heddebaut, and Das disclose a rule for behavior of the train that specifies the speed limit for the train after expiration of a stop duration. *See* EX1005, 6:50-67; EX1006, [0048]-[0049]; EX1007, 8:14-24. A POSITA would have been motivated to combine Kane, Heddebaut, and Das for the same reasons discussed above with reference to claim 3, Section VII.B.1.

**C. Ground 1C – Claims 9-11 and 16-17 Are Obvious in View of Kane, Heddebaut, and Ackerman**

213. It is my opinion that claims 9-11 and 16-17 would have been obvious to a POSITA at the time of the claimed invention in view of the combination of Kane, Heddebaut, and Ackerman.

**1. Claim 9**

214. Claim 9 recites: **“The system of claim 1, wherein the vehicle-mounted subsystem further comprises a radio-frequency identification (RFID) subsystem configured to scan at least one RFID tag external to the vehicle to retrieve information stored on the at least one RFID tag.”** It is my opinion that claim 9 would have been obvious to a POSITA at the time of the purported invention in view of the combination of Kane, Heddebaut, and Ackerman.

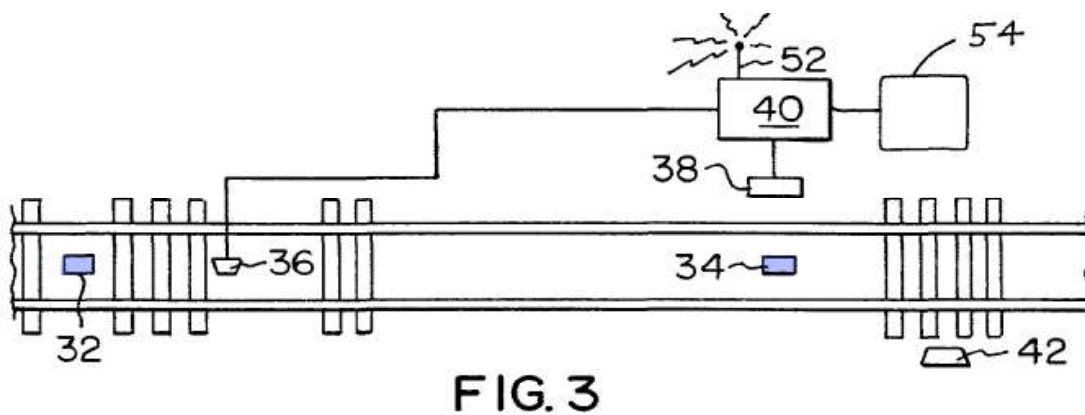
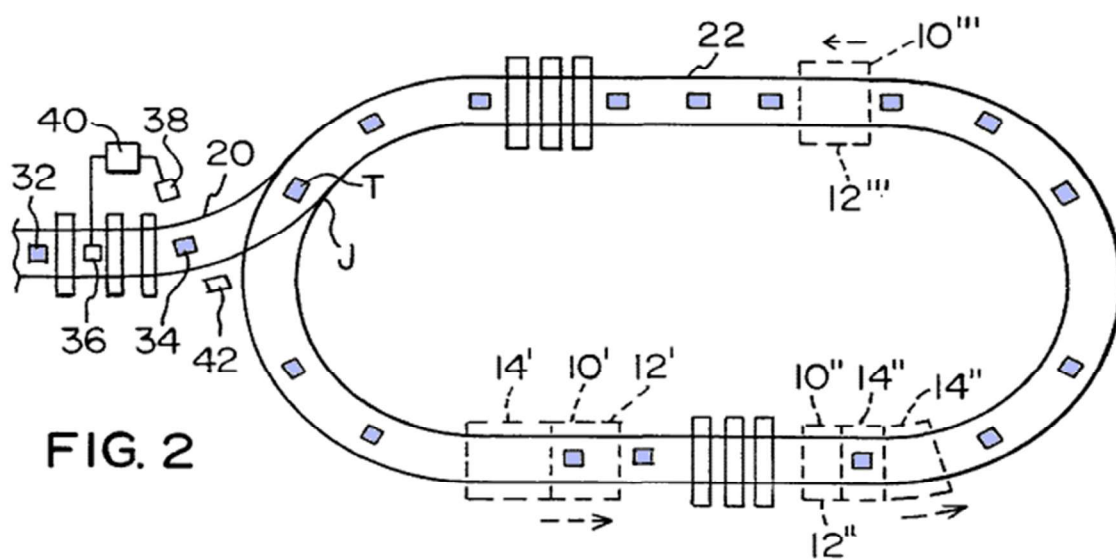
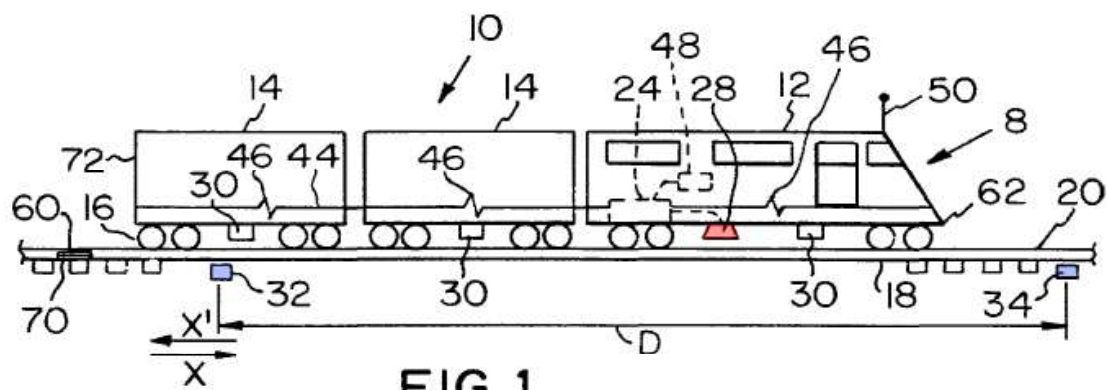
215. Ackerman discloses “a control system that includes a vehicle, such as a train” and “a vehicle track, a first reader, an onboard computer and a tachometer.”

EX1008, Abstract. Ackerman further discloses about the system:

Referring back to FIG. 1, a train reader, receiver or interrogator 28 is secured to a vehicle 12 and is adapted to read or receive signals emitted from tags “T” that represent identifying an exact location of the tag “T” positioned along the main portion 22 of the track 18. Two spaced apart initialization tags 32 and 34 are provided on the spur portion 20 of the track 18, as shown in FIGS. 1-3. Tags 32 and 34 are spaced apart a distance “D”. The reader 28 is also adapted to read signals from tags 32 and 34 in a similar manner as it reads signals from tags “T”. This information or data is then sent or relayed to and inputted into the onboard computer 24.

*Id.*, 4:65-5:9. This was a well-known technique for using track-based RFID tags to determine train location.

216. Ackerman also discloses that the tags “T” with which its reader/receiver/interrogator interacts are external to the vehicle and spaced along the train’s track, as shown in the figures below, in which I have annotated the reader/receiver/interrogator in red and the tags in blue:



*Id.*, Figs. 1-3, 4:62-5:9.

217. Ackerman also discloses that its reader/receiver/interrogator communicates with the track-based tags using “radio frequency (RF) communication”:

The above-described tag/reader system is a radio-based communication system, which uses radio frequency (RF) communication between the vehicle reader 28 and tags “T”, 32 and 34. The tag/reader system could also be optically based or inductively based. Each tag “T”, 32 and 34 is a passive transponder, encoded with a unique identification, which is excited by RF energy from vehicle-based reader 28. The location information is received by the reader and is then sent to the onboard computer 24 so that the train's location can be pinpointed by the onboard computer map.

*Id.*, 5:10-19.

218. In view of Ackerman’s teaching that each tag is encoded with a unique identification and communicates this information using RF energy, a POSITA would have understood this system to be a radio frequency identification, or “RFID,” system. A POSITA would have further understood that the on-vehicle reader “scans” the track-based tags when it excites them with RF energy and receives their location information in response.

219. A POSITA would have been motivated to use an RFID-based communication subsystem like the one disclosed in Ackerman in combination with Kane’s train control system and Heddebaut’s UWB communication system. The

location and control systems taught by these references are complementary and would commonly—and beneficially—be implemented alongside one another in a train control system.

220. First, adding Ackerman’s RFID subsystem to Kane’s GPS system and Heddebaut’s UWB system would provide improved location determination. In particular, Kane identifies a need for its positioning system to “unambiguously determine which of two adjacent tracks a train is on.” EX1005, 4:52-54. Consistent with Kane’s teaching, a POSITA would have understood the critical importance of determining the track on which a train is traveling and would recognize that uncertainty or errors in this determination would lead to inefficient train control (at best) and collisions between trains (at worst). While Kane’s GPS-based positioning system and Heddebaut’s UWB-based ranging system (if used along with its UWB communication system) would provide information about which track a train is traveling, a POSITA would have viewed Ackerman’s RFID-based system to offer an improved approach in this respect. In particular, because Ackerman’s on-train RFID reader receives unique identifying information from the track-based RFID tags, it can determine with near certainty which track it is on. *See* EX1008, 4:65-5:19; EX1030, K-294 to K-295. Kane’s positioning system would benefit from being able to use this information in the event there was any uncertainty about the

track on which the train is traveling, such as when a GPS signal is blocked by a tunnel.

221. Second, a POSITA would have recognized a benefit in having multiple distinct methods for determining the train's location to account for the relative strengths and weaknesses of certain methods in various conditions. For example, a POSITA would have recognized that GPS may lose accuracy when GPS signals are weaker, such as in a tunnel. Similarly, a POSITA would have recognized that UWB signals may be weak when the distance between transceivers is high. In these situations, a POSITA would have therefore recognized a benefit to adding Ackerman's RFID-based positioning to provide a useful, additional datapoint in determining the train's position. *See* EX1016, [0003] ("RFID tags can be read as long as they are within range of a reader.").

222. Third, adding Ackerman's RFID-based system would provide a mechanism for calibrating Kane's and/or Heddebaut's positioning techniques. Ackerman discloses that its RFID tags can be used to "calibrat[e] the train's distance measuring device(s)." EX1008, 4:45-49. Ackerman provides the following example of how the RFID tags can be used to calibrate a tachometer:

The train then moves in a forwardly "X" direction and passes over the tags 32 and 34 as schematically represented in FIG. 6. The reader 28 reads the location information transmitted by tags 32 and 34 and the onboard computer 24 identifies the location of the tags 32 and 34 and

calculates the distance between the tags 32 and 34. The tachometer 26 simultaneously measures the distance between the tags 32 and 34 and can then be calibrated pursuant to the following equation:

$$\text{distance between the tags 32 and 34} = (\text{the reading on the tachometer}) * (\text{a calibration factor}).$$

*Id.*, 5:61-6:4.

223. Ackerman further teaches:

This system is especially useful in moving block systems and permits calibration of the tachometer (or other arrangements, such as a Doppler radar), determination of the train direction and orientation of the train prior to the train entering the main portion 22 of the track 18. It is also possible to continuously calibrate the tachometer 26 as it travels along the main portion 22 of the track 18 by comparing the distance between two adjacent tags “T” with the distance measured by the tachometer 26 and calibrating the tachometer 26 in the same manner as it was initially calibrated when the train passed over tags 32 and 34. Further, the initialization permits the “vital” determination of the train length by utilizing two separate systems or arrangements to determine the train's length.

*Id.*, 8:27-40.

224. Fourth, adding Ackerman's RFID-based system would provide an additional mechanism for determining the train's direction of travel. Regarding this benefit, Ackerman teaches:

[B]ased upon the sequence in which the train 10 passes over the tags 32 and 34, the onboard computer 24 determines the direction of travel (in this case in the “X” direction). The train would be traveling in the “X” direction, shown in FIG. 1, had it first traveled over tag 34 and then tag 32. The tachometer reading determines the orientation of the vehicle 12 together with the determined direction of travel. Specifically, as shown in FIG. 4, if the tachometer 26 indicates a positive or clockwise rotation of the wheel axles and the train is traveling in the “X” direction, then the vehicle 12 is pointed in the forwardly direction, as shown in FIG. 1. If the tachometer indicates a negative or counter-clockwise rotation of the axles and the train is traveling in the “X” direction, then the vehicle 12 is pointed in a rearwardly direction as shown in FIG. 5.

*Id.*, 6:6-20.

225. As Ackerman teaches, this calibration mechanism can be useful to calibrate any “distance measuring device, be it either a tachometer or Doppler radar...” *Id.*, 2:2-7. A POSITA would have therefore recognized Ackerman’s calibration mechanism to be a useful addition to Kane’s train control system, which uses a tachometer for speed determinations, EX1005, 5:6-9, and to Heddebaut’s UWB ranging system, which operates on the same time-of-flight principle as a Doppler radar, EX1006, [0055].

## **2. Claim 10**

226. Claim 10 depends from claim 9 and imposes several additional limitations on the vehicle-mounted subsystem. It is my opinion that claim 10 would

have been obvious to a POSITA at the time of the purported invention in view of the combination of Kane, Heddebaut, and Ackerman.

227. Claim element [10A] recites: **“The system of claim 9, wherein: the vehicle-mounted subsystem is further configured to substantially continuously receive information relating to speed of the vehicle.”** Kane discloses that its vehicle-mounted subsystem uses a tachometer to continuously determine the speed of the train:

In addition to the positioning system 150, a tachometer 170 is also connected to the controller 110. The tachometer 170 measures the axle rotation, from which the speed of the train can be derived if the wheel size is known. In the event that the positioning system 150 becomes unavailable, the system 100 can operate by estimating distance traveled from the rotation of the axle or motor.

EX1005, 5:6-12.

228. Claim element [10B] recites: **“the vehicle-mounted subsystem determines a changing distance between the vehicle-mounted subsystem and the control signal interface subsystem based on the information stored on the at least one RFID tag and the information relating to speed of the vehicle.”** Ackerman teaches using its RFID-based system to “pinpoint” the train’s location when it passes the tag.

229. Ackerman teaches:

An onboard reader attaches to the vehicle and is adapted to read information from the position identifier. An onboard computer provided on the vehicle is interfaced with the onboard reader. The onboard computer is adapted to receive data from the onboard reader. A device for measuring the distance the vehicle has traveled, such as a tachometer, is interfaced with the onboard computer. The position identifiers identify location information to the onboard reader when the vehicle passes the position identifiers.

EX1008, 2:19-28.

230. Ackerman also teaches:

Each tag “T”, 32 and 34 is a passive transponder, encoded with a unique identification, which is excited by RF energy from vehicle-based reader 28. The location information is received by the reader and is then sent to the onboard computer 24 so that the train's location can be pinpointed by the onboard computer map. The onboard tachometer 26 provides displacement information to the onboard computer 24 when the train 10 travels between the tags “T”, 32 and 34.

*Id.*, 5:14-22.

231. Therefore, Ackerman teaches determining the position of the train based on information stored on at least one RFID tag.

232. Furthermore, as discussed above, Kane discloses that its train control system includes a tachometer to determine the speed of the train. Kane discloses that this information can be used to supplement the positioning system by providing

an estimate of “distance traveled from the rotation of the axle or motor.” EX1005, 5:6-12. Ackerman similarly discloses that a tachometer (and the speed information it provides) can be used to determine the train’s position between RFID tags: “The onboard tachometer 26 provides displacement information to the onboard computer 24 when the train 10 travels between the tags ‘T’, 32 and 34.” EX1008, 5:20-22. Displacement information from a tachometer corresponds to the vehicle speed.

233. Therefore, Kane and Ackerman also disclose determining the position of the train based on information relating to the speed of the vehicle.

234. As discussed for claim 9, a POSITA would have been motivated to add Ackerman’s RFID-based positioning technology to the train positioning techniques of Kane (GPS and tachometer) and Heddebaut (time-of-flight UWB ranging). *See* Section VII.C.1. When these techniques (using the RFID tags and the vehicle speed information to determine the train’s location) are used in Kane’s train control system, they would be used by Kane’s “positioning system 150” to determine the vehicle’s position. Kane teaches that this position information is, in turn, used to determine the distance between the train and the control signal interface subsystem.

235. In particular, Kane teaches:

The positioning system 150 continuously supplies the controller 110 with position information for the train to which the system 100 is attached. This position information allows the controller 110 to determine where the train is at any time. The positioning system 150 is

preferably sufficiently accurate to unambiguously determine which of two adjacent tracks a train is on. By using train position information obtained from the positioning system 150 as an index into a map database 160 (discussed in further detail below), the controller 110 can determine the train's position relative to wayside signal devices 190 in the system. As discussed in further detail below, this allows the controller 110 to send an interrogation signal to the wayside signal device 190 at the appropriate time.

EX1005, 4:48-61.

236. Kane also teaches:

A flowchart 300 illustrating operation of the system 100 is shown in FIG. 3. The process starts with the controller 110 querying the positioning system 150 (or, in some embodiments the tachometer 170 if position information from the positioning system 150 is not available) to determine the position of the train at step 302. The controller 110 then consults the database 160 to determine the nearest signaling device 190 based on the train's position at step 304. Next, the controller 110 determines whether the signaling device 190 is within the range of the transceiver 140 at step 306. If the nearest device is not within range, steps 302 and 304 are repeated until the next signaling device 190 is within range. When the next device 190 is within range, the controller 110 causes the transceiver 140 to transmit an interrogation message at step 308.

*Id.*, 5:25-39.

237. Therefore, in the system combining Kane's train control techniques with Ackerman's RFID-based positioning techniques, the resulting system would determine a changing distance between the train and a wayside control signal interface based on both location information received from RFID tags and speed information received from the tachometer.

### 3. Claim 11

238. Claim 11 recites: **"The system of claim 9, wherein the vehicle-mounted subsystem is further configured to determine a distance between the vehicle-mounted subsystem and the control signal interface subsystem based on the information stored on the at least one RFID tag."** It is my opinion that claim 11 would have been obvious to a POSITA at the time of the purported invention in view of the combination of Kane, Heddebaut, and Ackerman.

239. Like element [10B], claim 11 recites using information from an RFID tag to determine a distance between the vehicle-mounted subsystem and the control signal interface. For the same reasons discussed above with respect to element [10B], it is my opinion that claim 11 would have been obvious to a POSITA at the time of the purported invention in view of the combination of Kane, Heddebaut, and Ackerman. *Supra*, ¶¶ 228-37. A POSITA would have been motivated to combine Kane, Heddebaut, and Ackerman for the same reasons discussed above with reference to claim 10, Section VII.C.2.

#### 4. Claim 16

240. Claim 16 depends from claim 13 and imposes several additional limitations on the vehicle-mounted subsystem. It is my opinion that claim 16 would have been obvious to a POSITA at the time of the purported invention in view of the combination of Kane, Heddebaut, and Ackerman.

241. Claim element [16A] recites: **“The system of claim 13, wherein the vehicle-mounted subsystem further comprises: a radio-frequency identification (RFID) subsystem configured to scan at least one RFID tag external to the vehicle to retrieve information stored on the at least one RFID tag.”** For the same reasons discussed above with respect to claim 9, it is my opinion that claim element [16A] would have been obvious to a POSITA at the time of the purported invention in view of the combination of Kane, Heddebaut, and Ackerman. *See* Section VII.C.1.

242. Claim element [16B] recites: **“wherein the vehicle-mounted subsystem is further configured to determine a distance between the vehicle-mounted subsystem and the control signal interface subsystem based on the information stored on the at least one RFID tag.”** Like element [10B], claim element [16B] recites using information from an RFID tag to determine a distance between the vehicle-mounted subsystem and the control signal interface. For the same reasons discussed above with respect to element [10B], it is my opinion that

claim element [16B] would have been obvious to a POSITA at the time of the purported invention in view of the combination of Kane, Heddebaut, and Ackerman. *Supra*, ¶¶ 228-37.

243. A POSITA would have been motivated to combine Kane, Heddebaut, and Ackerman for the same reasons discussed above with reference to claims 9-10, Sections VII.C.1-VII.C.2.

## **5. Claim 17**

244. Claim 17 recites: **“The system of claim 16, wherein: the vehicle-mounted subsystem is further configured to substantially continuously receive information relating to speed of the vehicle; and the vehicle-mounted subsystem determines a changing distance between the vehicle-mounted subsystem and the control signal interface subsystem based on the information stored on the at least one RFID tag and the information relating to speed of the vehicle.”** For the same reasons discussed above with respect to claim 10, it is my opinion that claim 17 would have been obvious to a POSITA at the time of the purported invention in view of the combination of Kane, Heddebaut, and Ackerman. *See* Section VII.C.2. A POSITA would have been motivated to combine Kane, Heddebaut, and Ackerman for the same reasons discussed above with reference to claim 10, Section VII.C.2.

**D. Ground 1D – Claims 12 and 18 Are Obvious in View of Kane, Heddebaut, and Hungate**

245. It is my opinion that claims 12 and 18 would have been obvious to a POSITA at the time of the claimed invention in view of the combination of Kane, Heddebaut, and Hungate.

**1. Claim 12**

246. Claim 12 depends from claim 1 and imposes several additional limitations. It is my opinion that claim 12 would have been obvious to a POSITA at the time of the purported invention in view of the combination of Kane, Heddebaut, and Hungate.

247. Claim element [12A] recites: **“The system of claim 1, further comprising: an access point external to the vehicle.”** Hungate teaches “FIG. 1 is a block diagram of an overview of one embodiment of the invention. It includes a central train control network 10, a plurality of wayside controllers 20, and onboard systems 30 onboard the many trains.” EX1009, 2:57-60. This is depicted in Hungate’s Figure 1:

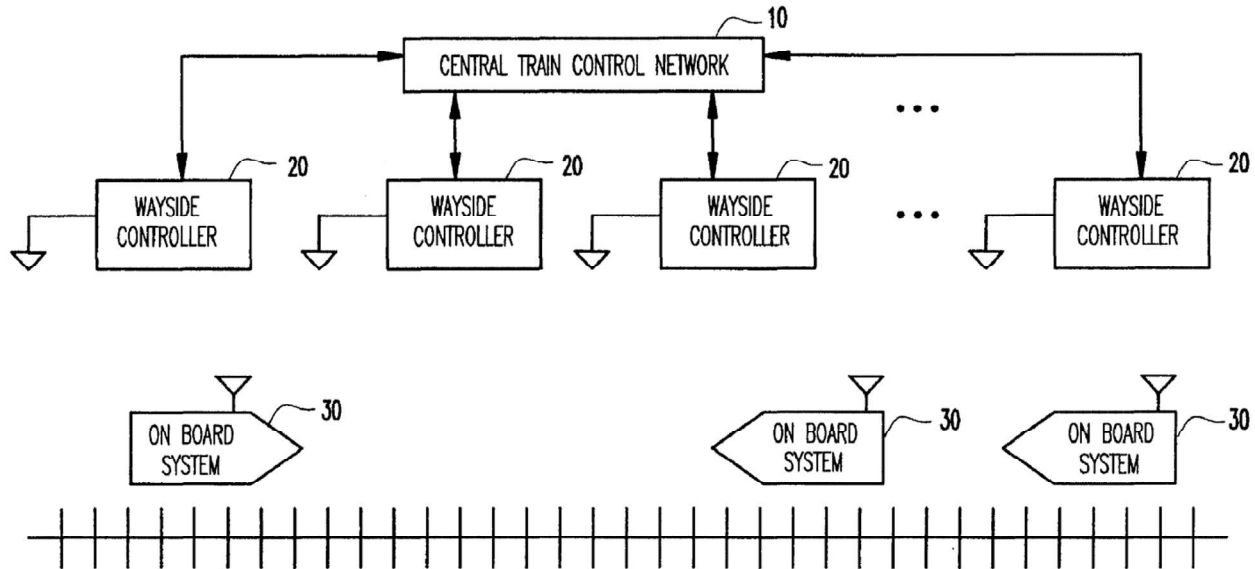


FIG. 1

*Id.*, Fig. 1. Therefore, Hungate discloses wayside controllers 20 as access points external to the trains.

248. Claim element [12B] recites: **“wherein the vehicle-mounted subsystem is further configured to: store data relating to prior behavior of the vehicle.”** As discussed above, Hungate teaches “onboard systems 30,” which are mounted to trains. Hungate also teaches that onboard system 30 includes “an onboard computer (OBC) 31.” *Id.*, 4:40-42. Further, Hungate teaches,

In the example of FIG. 4, a train identification module 34 provides train identification to the OBC 31, which information also is incorporated into the train position report transmitted by the train data radio 33. In the example of FIG. 4, a wheel tachometer 35 also provides information to the OBC 31 from which train speed may be calculated. In some

embodiments, a dead reckoning distance travelled may be estimated by the OBC 31, based on information derived from the wheel tachometer 35, and the distance travelled also may be transmitted by the train data radio 33 to the wayside controllers 20. In some embodiments, the OBC 31 also may automatically generate block release reports, which would be transmitted by the train data radio 33 to the wayside controllers 20.

*Id.*, 4:60-5:6. “A block release report refers to an indication that a train has completed its transit of a portion of track,” and the train position report includes train position, speed, and distance travelled data. *Id.*, 3:10-11, 4:51-5:6. This data relates to prior behavior of the train: the track portions it has completed, its prior positions and speed, and the distance it has travelled.

249. Hungate does not explicitly describe storing this data, but a POSITA would have expected a train’s computer, such as OBC 31, to include memory where the data would be stored before transmission. For example, both Kane and Heddebaut describe storage memory included in their vehicle-mounted subsystems. EX1005, 4:62-67; EX1006, [0048]. Also, storing information before transmitting was known in the art: for example, U.S. Patent No. 6,338,152 teaches storing fault logs prior to transmitting them to wayside access points. EX1024, 4:39-44, 6:11-13, 6:48-7:22, Fig. 3. A POSITA would have understood that storing the data relating to prior behavior of the train would allow the vehicle-mounted subsystem to gather and keep the data at least until successful transmission to the central station occurred.

250. Claim element [12C] recites: **“communicate the data relating to prior behavior of the vehicle with the access point.”** Hungate teaches that onboard system 30 also includes “a train data radio 33.” EX1009, 4:40-43. Hungate teaches that block release reports and train position reports are “transmitted by the train data radio 33 to the wayside controllers 20.” *Id.*, 4:55-5:6.

251. Thus, Hungate communicates the data relating to prior behavior of the vehicle with an access point, as claimed.

252. It would have been obvious to a POSITA to add Hungate’s distributed architecture for monitoring train behaviors to the combination of Kane and Heddebaut discussed above with respect to, for example, claim 1 in Ground 1A. Kane enforces behavior rules in its train control system (EX1005, 2:6-12, 2:41-43, 6:4-25, 6:55-67, 7:45-51, Fig. 3, claims 1-7, 9, 31, and 39-40), and Hungate teaches techniques to improve the safety and efficiency of train operation in such a system, such as storing prior behavior of the trains and communicating it to a central control entity (EX1009, 3:10-19 (block release reports and train position reports enable “dynamic railroad traffic planning”); 3:55-4:5 (position reports enable functions that “enhance[] the vitality of the overall train control system”); 4:40-5:6). This allows a central control entity to monitor the behavior and position of multiple trains in a network and transmit revised control signals based on that information. For example, Hungate teaches,

The present invention for controlling train movement uses a distributed architecture. In one embodiment, wayside controllers receive signals from individual trains, including position information which can be derived from a navigation system. The wayside controllers interface with a central train control network and coordinate local train movement. A designated section of the track network is assigned to each wayside controller, and that controller can issue incremental movement authority to a train, within that designated section of the track network.

*Id.*, 1:61-2:3.

253. In view of these teachings a POSITA would have recognized that Hungate's system addresses a known need for fast transmission of positioning data in locomotive systems by providing for the automatic uploading and downloading of such data to/from locomotives to/from a remote database. A POSITA would have therefore been motivated to implement Hungate's block release reports/train position reports and wayside controllers in Kane's train control system.

254. Indeed, a POSITA would recognize that there are a number of benefits of including Hungate's block release reports/train position reports and wayside controllers in a train control system, even beyond the benefits expressly identified by Hungate. For example, Hungate's solution of logging and uploading train positioning data would allow the central station in a train control system to track the behaviors of trains on the tracks and send that information to a central station, which

would determine if the behaviors affect other trains in the system, if the train engineer requires additional training, or if the train needs maintenance.

255. Kane and Heddebaut both describe transmitting position and speed information to a central control entity. EX1005, 7:62-64; EX1006, [0061]. Hungate details how to implement this functionality by sending block release reports and train position reports to wayside controllers. EX1009, 4:40-5:6; *see also id.* 3:10-19. Although these reports could be transmitted directly from the train to a central control entity, a POSITA would have understood that trains sometimes travel far away from a central control entity or travel to locations that make transmission to a central control entity difficult (e.g., tunnels). For example, Heddebaut teaches:

However, when considering the propagation of sinewave radioelectric signals through a tunnel, at low frequency, i.e. just a few hundred MHz, these signals are attenuated very rapidly. Attenuation may reach values of the order of 30 to 40 dB per 100 m at 100 MHz through a road tunnel. Such physical characteristic renders thereof the use thereof incompatible with the ranges between stations currently contemplated in modern urban guided transport (of the order of one kilometre).

*See* EX1006, [0006]; *see also id.*, [0003], [0005]. Hungate provides these reports even when the train is not constantly in communication range of the central control entity because it discloses techniques for storing the behavior data on the train until it is possible to share the stored behavior data with a wayside controller in communication with the central control entity. EX1009, 4:40-5:6; *see also id.* 3:10-

19. Thus, a POSITA would have been motivated to implement Hungate's teaching of sending block release/train position reports to wayside controllers in Kane and Heddebaut's train control system.

256. Moreover, a POSITA would have had a reasonable expectation of success for this combination because Kane, Heddebaut, and Hungate teach train control systems that rely on communicating between trains and wayside devices. EX1005, 5:37-39, 4:15-31, 5:59-6:4, Fig. 3; EX1006, [0041], [0044]-[0045], [0048]-[0049]; EX1009, 4:40-5:6, 3:10-19.

## **2. Claim 18**

257. Claim 18 recites: **“The system of claim 13, further comprising: an access point external to the vehicle; and wherein the vehicle-mounted subsystem is further configured to: store data relating to prior behavior of the vehicle; and communicate the data relating to prior behavior of the vehicle with the access point.”** For the same reasons discussed above with respect to claim 12, it is my opinion that claim 18 would have been obvious to a POSITA at the time of the purported invention in view of the combination of Kane, Heddebaut, and Hungate. *See* Section VII.D.1.

**E. Ground 1E – Claims 13-15 Are Obvious in View of Kane, Heddebaut, and Grisham**

258. It is my opinion that claims 13-15 would have been obvious to a POSITA at the time of the claimed invention in view of the combination of Kane, Heddebaut, and Grisham.

**1. Claim 13**

259. Claim element [13A] recites: **“The system of claim 1, further comprising: a second vehicle-mounted subsystem including a UWB communications component, wherein the second vehicle-mounted subsystem is configured to be mounted on another vehicle.”** For the same reasons as discussed above with respect to element [13A] in Ground 1A, it is my opinion that claim element [13A] would have been obvious to a POSITA at the time of the purported invention in view of the combination of Kane, Heddebaut, and Grisham. *Supra*, ¶¶ 165-67.

260. Claim element [13B] recites: **“wherein the vehicle-mounted subsystem is configured to: communicate with the UWB communications component of the control signal interface subsystem via the UWB communications component of the vehicle-mounted subsystem.”** For the same reasons as discussed above with respect to elements [6B] and [13B] in Ground 1A, it is my opinion that claim element [13B] would have been obvious to a POSITA at

the time of the purported invention in view of the combination of Kane, Heddebaut, and Grisham. *Supra*, ¶¶ 151, 168.

261. Claim element [13C] recites: **“communicate with the UWB communications component of the second vehicle-mounted subsystem via the UWB communications component of the vehicle-mounted subsystem.”** For the same reasons as discussed above with respect to element [13C] in Ground 1A, it is my opinion that claim element [13C] would have been obvious to a POSITA at the time of the purported invention in view of the combination of Kane, Heddebaut, and Grisham. *Supra*, ¶¶ 169-71.

262. Claim element [13D] recites: **“determine a distance between the vehicle-mounted subsystem and the control signal interface subsystem based on a time-of-flight of at least one communication between the UWB communications component of the control signal interface subsystem and the UWB communications component of the vehicle-mounted subsystem.”** For the same reasons as discussed above with respect to elements [6C] and [13D] in Ground 1A, it is my opinion that claim element [13D] would have been obvious to a POSITA at the time of the purported invention in view of the combination of Kane, Heddebaut, and Grisham. *Supra*, ¶¶ 152, 172.

263. Claim element [13E] recites: **“determine a distance between the vehicle-mounted subsystem and the second vehicle-mounted subsystem based**

**on a time-of-flight of at least one communication between the UWB communications component of the second vehicle-mounted subsystem and the UWB communications component of the vehicle-mounted subsystem.”** It is my opinion that claim element [13E] would have been obvious to a POSITA at the time of the purported invention in view of the combination of Kane, Heddebaut, and Grisham.

264. Grisham discloses a set of interrelated units each mounted on a rail-vehicle:

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 900*f* and method 1000*f*. In this embodiment, the railroad collision avoidance system 900*f* 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 others 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).

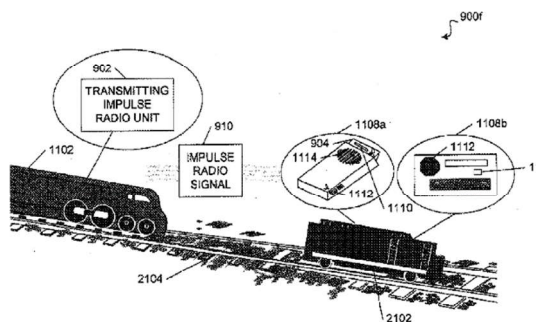


FIG. 21

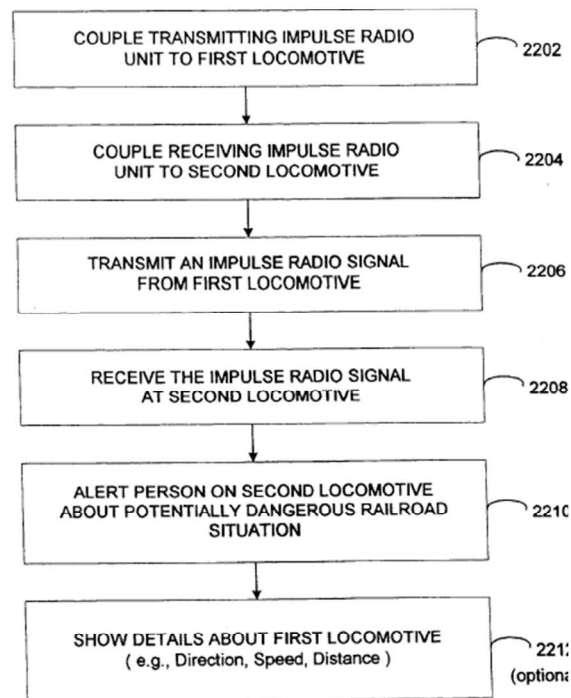


FIG. 22

EX1010, Figs. 21-22, 23:33-47. The receiving impulse radio unit 904 on a second train receives the signal from the transmitting impulse radio unit 902. *Id.*, 23:48-49, 24:25-29. The signal is a UWB signal. *Id.*, 16:39-49, 16:59-60.

265. Therefore, in my opinion, Grisham discloses a vehicle-mounted subsystem with UWB communications component (transmitting impulse radio unit 902) communicating with a second vehicle-mounted subsystem with UWB communications component (receiving impulse radio unit 904).

266. Grisham's radio-unit controllers in the first and second radio units (the first and second vehicle mounted modules) use "time position measurement" to

“measure the propagation delay and determine the link distance between the receiving impulse radio unit 904 and the locomotive 1102.” *Id.*, 24:18-24. Grisham describes this application of time-of-flight technique by reference to U.S. Patent No. 6,133,876 (“Fullerton,” EX1017), which Grisham incorporates by reference. *Id.*, 14:56-62.

267. Fullerton discloses calculating time-of-flight using two sequences of pulses between two transceivers. EX1017, 2:31-46. Fullerton states that “a time difference between the delayed first reference signal and the first reference signal is measured,” *id.*, 2:40-41, and that the difference in the two times is the “total time of flight” of the sequences and the distance between the transceivers is determined from the time difference, *id.*, 2:42-46.

268. It is my opinion that a POSITA would have read Grisham (including Fullerton) to disclose that time-of-flight calculations are performed by the embodiment shown in Figures 21 and 22 of Grisham. *See* EX1010, 24:18-24.

269. It is my opinion that it would have been obvious to use Grisham’s train-to-train UWB time-of-flight ranging to augment the combination of Kane and Heddebaut. Heddebaut discloses that its UWB ranging system is used to determine—and maintain—a “safety distance” between vehicles and that “such calculation may [] take place on-board trains without resorting to fixed technical means, on the ground.” EX1006, [0057]-[0062]. To the extent Heddebaut does not

already disclose using its UWB ranging system to make this distance determination onboard each vehicle, Grisham provides such disclosure, and a POSITA would have been motivated to look to Grisham to provide the distance information to implement this “safety distance” functionality.

270. Additionally, as discussed in connection with Claim 6 (Section VII.A.3), a POSITA would have recognized that the positioning systems contemplated by Kane (e.g., GPS) have limitations. Thus, utilizing UWB ranging for train-to-train ranging would have offered an additional benefit of providing each train’s position relative to other trains in the system, thereby providing an additional layer of collision avoidance in the event that other location-determination systems become unreliable.

## **2. Claim 14**

271. Claim element [14A] recites: **“The system of claim 13, wherein the vehicle-mounted subsystem is further configured to: generate an alert if the distance between the vehicle-mounted subsystem and the control signal interface subsystem is less than a first threshold.”** For the same reasons as discussed above with respect to claim 7 and element [14A] in Ground 1A, it is my opinion that claim element [14A] would have been obvious to a POSITA at the time of the purported invention in view of the combination of Kane, Heddebaut, and Grisham. *Supra*, ¶¶ 157-60, 189.

272. Claim element [14B] recites: **“generate an alert if the distance between the vehicle-mounted subsystem and the second vehicle-mounted subsystem is less than a second threshold.”** It is my opinion that claim element [14B] would have been obvious to a POSITA at the time of the purported invention in view of the combination of Kane, Heddebaut, and Grisham.

273. Grisham discloses the use of an alarm to alert the operator: “Either display 1108*a* or 1108*b* 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).” EX1010, 23:57-60, Fig. 21.

274. It is my opinion that it would have been obvious to a POSITA to implement Grisham’s alarm to generate alerts if the train is in the vicinity of another train. A POSITA would have understood that a responsive action should be taken when the distance between two trains becomes unsafe (i.e., below a “safety distance” disclosed in Heddebaut). *See* EX1006, [0061]-[0062]; EX1035, 5065. While automatic responsive actions may be available, a POSITA would have recognized that the simplest way to remedy the safety violation would often be to alert the operator so that he or she would be able to slow the train and increase the distance.

### **3. Claim 15**

275. Claim 15 recites: **“The system of claim 13, wherein the vehicle-mounted subsystem is further configured to: cause a braking system of the**

vehicle to activate if the distance between the vehicle-mounted subsystem and the control signal interface subsystem is less than a first threshold; and cause the braking system of the vehicle to activate if the distance between the vehicle-mounted subsystem and the second vehicle-mounted subsystem is less than a second threshold.” The limitations of claim 15 are discussed above in connection with Ground 1A and are further rendered obvious in view of a combination that includes, in addition to the references discussed in Ground 1A, Grisham’s train-to-train UWB time-of-flight ranging. A POSITA would have also been motivated to combine Kane, Heddebaut, and Grisham for the same reasons discussed above with reference to claim 13, Section VII.E.1.

**F. Ground 1F – Claims 16-17 Are Obvious in View of Kane, Heddebaut, Grisham, and Ackerman**

**1. Claims 16-17**

276. It is my opinion that claims 16-17 would have been obvious to a POSITA at the time of the claimed invention in view of the combination of Kane, Heddebaut, Grisham, and Ackerman.

277. Claim 16 recites: **“The system of claim 13, wherein the vehicle-mounted subsystem further comprises: a radio-frequency identification (RFID) subsystem configured to scan at least one RFID tag external to the vehicle to retrieve information stored on the at least one RFID tag; and wherein the vehicle-mounted subsystem is further configured to determine a distance**

**between the vehicle-mounted subsystem and the control signal interface subsystem based on the information stored on the at least one RFID tag.”**

278. Claim 17 recites: **“The system of claim 16, wherein: the vehicle-mounted subsystem is further configured to substantially continuously receive information relating to speed of the vehicle; and the vehicle-mounted subsystem determines a changing distance between the vehicle-mounted subsystem and the control signal interface subsystem based on the information stored on the at least one RFID tag and the information relating to speed of the vehicle.”**

279. The limitations of claims 16-17 are discussed above in connection with Ground 1C and are further rendered obvious in view of a combination that includes, in addition to the references discussed in Ground 1C, Grisham’s train-to-train UWB time-of-flight ranging. A POSITA would have also been motivated to combine Kane, Heddebaut, Grisham, and Ackerman for the same reasons discussed above with reference to claim 13 in Ground 1E.

**G. Ground 1G – Claim 18 Is Obvious in View of Kane, Heddebaut, Grisham, and Hungate**

**1. Claim 18**

280. It is my opinion that claim 18 would have been obvious to a POSITA at the time of the claimed invention in view of the combination of Kane, Heddebaut, Grisham, and Hungate.

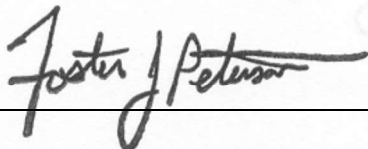
281. Claim 18 recites: **“The system of claim 13, further comprising: an access point external to the vehicle; and wherein the vehicle-mounted subsystem is further configured to: store data relating to prior behavior of the vehicle; and communicate the data relating to prior behavior of the vehicle with the access point.”** The limitations of claim 18 are discussed above in connection with Ground 1D and are further rendered obvious in view of a combination that includes, in addition to the references discussed in Ground 1D, Grisham’s train-to-train UWB time-of-flight ranging. A POSITA would have also been motivated to combine Kane, Heddebaut, Grisham, and Hungate for the same reasons discussed above with reference to claim 13 in Ground 1E.

## VIII. 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: May 21, 2024



\_\_\_\_\_

## IX. CLAIM LISTING

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

| <b>Claim 1</b>                                                                                                                                                                                                                                                                                                                                                                                     |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>[1-Pre] 1.</b> A system for evaluating vehicle operation compliance, wherein the system comprises:                                                                                                                                                                                                                                                                                              |
| <b>[1A]</b> a control signal interface subsystem; and                                                                                                                                                                                                                                                                                                                                              |
| <b>[1B]</b> a vehicle-mounted subsystem configured to:                                                                                                                                                                                                                                                                                                                                             |
| <b>[1C]</b> communicate with the control signal interface subsystem to receive information corresponding to a status of a control signal;                                                                                                                                                                                                                                                          |
| <b>[1D]</b> determine a rule for behavior of a vehicle according to the information corresponding to the status of the control signal; and                                                                                                                                                                                                                                                         |
| <b>[1E]</b> observe operation of the vehicle to evaluate compliance with the rule; wherein:                                                                                                                                                                                                                                                                                                        |
| <b>[1F]</b> the control signal interface subsystem comprises an ultra-wideband (UWB) communications component;                                                                                                                                                                                                                                                                                     |
| <b>[1G]</b> the vehicle-mounted subsystem comprises an ultra-wideband (UWB) communications component; and                                                                                                                                                                                                                                                                                          |
| <b>[1H]</b> the vehicle-mounted subsystem and the control signal interface subsystem are further configured to communicate UWB signals carrying data pertinent to evaluating vehicle operation compliance, the data comprising at least one of: a unique ID associated with the vehicle-mounted subsystem, a signal indication, a track number, a track direction, speed, and direction of travel. |
| <b>Claim 2</b>                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>2.</b> The system of claim 1, wherein the rule corresponds to the status of the control signal being at least one of red, double red, yellow, or double yellow.                                                                                                                                                                                                                                 |
| <b>Claim 3</b>                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>3.</b> The system of claim 1, wherein the rule specifies a stop-time duration for the vehicle.                                                                                                                                                                                                                                                                                                  |
| <b>Claim 4</b>                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>4.</b> The system of claim 3, wherein the rule specifies a speed for the vehicle.                                                                                                                                                                                                                                                                                                               |
| <b>Claim 5</b>                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>5.</b> The system of claim 4, wherein the rule specifies a maximum speed for the vehicle after an expiration of the stop-time.                                                                                                                                                                                                                                                                  |
| <b>Claim 6</b>                                                                                                                                                                                                                                                                                                                                                                                     |

|                                                                                                                                                                                                                                                                                                                                     |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>[6A]</b> 6. The system of claim 1, wherein the vehicle-mounted subsystem is configured to: interface with a braking system of the vehicle;                                                                                                                                                                                       |
| <b>[6B]</b> communicate with the UWB communications component of the control signal interface subsystem via the UWB communications component of the vehicle-mounted subsystem; and                                                                                                                                                  |
| <b>[6C]</b> determine a distance between the vehicle-mounted subsystem and the control signal interface subsystem based on a time-of-flight of at least one communication between the UWB communications component of the control signal interface subsystem and the UWB communications component of the vehicle-mounted subsystem. |
| <b>Claim 7</b>                                                                                                                                                                                                                                                                                                                      |
| 7. The system of claim 1, wherein the vehicle-mounted subsystem is further configured to generate an alert if a distance between the vehicle-mounted subsystem and the control signal interface subsystem is less than a threshold.                                                                                                 |
| <b>Claim 8</b>                                                                                                                                                                                                                                                                                                                      |
| 8. The system of claim 1, wherein the vehicle-mounted subsystem is further configured to cause a braking system of the vehicle to activate if a distance between the vehicle-mounted subsystem and the control signal interface subsystem is less than a threshold.                                                                 |
| <b>Claim 9</b>                                                                                                                                                                                                                                                                                                                      |
| 9. The system of claim 1, wherein the vehicle-mounted subsystem further comprises a radio-frequency identification (RFID) subsystem configured to scan at least one RFID tag external to the vehicle to retrieve information stored on the at least one RFID tag.                                                                   |
| <b>Claim 10</b>                                                                                                                                                                                                                                                                                                                     |
| <b>[10A]</b> 10. The system of claim 9, wherein: the vehicle-mounted subsystem is further configured to substantially continuously receive information relating to speed of the vehicle; and                                                                                                                                        |
| <b>[10B]</b> the vehicle-mounted subsystem determines a changing distance between the vehicle-mounted subsystem and the control signal interface subsystem based on the information stored on the at least one RFID tag and the information relating to speed of the vehicle.                                                       |
| <b>Claim 11</b>                                                                                                                                                                                                                                                                                                                     |
| 11. The system of claim 9, wherein the vehicle-mounted subsystem is further configured to determine a distance between the vehicle-mounted subsystem and the control signal interface subsystem based on the information stored on the at least one RFID tag.                                                                       |
| <b>Claim 12</b>                                                                                                                                                                                                                                                                                                                     |

|                                                                                                                                                                                                                                                                                                                                          |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>[12A]</b> 12. The system of claim 1, further comprising: an access point external to the vehicle; and                                                                                                                                                                                                                                 |
| <b>[12B]</b> wherein the vehicle-mounted subsystem is further configured to: store data relating to prior behavior of the vehicle; and                                                                                                                                                                                                   |
| <b>[12C]</b> communicate the data relating to prior behavior of the vehicle with the access point.                                                                                                                                                                                                                                       |
| <b>Claim 13</b>                                                                                                                                                                                                                                                                                                                          |
| <b>[13A]</b> 13. The system of claim 1, further comprising: a second vehicle-mounted subsystem including a UWB communications component, wherein the second vehicle-mounted subsystem is configured to be mounted on another vehicle; and                                                                                                |
| <b>[13B]</b> wherein the vehicle-mounted subsystem is configured to: communicate with the UWB communications component of the control signal interface subsystem via the UWB communications component of the vehicle-mounted subsystem;                                                                                                  |
| <b>[13C]</b> communicate with the UWB communications component of the second vehicle-mounted subsystem via the UWB communications component of the vehicle-mounted subsystem;                                                                                                                                                            |
| <b>[13D]</b> determine a distance between the vehicle-mounted subsystem and the control signal interface subsystem based on a time-of-flight of at least one communication between the UWB communications component of the control signal interface subsystem and the UWB communications component of the vehicle-mounted subsystem; and |
| <b>[13E]</b> determine a distance between the vehicle-mounted subsystem and the second vehicle-mounted subsystem based on a time-of-flight of at least one communication between the UWB communications component of the second vehicle-mounted subsystem and the UWB communications component of the vehicle-mounted subsystem.         |
| <b>Claim 14</b>                                                                                                                                                                                                                                                                                                                          |
| <b>[14A]</b> 14. The system of claim 13, wherein the vehicle-mounted subsystem is further configured to: generate an alert if the distance between the vehicle-mounted subsystem and the control signal interface subsystem is less than a first threshold; and                                                                          |
| <b>[14B]</b> generate an alert if the distance between the vehicle-mounted subsystem and the second vehicle-mounted subsystem is less than a second threshold.                                                                                                                                                                           |
| <b>Claim 15</b>                                                                                                                                                                                                                                                                                                                          |
| <b>[15A]</b> 15. The system of claim 13, wherein the vehicle-mounted subsystem is further configured to: cause a braking system of the vehicle to activate if the distance between the vehicle-mounted subsystem and the control signal interface subsystem is less than a first threshold; and                                          |

|                                                                                                                                                                                                                                                                                       |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>[15B]</b> cause the braking system of the vehicle to activate if the distance between the vehicle-mounted subsystem and the second vehicle-mounted subsystem is less than a second threshold.                                                                                      |
| <b>Claim 16</b>                                                                                                                                                                                                                                                                       |
| <b>[16A] 16.</b> The system of claim 13, wherein the vehicle-mounted subsystem further comprises: a radio-frequency identification (RFID) subsystem configured to scan at least one RFID tag external to the vehicle to retrieve information stored on the at least one RFID tag; and |
| <b>[16B]</b> wherein the vehicle-mounted subsystem is further configured to determine a distance between the vehicle-mounted subsystem and the control signal interface subsystem based on the information stored on the at least one RFID tag.                                       |
| <b>Claim 17</b>                                                                                                                                                                                                                                                                       |
| <b>[17A]</b> The system of claim 16, wherein: the vehicle-mounted subsystem is further configured to substantially continuously receive information relating to speed of the vehicle; and                                                                                             |
| <b>[17B]</b> the vehicle-mounted subsystem determines a changing distance between the vehicle-mounted subsystem and the control signal interface subsystem based on the information stored on the at least one RFID tag and the information relating to speed of the vehicle.         |
| <b>Claim 18</b>                                                                                                                                                                                                                                                                       |
| <b>[18A] 18.</b> The system of claim 13, further comprising: an access point external to the vehicle; and                                                                                                                                                                             |
| <b>[18B]</b> wherein the vehicle-mounted subsystem is further configured to: store data relating to prior behavior of the vehicle; and                                                                                                                                                |
| <b>[18C]</b> communicate the data relating to prior behavior of the vehicle with the access point.                                                                                                                                                                                    |