

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

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

Petitioners,

v.

METROM RAIL, LLC

Patent Owner.

Case No. IPR2023-0460

Patent No. 10,737,709

DECLARATION OF MICHAEL BRAASCH, PH.D.

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I, Michael Braasch, declare:

1. I have been retained by Wolf, Greenfield & Sacks, P.C., counsel for Petitioners Humatics Corp., Ground Transportation Systems USA Inc., Siemens Mobility, Inc., and Piper Networks, Inc., to assess claims 1-20 (the “challenged claims”) of U.S. Patent No. 10,737,709 (“the ’709 patent”). I am being compensated for my time at my standard rate of \$500.00 per hour, plus actual expenses. My compensation is not dependent in any way upon the outcome of the *inter partes* review of the ’709 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 Exhibit 1004. The following is a brief summary of my relevant qualifications and professional experience.

3. I am currently a Professor with tenure in the School of Electrical Engineering and Computer Science at Ohio University. I received my Bachelor of Science and Master of Science degrees in Electrical Engineering from the Ohio University in 1988 and 1989 respectively. In 1992, I received a Ph.D. in Electrical Engineering also from Ohio University. During that time, my post-baccalaureate and doctoral work focused on navigation systems. My M.S. thesis involved the

development of a computer simulation of an interrogation-reply ranging system known as the Distance Measuring Equipment (DME).

4. From 1989 to 1993, I was a research engineer in the Avionics Engineering Center at Ohio University. I became an assistant professor in the Department of Electrical and Computer Engineering at Ohio University in 1994 and have been on the faculty at Ohio University since that time. I have held the title of Professor in the School of Electrical Engineering and Computer Science since 2003 and was appointed as the Thomas Professor of Electrical Engineering in 2004. As a professor of Electrical Engineering, I have taught courses in navigation including ranging systems such as DME.

5. I am a Licensed Professional Engineer (P.E.) in the State of Ohio. In my professional career, I have specialized in the areas of electronic navigation receiver design, electronic navigation system engineering, satellite-based navigation systems, inertial navigation systems, and integrated navigation systems.

6. Since the mid-1980s, I have been involved with research related to navigation and transportation systems including navigation system computer modeling and validation; characterization of GPS error sources and development of mitigation strategies; design, development and testing of software-defined GPS receiver architectures; design, development and flight testing of advanced cockpit displays; and analysis of safety-certification issues in unmanned aerial vehicle

operations. I have been the recipient of over 65 research grants and contracts, including awards from the U.S. Department of Transportation, Federal Aviation Administration, Air Force Office of Scientific Research and NASA. In 1992, I received the RTCA (formerly known as the Radio Technical Commission for Aeronautics) William E. Jackson Award in recognition of an outstanding aviation electronics publication.

7. I have published over 80 journal articles, book chapters, conference papers, and workshop papers, most of which were related to navigation systems. I have authored or co-authored over 20 academic publications in the areas of graphical display systems, electronic navigation system engineering, satellite-based navigation systems with emphasis in GPS, and integrated navigation systems. These publications include book chapters in *Global Positioning System: Theory and Applications*, American Institute of Aeronautics and Astronautics, Washington, D.C. (1996). A complete list of my publications is included in my curriculum vitae (EX1004).

8. I have given numerous presentations at various conferences and universities worldwide on these topics. In particular, I have been invited to speak and publish in connection with conference proceedings on navigation systems at venues around the world. Additional contributions of mine to the field are set forth in my current curriculum vitae (EX1004).

9. In addition to gaining expertise via my academic training, professional experiences, and research accomplishments described above, I have kept abreast of various sub-disciplines within the field of navigation systems, such as locating technologies, by reading technical literature, attending and presenting at conferences, and attending and presenting at symposia. I have been invited to participate in the peer review process for various technical journals, and conferences, and have reviewed manuscripts submitted by other engineers relating to navigation system technology. Furthermore, I have collaborated with or have communicated with many of the engineers in the field of navigation systems.

II. MATERIALS REVIEWED AND CONSIDERED

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

Exhibit	Description
1001	U.S. Patent No. 10,737,709
1002	Prosecution History of U.S. Patent No. 10,737,709
1005	Provisional Application No. 62/177,683

1006	German Patent Application Pub. No. DE102008020700A1 (“Meyer-German”) (Attached as Exhibit A to EX1008)
1007	Certified English-Language Translation of German Patent Application Pub. No. DE102008020700A1 (“Meyer”) (Attached as Exhibit B to EX1008)
1008	Declaration of Harry Gigas
1009	U.S. Patent No. 7,148,791 (“Grisham”)
1010	WO International Publication No. 2013/056244 (“Cross”)
1011	U.S. Patent No. 6,133,876
1012	U.S. Patent Publication No. 2011/0006912
1013	U.S. Patent Publication No. 2010/0039978
1014	U.S. Patent Publication No. 2012/0182191
1015	U.S. Patent No. 5,283,589
1016	U.S. Patent No. 6,597,293
1017	U.S. Patent Application Pub. No. 2010/0124898A1
1018	U.S. Patent Application Pub. No. 2011/0084854A1
1019	C. L. Bennett and G. F. Ross, “Time-domain electromagnetics and its applications,” in <i>Proceedings of the IEEE</i> , vol. 66, no. 3, pp. 299-318, March 1978, doi: 10.1109/PROC.1978.10902.
1020	U.S. Patent Application Pub. No. 2012/0296562A1
1021	U.S. Patent Application Pub. No. 2016/0176422A1
1022	Newton’s Telecom Dictionary, 27 th Expanded and Updated Edition
1023	Dictionary of Computer Science Engineering and Technology (2000)
1024	Microsoft Computer Dictionary, 5 th Edition (2002)
1025	Docket as of January 5, 2023 for <i>Metrom Rail, LLC v. Siemens Mobility, Inc., et al.</i> , 1-22-cv-00049 (D. Del.)
1026	First Amended Complaint, <i>Metrom Rail, LLC v. Siemens Mobility, Inc., et al.</i> , 1-22-cv-00049, Dkt. No. 32 (D. Del. Apr. 26, 2022)

III. MY UNDERSTANDING OF PATENT LAW

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

12. 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.

13. I understand that, in this proceeding, Petitioner has the burden of proving that the challenged claims of the '709 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.

14. 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 ("POSA") 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. If a claim element is expressed as a

“means” for performing a specified function, I understand that it covers the corresponding structure described in the specification and equivalents of the described structure. I have applied these standards in preparing the opinions in this declaration.

15. 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 understand that for a patent claim to be entitled to the benefit of the filing date of an earlier application to which the patent claims priority, the earlier application must have described the claimed invention in sufficient detail to convey with reasonable clarity to the POSA that the inventor had possession of the claimed invention as of the earlier application’s filing date. I understand that a disclosure that merely renders the claimed invention obvious is not sufficient written description for the claim to be entitled to the benefit of the filing date of the application containing that disclosure.

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

A. Anticipation

17. I understand that, for a patent claim to be “anticipated” by the prior art (and therefore not novel), each and every limitation of the claim must be found, expressly or inherently, in a single prior-art reference. I understand that a claim limitation is disclosed for the purpose of anticipation if a POSA would have understood the reference to disclose the limitation based on inferences that a POSA would reasonably be expected to draw from the explicit teachings in the reference when read in light of the POSA’s knowledge and experience.

18. I understand that a claim limitation is inherent in a prior art reference if that limitation is necessarily present when practicing the teachings of the reference, regardless of whether a person of ordinary skill recognized the presence of that limitation in the prior art.

B. Obviousness

19. 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.

20. 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 ’709 patent.

21. I understand that in order for a claimed invention to be considered obvious, a POSA 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.

22. 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 POSA, the following are examples of approaches and rationales that may be considered:

- combining prior-art elements according to known methods to yield predictable results;

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

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

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

24. I have been informed and understand that for purposes of assessing whether prior-art references disclose every element of a patent claim (thus “anticipating” the claim) and/or would have rendered the claim obvious, the patent and the prior-art references must be assessed from the perspective of a person having ordinary skill in the art (“POSA”) 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 POSA 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.

25. The ’709 patent involves technology in the field of positioning systems and techniques. I have been asked to provide my opinions as to the state of the art in this field by 2015. I use this timeframe because the face of the ’709 patent indicates an earliest claimed priority date of the March 23, 2015 filing date of a provisional application. ’709 patent (EX1001), (60). Whenever I offer an opinion in this declaration about the knowledge of a POSA, the manner in which a POSA would have understood the claims of the ’709 patent or its description, the

manner in which a POSA would have understood the prior art, or what a POSA would have been led to do based on the prior art, I am referencing the 2015 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.

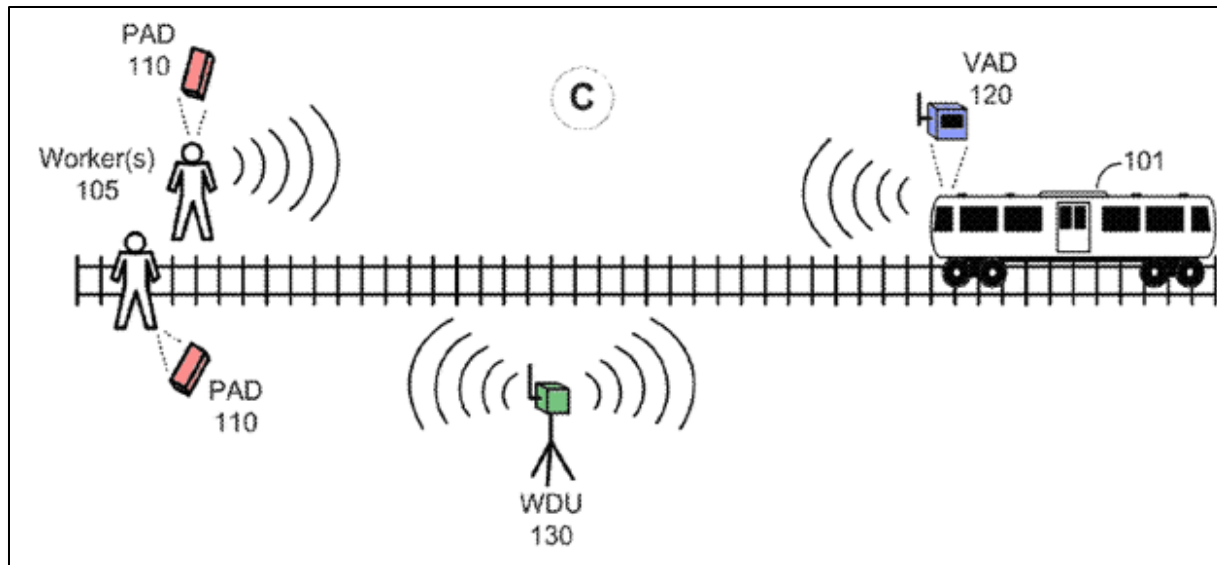
27. In my opinion, a POSA in 2015 would have had a background in wireless electronics, including at least a bachelor's degree in electrical engineering or a related field and would have had at least two years of experience with using such electronics for control systems applications such as collision avoidance systems or positioning systems. More education could substitute for experience, and vice versa. This person would have been capable of understanding and applying the teachings of the '709 patent and the prior-art references discussed in this declaration.

28. By 2015, I held a Ph.D. in Electrical Engineering, and I had 20+ years of experience with positioning and control systems and techniques. Therefore, I was a person of more than ordinary skill in the art during the relevant timeframe. However, I worked with many people who fit the characteristics of the POSA, and

I am familiar with their level of skill. When developing the opinions set forth in this declaration, I assumed the perspective of a person having ordinary skill in the art, as set forth above.

V. THE '709 PATENT

29. The '709 patent concerns systems and devices for protecting workers (e.g., railroad workers) from collisions with approaching trains. EX1001, Abstract. For example, the system “issue[s] alerts” to railroad workers, for example, “when a particular vehicle (e.g., a train...) is approaching.” EX1001, 2:29-32. The patent criticizes prior art systems as being “costly, inefficient, and/or ineffective” (EX1001, 1:22-27), but the disclosed system nonetheless uses conventional electronics (e.g., wireless communication circuits) and conventional techniques (e.g., transmitting alert signals) for alerting workers to dangers. Specifically, the system includes a “portable alert device (PADs)” that are “worn by worker(s)” (e.g., attached to “worker(s)” clothing) that communicates with one or more companion devices. EX1001, 2:37-65. These companion devices may include (i) “vehicle alert devices (VADs)” that are “mounted on vehicles (e.g., the train)” and/or (ii) “wayside detection units (WDUs)” that are positioned “near [the vehicle path]” (e.g., at the “work site”). EX1001, 2:37-65. The PAD, VAD, and WDU are illustrated in Figure 1A, copied below:



As I discuss below (§§ V.A.1-4), PADs, WDUs, and VADs exchange wireless signals using conventional “antennas” for “transmitting and/or receiving signals.” EX1001, 8:52-58, 11:55-64, 14:15-17. Based on the exchanged signals, the VADs, PADs, and WDUs “interact during operation of the system, to provide the intended protection.” EX1001, 7:19-21. For example, the PADs, WDUs, and VADs may be “configured to operate (trigger alerts)” “based on user preferences and/or parameters,” such as “operator-configurable combinations of distances, speeds, location, etc.” EX1001, 5:16-23.

30. As I discuss in §§ V.A.2-4 below, each of the PADs, WDUs, and VADs are disclosed as comprising conventional electronic components (e.g., antennas, power supplies, processors, etc.) for transmitting, receiving, and processing wireless signals that were well-known in the prior art. *See, e.g.*, EX1001, 8:29-10:46, FIG. 2A (describing PAD’s components); 10:47-13:47, FIG.

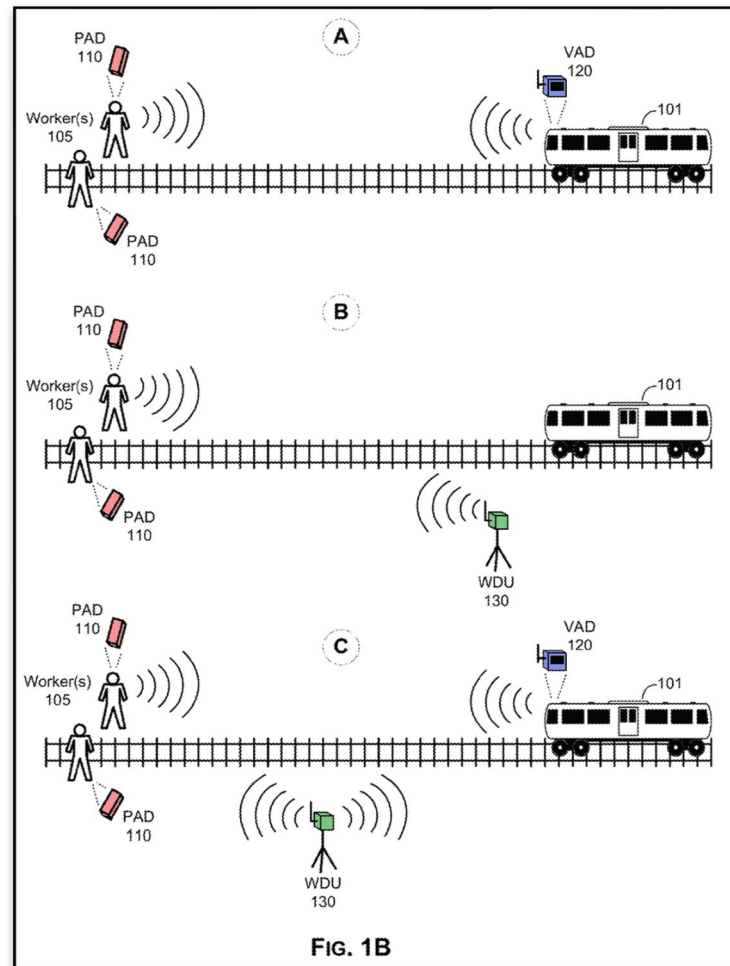
3 (describing VAD's components); 13:48-15:31, FIG. 4 (describing WDU's components). As seen in Figures 2A, 3, and 4 below, each device is configured for its particular application. For example, the PAD can be a "small and light device" with a clip for attaching to a worker. EX1001, 2:66-3:3. The worker-worn PAD also has audio and visual indicators that are "configured to provide visual and/or audio indication in response to triggering of alerts" (EX1001, 9:15-26) as well as "an alert acknowledgement element, such as a confirmation button to silence alarms" (EX1001, 3:11-14). The vehicle-mounted VAD, in turn, includes an "operator unit" with a "user interface" (e.g., display) that "provide[s] the vehicle operator" with "alert related data" (e.g., "distance to the workers"). EX1001, 11:16-54. And the wayside WDU includes sensors that "monitor, detect, and track [an] approach[ing] vehicle," as well as "support structure" (e.g., a tripod) that allows the WDU to be placed "near train tracks" (EX1001, 14:5-26).

A. Described Embodiments

1. Interaction of Companion Devices

31. As I discuss below, the VADs, PADs, and WDUs "interact during operation of the system, to provide the intended protection." EX1001, 7:16-21. In operation, the worker-worn PADs communicate via wireless signals with VADs mounted on trains and with the wayside WDUs that are positioned at a worksite with workers present. EX1001, 2:36-51. Examples of the '709 patent's system are

depicted in annotated Figure 1B, below, in which I have annotated the VADs in blue, the WDU in green, and the PADs in red:



32. In operation of the (A) embodiment in FIG. 1B above, the train is “equipped with a VAD” and the VAD “broadcasts signals to interface with the PADs... to detect if the train... is in proximity.” EX1001, 7:22-31. When PADs “are detected by any train-based VAD,” the “PADs... issue an alert (e.g., audible alarm).” EX1001, 7:25-31 “[W]hen the PADs... are detected,” the VAD “may further provide information to the operator” of the train. EX1001, 7:31-33. For

example, the VAD may “receiv[e] signal indications triggering of alerts,” as well as “confirmation of such alerts by workers.” EX1001, 11:55-60. The VAD, after triggering alerts, generates data that can be used to (i) calculate “how many PADs... (and thus workers...) are present within the specified distance” (EX1001, 7:33-36); (ii) determine “distance to workers”; (iii) “indicate whether workers have confirmed the alarm” (EX1001, 2:55-60); and (iv) determine the “calculated time till [the vehicle] reach[es] the workers” (EX1001, 11:41-46).

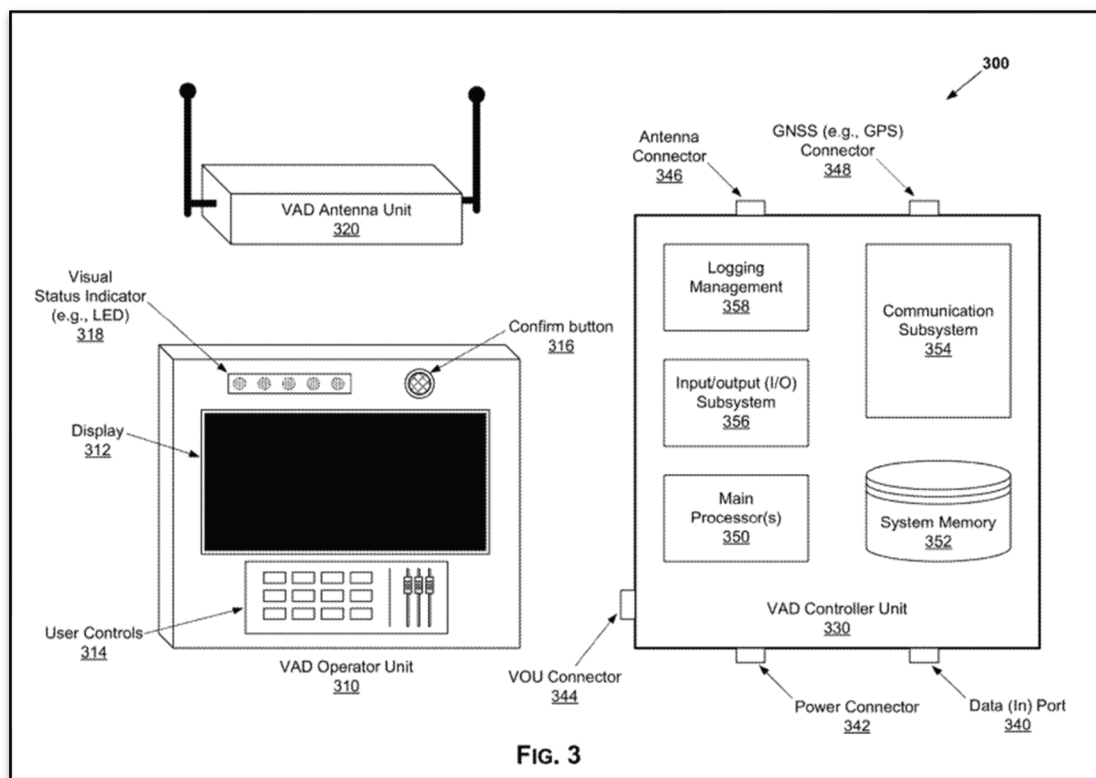
33. In operation of the (B) embodiment in FIG. 1B above, no VADs are employed, but “rather, the [PADs] are only in communication with the [WDUs].” EX1001, 7:41-44. The WDUs “monitor for and detect approaching vehicles” like the “train,” “broadcast alarms (or signals [that] trigger[] alarms) when a vehicle is in proximity” such as when it is “at [a] particular distance from the wayside device and/or moving at a particular speed.” EX1001, 7:43-48. For instance, the WDU “detect[]s” the train when the train “passes” or when the train “moves within certain distance from” the WDU. EX1001, 7:48-52. The WDU then “sends a proximity warning to all local PADs.” EX1001, 7:49-53. Thus, WDUs “detect[] approaching vehicles, trigger[] alerts [by the PADs] (e.g., by broadcasting signals configured for interfacing with the” PADs), which “trigger[s] critical alarms when a train enters a work area.” EX1001, 13:62-14:2.

34. In operation of the (C) embodiment in FIG. 1B above, the worker-worn PADs communicate via wireless signals with VADs on trains and with WDUs that are positioned at a worksite with workers present. EX1001, 2:37-52. The VADs and WDUs are configured to transmit either alerts to the worker-worn PADs or to transmit signals that cause the PADs to trigger alerts. EX1001, 2:40-43. The VAD “may communicate directly with the WDU 120 as the train approaches it” or when the train is “a specified distance” from the WDU, which causes the WDU to “send proximity warnings (trigger alarms) to all local PADs.” EX1001, 7:65-8:2. Additionally, “the VAD 120 may communicate directly with the local PADs 110, to trigger alarm” (e.g., when the VAD is “at a particular distance [from the PAD] and/or speed”). EX1001, 8:4-5. That is, the PADs may “be activated and/or triggered by vehicle-mounted devices for redundancy (thus enhanced protection).” EX1001, 7:61-64. For example, a VAD is configured to “trigger alerts under particular conditions—e.g., when it detects it is approaching a crew equipped with” PADs. EX1001, 2:52-55. Likewise, a WDU is configured to trigger an alert when, for example, it detects a train approaching a worksite. EX1001, 2:60-65. When an alert is triggered, the PADs may “issue an indication (e.g., audio, visual, tactile, etc.) to alert the worker wearing it of an approaching object (that pose[s] a safety concern).” EX1001, 3:3-9.

2. Vehicle Alert Devices (VADs)

35. The VAD comprises components that are temporarily or “permanently mounted” on vehicles, such as a train. EX1001, 3:23-26. The VAD comprises “a first physical unit comprising the antennas (and related circuitry or other support components)” and “one or more physical units housing the remaining components of the VADs.” EX1001, 3:48-52. Alternatively, the VAD may be “within a single housing incorporating and/or attaching all components of the VAD.” EX1001, 11:5-6, 3:42-44 (disclosing that the VAD may also be a “singular physical component, incorporating all components (including antennas)”).

36. As FIG. 3 (below) illustrates, the VAD comprises a communication component that comprises an “antenna unit,” which comprises “one or more antennas... configured for use in transmitting and/or receiving signals.” EX1001, 11:12-15, 11:55-60. The “antenna unit may be ... plac[ed]... on [the] roof of [the] front car [on the] train.” EX1001, 3:48-58.



37. The VAD also comprises “hardware (including circuitry and/or other hardware components), software, and combination[s] thereof” to support “the vehicle-mounted functionality.” EX1001, 10:50-55. For instance, the VAD comprises a “main processor,” which has “suitable circuitry operable to process data, and/or control and/or manage operations of the VAD... and/or tasks and/or applications performed” by the VAD. EX1001, 12:5-8. The main processor may be “a general purpose processor (e.g., CPU)” or “a special purpose processor (e.g., application-specific integrated circuit (ASIC).” EX1001, 12:11-14. As the ’709 patent explains, “the terms ‘circuits’ and ‘circuitry’ refer to physical electronic components (e.g., hardware) and any software and/or firmware (‘code’) which may

configure the hardware, be executed by the hardware, and or otherwise be associated with the hardware.” EX1001, 1:64-2:1.

38. The VAD further comprises an “operator unit” (EX1001, 11:12-15), which includes “input/output (I/O) components” (EX1001, 11:16-23). The I/O components may include a “display” and “user controls.” EX1001, 11:16-23. The user controls may “be implemented in the form of a touch screen (e.g., as part of the display...), or be implemented with an alpha-numeric display.” EX1001, 11:39-41. The user controls “comprise various types of user input elements” such as “buttons” or “dials” that “allow[the] vehicle operator(s)... to provide input” and/or “configure the VAD... and its operations.” EX1001, 11:34-38. The VAD’s operator unit may also “provid[e] indications relating to triggering of alerts and/or receiving feedback (e.g., confirmation) relating to such indications.” EX1001, 11:23-27. For example, the VAD operator unit may include “a speaker... configured for providing audible indications of triggered alerts” and a configuration button... configured to receive indication of user acknowledgment... when alert indication(s) is/are outputted.” EX1001, 11:27-34; 3:35-38. The VAD’s I/O components may also “provide the vehicle operator” with “alert related data (e.g., indicate the quantity of workers detected, and the approximate distance to the workers, calculated time tile reaching the workers, etc.).” EX1001, 11:41-67; 3:38-41. The VAD also “broadcast[s] signals that are specifically configured

to interface[] with the... PADs ... and may also interface with the... WDU... to provide increased distance.” EX1001, 3:31-35.

3. Personal Alerts Devices (PADs)

39. The PAD is a “portable device[]” (EX1001, 8:19) that “may be designed and configured as [a] small and light device.” EX1001, 2:66-3:1. The PAD may have an “attachment structure” for “wearability” (EX1001, 8:39-51), like “a clip, arm band or belt clip” (EX1001, 3:1-3). For example, as shown in FIG. 2A, which I have annotated below, the PAD includes “a clip structure 260, so that the PAD 200 may be clipped onto the worker’s clothing [or] belt.” EX1001, 8:45-51.

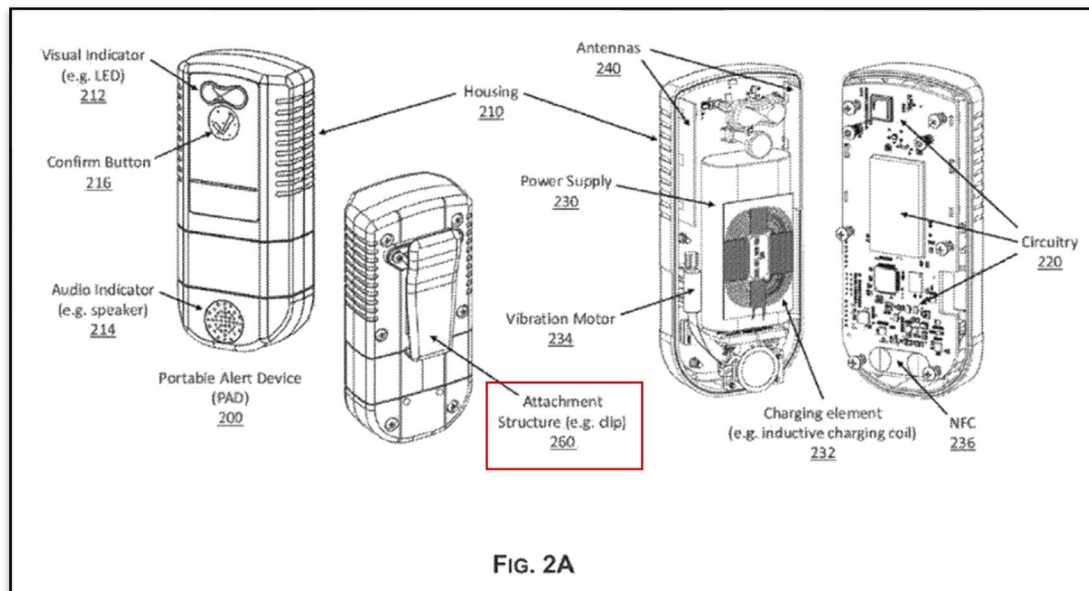
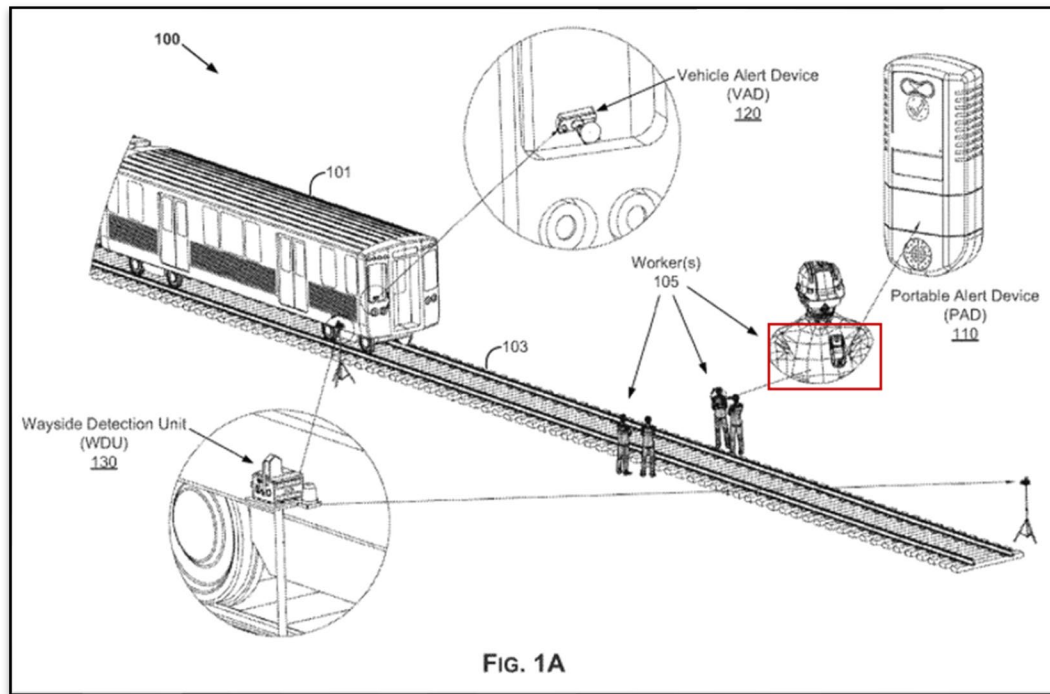


FIG. 1A, which I have annotated below, depicts the PAD attached to the worker:



40. The PAD comprises a “housing” for “enclosing various components of the PAD.” EX1001, 8:29-31. The PAD also contains “an integrated/internal power supply... for powering the various components of the PAD.” EX1001, 8:59-61. The ’709 patent explains that the “power supply” “may be rechargeable” (EX1001, 8:61-62), for example, rechargeable “batteries or similar power sources” (EX1001, 5:43-45).

41. The PAD comprises “one or more antennas” “configured for transmitting and/or receiving signals” such as “broadcast[ing] alert related signals” to train-based VADs (discussed above, § V.A.2) and/or wayside WDU (discussed below, § V.A.4). EX1001, 8:52-55.

42. The PAD includes “warning component[s],” such as an “audio warning component” like a “speaker,” a “visual warning component” like an “LED indicator,” and/or a “tactile indicator component” for “vibration.” EX1001, 3:6-11. The PADs “provide alerts regarding approaching vehicles that may pose safety threats to workers at particular locations.” EX1001, 8:17-21. For example, the PAD provides “one or more of visual, audio, and tactile indications” (EX1001, 9:22-24) when “issu[ing] an indication... to alert the worker... of an approaching object” (EX1001, 3:3-5). The alert indications “may continue until acknowledged by the workers.” EX1001, 7:53-56. For instance, the “audible alarms [will] continue until silenced” until the worker “hit[s] a ‘confirm’ button.” EX1001, 7:53-56. The PAD “may, in response to receiving user confirmations, generate and transmit acknowledg[ment] messages” to WDUs. EX1001, 9:31-35.

43. Further, the PAD “may be configurable to provide alerts adaptively based on a particular pre-set conditions—e.g., to provide at least a 15 second warning in line of sight conditions, when a train is approaching at 60 mph.” EX1001, 3:18-22. “[M]ultiple threshold types may be used.” EX1001, 4:48-49. For instance, “at low speeds, below a configurable speed threshold, the workers will not get a TTA [i.e., time-to-arrival] or DFT [i.e., distance-from-train] alerts; rather, the alert triggering is held off until the train/vehicle comes within a programmed short distance.” EX1001, 4:54-57. Thus, alerts may be triggered

“when a preset (programmed) alert trigger threshold is satisfied,” such as when a “vehicle’s speed exceed[s] [a] particular limit” or the “distance to workers fall[s] below [a] particular value.” EX1001, 4:45-48.

44. In setting up “particular pre-set conditions” (EX1001, 3:18-22), “particular areas/locations” may be a factor for the “operator (e.g., a transit agency)” to “modif[y] alerting rules.” (EX1001, 4:61-67). The PAD can be “reconfigured” “by [the] use of (re-)customization stations at entry points to those areas/locations,” in which the “rules are... updated” after the PAD is “placed in proximity to the customization stations briefly.” EX1001, 5:4-8. The “PAD charging station” may “support and/or facilitate exchange of data with the PADs,” such as the “input of data into the PAD” like “(re)configuration data.” EX1001, 10:3-7.

45. The PAD comprises “circuitry... for performing various actions in support of its functions.” EX1001, 9:4-5. For example, circuitry is “operable to store data (including code); run and/or execute various applications and/or functions (alert related); handle transmitted and/or reception of signals (and processing transmitted and/or received signals); provide power management; manage logging operations in the PAD” and “handle input/output functions (e.g., supporting different forms of alert indications, including visual, audio, and/or tactile, and handling user input, such as acknowledge[ment] of alerts.” EX1001,

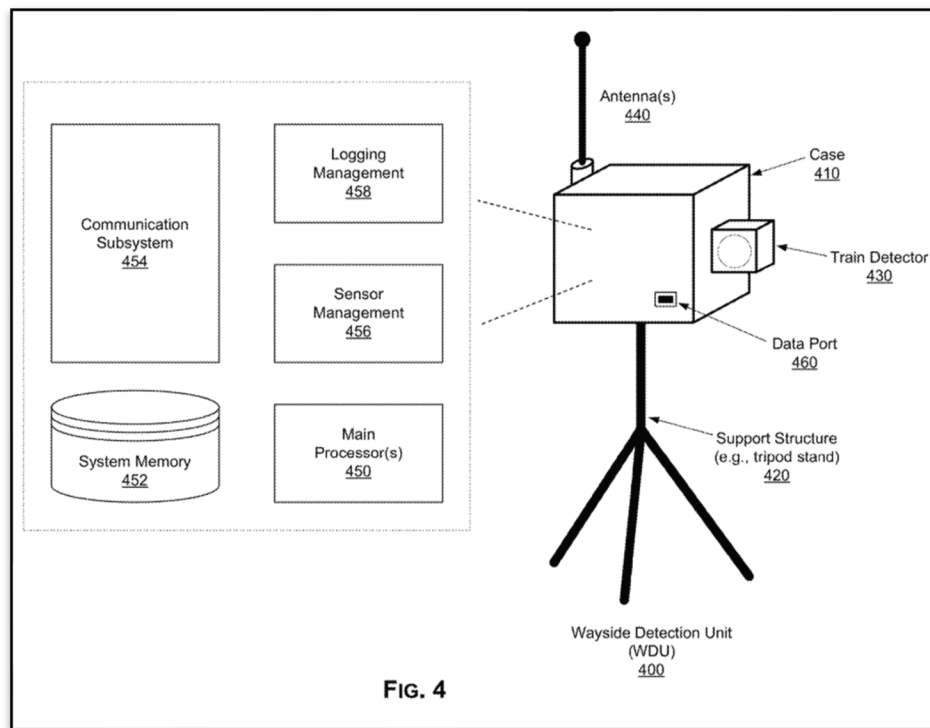
9:6-14. The PAD may also “comprise circuitry for data recording and/or logging,” which may be used “for training, for location tracking, and/or even for even recreating (e.g., during accident investigation).” EX1001, 6:10-13. The “log files” comprise” information about “alerts as well as related events and/or activities” like “users’ responses, such as alert silencing actions.” EX1001, 6:13-20.

46. The PADs “communicate with one or more companion [alert] devices, which are configured to directly trigger (and transmit signals causing issuing of alerts by the PADs...) alerts, or transmit signals causing issuing of alerts by the PADs.” EX1001, 2:40-43. The PADs may also, “in response to receiving user confirmations, generate and transmit acknowledge[ment] messages[] to other alert devices” such as WDU, VADs, and/or other PADs. EX1001, 9:27-35. The PADs may also “relay alerts (e.g., of approaching trains) to other devices nearby... that may have not been able to receive the signals/alerts directly.” EX1001, 6:57-63.

4. Wayside Device Units (WDUs)

47. The WDUs (FIG. 4 below) are “devices that are placed in a ‘wayside’ manner,” such as “along or near path of the approaching... train” (e.g., near “the worksite”). EX1001, 2:44-52. The WDU “provide redundant warning capabilities” for “additional range” (EX1001, 2:62-65) or for “increased distance” (EX1001, 3:35). WDUs “typically... comprise (or can be coupled to) a support structure... such as a rigid tripod... [for] placement of the WDU... near train

tracks.” EX1001, 14:23-26. The WDUs “comprise a housing... for enclosing various components of the WDU... and/or allowing attachment to certain external elements or structures” (EX1001, 14:5-8) such as an antenna.



48. To “detect[] approaching vehicles” and “trigger[] alerts at [PADs]” (EX1001, 13:62-14:4), the WDU comprises “antenna(s)” which are “configured to support broadcast of alert related signals.” EX1001, 15:11-14. The antenna(s) “transmit[s] and/or receiv[es] signals (e.g., broadcast[s] alert related signals).” EX1001, 14:15-17. The WDU may also “relay alerts... to other devices nearby, thus improving the field strength of warning signals, by increasing the probability that all nearby PADs... receive the alerts (even devices that may not have been able to receive the signals/alerts directly).” EX1001, 6:57-63.

49. The WDU also comprises a “power supply” (EX1001, 5:49-53) and “circuitry for performing various operations in support of its function[s]” (EX1001, 13:51-14:28). For instance, the “main processor” is “operable to process data, and/or control and/or manage operations of the WDU... and/or tasks and/or applications performed in the WDU.” EX1001, 14:33-36. The main processor also “enable[s] running and/or execution of applications, programs, and/or code.” EX1001, 14:43-46.

B. Prosecution History of the '709 Patent

50. The application that became the '709 patent was filed on January 14, 2019 though it purports to claim priority to a provisional application No. 62/177,683, filed on March 23, 2015. EX1001, 1:5-12. I have not been asked to determine whether the challenged claims of the '709 patent contain written description support in provisional application No. 62/177,683 and, instead, have been asked to assume for purposes of this declaration only, that the challenged claims are entitled to a priority date of March 23, 2015.

51. I have reviewed the prosecution history of the '709 patent (EX1002). The as-filed application included 20 claims. EX1002, 15-55. In a preliminary amendment, the applicant canceled these originally filed claims and added 20 new claims. EX1002, 168-177. The examiner did not issue any office actions and, on

March 31, 2020, the '940 Application received a Notice of Allowance. EX1002, 181. The '709 patent issued on August 11, 2020. EX1001, Cover Page.

C. The Challenged Claims

52. I have been asked to provide my opinions regarding claims 1-20 (the “challenged claims”). Section VII below includes a Claim Listing of claims 1-20 with annotations added to label claim limitations.

53. Claims 1-19 are each directed to one of the three companion devices discussed in the specification. As I discuss below:

- Independent claim 1 and its dependent claims 2-11 recite a system that includes a “train-mounted unit.”
- Independent claim 12 and its dependent claims 13-19 recite a system that includes “one or more wayside units.”

54. Each of claims 1 and 12 recites basic components that its respective device includes (*e.g.*, “antennas,” “circuits”) and requires that the device “operate cooperatively” with a companion device (the companion device being a “wayside unit” in claim 1 and “a “train-mounted unit” in claim 12) to “provide alerts to one or more workers operating on or near the track.” Although not discussed in the specification, claims 1 and 12 further specify each of the respective companion devices is configured to “transmit and/or receive . . . ultra-wideband (UWB)

signals” and that the provision of alerts to workers is “based on communication of the UWB signals.”

55. The dependent claims add conventional features of electronic devices, and well-known features of safety-alert systems. For example, the claims that depend from claim 1 (claims 2-11), are summarized as follows:

- claim 2 recites that the train-mounted unit “broadcast[s]” signals;
- claims 3-4 recite that the train-mounted unit generates data or other feedback information that is output to the train operator;
- claim 5 allows the train to receive an alert acknowledgement from the worker(s);
- claim 6 adds conventional data-logging;
- claim 7 adds conventional input/output components
- claim 8 recite a generic housing;
- claim 9 generically recites making the train-mounted unit portable, detachable, and movable;
- claim 10 recites that the components of the train-mounted unit can be physically separated, with the antenna placed on the train exterior;
- claim 11 recites that the input/output unit is “configured for use by an operator of the train.”

56. The claims that depend from claim 12 (claims 13-19) recite similar generic and well-known components and operations, such as a “power supply,” a “housing,” a “support structure,” conventional data-logging, etc.

57. The final independent claim, Claim 20, is directed to a system including each of the three companion devices. Additionally, although not discussed or described in the specification, claim 20 requires that each of these companion devices is a “UWB radio.” Specifically, as I discuss below:

- Independent claim 20 recites a system that includes “one or more UWB radios at pre-determined locations,” “one or more worker UWB radios,” and “a vehicle UWB radio.”

58. Claim 20 further recites a “processor” within the vehicle UWB radio and a “processor” within the worker UWB radio. The vehicle-based processor determines the “location in which the one or more workers are working” based on UWB communication with a worker radio and “generates an alert to the operator of the vehicle.” The worker-based processor similarly “generates alerts to a worker” based at least in part on one or more criteria related to the position or movement of the vehicle.

VI. CLAIM INTERPRETATION

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

sections below the interpretations I have applied to certain claim terms, in accordance with the standards set forth in Section III above. For the reasons I discuss below in Sections VII.A-VII.G below, 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

60. I have been asked to provide my opinion concerning whether claims 1-20 of the '709 patent are anticipated by or would have been obvious to a POSA in light of the prior-art. For the reasons explained below, it is my opinion that each of claims 1-20 would have been obvious to a POSA over the prior art discussed below.

A. Ground 1: Claims 1-5, 7, 10-16, and 19-20 Would Have Been Obvious over Meyer in view of Grisham

1. Overview of Ground 1

61. For the reasons I discuss below in §§ VII.A.2-9, it is my opinion that claims 1-5, 7, 10-16, and 19-20 would have been obvious over Meyer (EX1007) in view of Grisham (EX1009).

2. Meyer (EX1007): German Patent No. DE102008020700A1

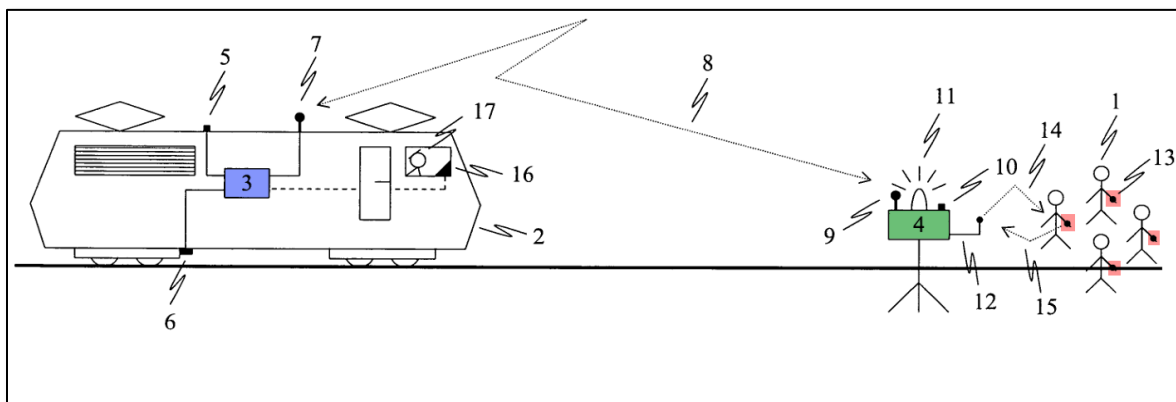
62. From its face, Meyer is a German patent that issued on May 11, 2009 from a patent application that was originally filed on April 24, 2008. Because Meyer issued and was published in 2009, I understand that Meyer qualifies as prior

art even if the challenged claims were entitled to the March 23, 2015 filing date of Provisional Application No. 62/177,683 (*see* '709 patent, code (60)). I understand that Meyer was not cited during prosecution of the '709 patent. *See* '709 patent, code (56) (references cited).

63. Like the '709 patent, Meyer describes a “railway collision warning system.” Meyer, Abstract. Meyer’s system is specifically designed to generate a warning when it is determined that there is a “collision risk between the rail-bound vehicle (2) and at least one person (1).” *Id.* As Meyer explains, prior art collision warning systems were often only able to “detect a collision risk between traffic participants of the same type, such as ships or between tow railway vehicles.” Meyer, ¶12. Therefore, these prior art systems were poorly suited to provide collision protection in “railway operations,” which involve “construction work and maintenance work” being “performed along the rail track, without closing the entire track section to all track.” Meyer, ¶12. Thus, Meyer’s system is designed to “provide a safer and more cost-effective capability for collision warning between a railway vehicle and personnel, in particular, construction crews.” Meyer, ¶15.

64. Like the '709 patent, Meyer describes a system with three types of devices/components. First, the system includes a “stationary unit” that is “arranged on [a] rail-bound vehicle” (e.g., a train). Meyer, ¶¶16-17, 35. Second, the system includes a “mobile unit” that is “arranged in the proximity of at least one person,”

such as “along the track section” of a “railway construction site.” Meyer, ¶¶16, 18, 35. Finally, the system includes “transponders” that are “arranged on or attached to the personnel to be warned.” Meyer, ¶¶23, 40. These personnel may be “construction crew performing work on the track section.” Meyer, ¶35.



66. Meyer's train-based stationary unit is "connected to a GNSS (global navigation satellite system) 5 and to a travel detection unit 6 to determine the current travel information and the position of the rail-bound vehicle, the vehicle speed, the current direction of travel, and the track occupied by the rail-bound vehicle 2." Meyer, ¶36. The stationary unit is also "connected to a transmission unit 7 such that the travel information determined by the stationary unit 3 is transmitted using a corresponding radio signal 8 that transmits the data packets

containing the current travel information.” Meyer, ¶36. This “radio signal 8 is preferably transmitted with the broadcast method such that it can be received in a certain radius about the rail-bound vehicle 2.” Meyer, ¶36.

67. The track-based mobile unit is “set up in the proximity of” workers (or “personnel 1”) on or near the train’s track. The mobile unit includes a “receiving unit 9 to receive the radio signal 8 transmitted by the stationary unit 3 using the transmission unit 7 when the mobile unit 4 is located in the transmission radius of the rail-bound vehicle 2.” Meyer, ¶37. The mobile unit may also be “equipped with a GNSS sensor 10 to autonomously determine the current position of the mobile unit 4.” Meyer, ¶37. Additionally, the mobile unit may include a “near-range transmitter 12” configured to “transmit a near-range warning signal 14 that can be received by [nearby devices],” such as the worker-based transponders, discussed below. Meyer, ¶41. These components may be supported by an “autonomous power supply.” Meyer, ¶18.

68. The worker-based transponders can be “arranged on or attached to the personnel” that are present on or near a train’s track. Meyer, ¶23. In certain examples these transponders can be “worn on the wrist in the form of a wristwatch.” Meyer, ¶40. These transponders are also able to generate warning signals “by acoustic, optical, or haptic means, that is to say, by emitting a corresponding warning signal.” Meyer, ¶40. The transponders are able to receive

“near-range warning signals,” such as those transmitted by a trackside mobile unit. Meyer, ¶41. The transponders may also include an “actuation button that can be pressed when a corresponding warning signal was received” by the transponder. Meyer, ¶42. In such a circumstance, the transponder may also have the capability to transmit a “corresponding near-range acknowledgement signal 15.” Meyer, ¶42.

69. In operation, these three components of Meyer’s system—the train-based stationary unit, track-based mobile unit, and worker-based transponders—interact to protect the on- or near-track workers by generating alerts to the workers when there is a risk of collision between the train and the workers. Specifically, the system operates as follows:

- When the vehicle approaches the mobile unit, the stationary unit’s “transmission unit” broadcasts a radio signal that is received by the mobile unit’s “receiving unit.” Meyer, ¶¶ 36-39.
- The radio signal contains “travel information” for the “rail-bound vehicle.” Meyer, ¶39. This “travel information” may include, without limitation “the current vehicle speed of the rail bound vehicle, the current vehicle position, and/or the current direction of travel.” Meyer, ¶20. This travel information may be “continuously determine[d]” by a “travel detection unit that has a connection to the stationary unit.” Meyer, ¶17.

- The mobile unit “extracts” this travel information from the received radio signal and uses the information to “determine a collision risk.” Meyer, ¶39.
- If the mobile unit determines that there is a collision risk, the mobile unit either (a) generates a warning signal using a light signal facility that can be “perceived” by the personnel (Meyer, ¶¶37-39) or (b) uses its near-range transmitter to transmit a near-range warning signal to any nearby worker-based transponders. Meyer, ¶41.
- In the latter example, when the worker-based transponders receive the near-range warning signal, the transponders generate an “acoustic, optical, or haptic signal . . . to warn the personnel 1 about an imminent collision with a rail-bound vehicle.” Meyer, ¶41.
- The workers can then use the actuation button of their transponders to acknowledge receipt of the warning signal. If they do so, the transponder transmits a “near-range acknowledgement signal” to the mobile unit. Meyer, ¶42.
- Based on the received acknowledgement signal(s), the mobile unit then determines the number of acknowledgement signals received from the worker-based transponders and determine if all personnel have reacted to the warning signal. Meyer, ¶43.

- If not all personnel have acknowledged the warning signal, the mobile unit “transmit[s] a radio signal to the rail-bound vehicle 2 to notify the latter that the hazard zone is not yet clear of personnel 1.” Meyer, ¶44.
- Upon receiving this notification from the mobile unit, the stationary unit may use a “display unit 16 in the operator cab of the vehicle operator 17 to display to the latter that there is an imminent collision risk with the personnel.” Meyer, ¶44.
- By using the display to alert the operator, the stationary unit enables the operator to “initiate appropriate measures” to avoid a collision. Meyer, ¶44. However, the stationary unit may also be “connected to the internal electronics of the rail-bound vehicle 2” such that the stationary unit can “automatically slow down the rail-based vehicle 2” based on the determination that a collision is imminent. Meyer, ¶45.

3. Grisham (EX1009): U.S. Patent No. 7,148,791

70. From its face, Grisham is a U.S. patent that issued on December 12, 2006. Because Grisham issued in 2006, I understand that Grisham qualifies as prior art even if the challenged claims were entitled to the March 23, 2015 filing date of Provisional Application No. 62/177,683 (*see* ’709 patent, code (60)).

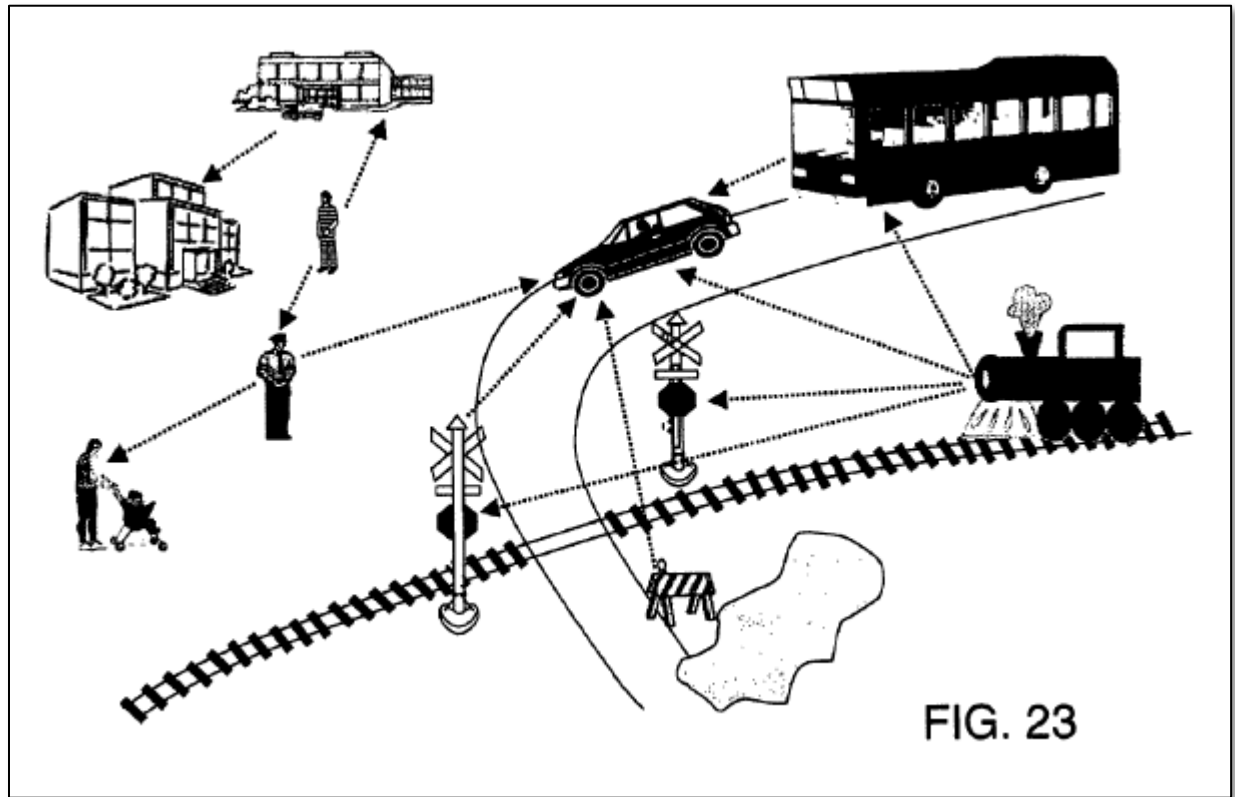
71. Like the ’709 patent, Grisham relates to a “danger proximity warning system” that can be used to “warn a person when there is a potentially dangerous

situation,” such as a dangerous situation arising from a “locomotive” approaching object(s) and/or person(s) in its path. Grisham, Abstract.

72. In general, Grisham’s warning system includes at least two—but potentially more—devices. The warning system includes at least a first device that is “coupled to” a “locomotive” and a second device that is “coupled to” a “second object.” Grisham, 19:52-65. Depending on how the system is implemented, the second object may be a “railroad pole, work vehicle, or another locomotive.” Grisham, 19:52-65. In at least some implementations, the system may include a device (either the aforementioned second device or an additional third device) that is “carried on or by a person.” Grisham, 27:40-44.

73. Grisham describes several specific example embodiments in which its first device is coupled to a locomotive and its second device is coupled to some other object that may be present in the railway environment. However, Grisham is clear that these example embodiments are only meant to be illustrative and that “various types of warnings of potentially dangerous systems that can be conveyed from the danger proximity warning system to persons in accordance with the present invention.” Grisham, 29:34-37. For example, Grisham illustrates the scalability of its disclosed system by providing an example system including a number of devices coupled to a variety of different objects both within and beyond a railway environment. According to Grisham, in this example system, there is a

device associated with “[e]ach of the vehicles, poles, people, etc.” 29:37-39. This example system is depicted in Figure 23, copied below:



74. In Grisham’s proximity warning system, each of the aforementioned devices is an “impulse radio unit.” An “impulse radio” is “a radio system based on short, low duty-cycle pulse.” Grisham, 5:21-22. As used in Grisham, “impulse radio” is interchangeable with “ultra-wideband system, or ultra-wideband communication systems.” Grisham, 5:8-13. Accordingly, “[i]n a preferred embodiment, the emitted signal is wide-band or ultrawide-band.” Grisham, 17:34-35.

75. As is well known in the art, there is an inverse relationship between the duration (in time) of an electromagnetic pulse and its spectrum (bandwidth). The narrower the pulse, the wider the span of frequencies it occupies. In an ultra-wideband (UWB) system, extremely narrow pulses (e.g., a fraction of a nanosecond) have extremely wide bandwidths (e.g., several gigahertz). Research into the practical applications of ultra-narrow pulse signals was reported in a 1978 paper by Bennett and Ross (EX1019). Subsequently, Fullerton was granted patents covering the generation, transmission, reception and demodulation of ultra-narrow pulse trains for communication applications (see e.g., U.S. Pat. Nos. 4,641,317 and 4,743,906). The phrase ‘impulse radio’ is derived from the theoretical concept, well known in the art, of an ‘impulse function.’ Such a theoretical function is infinitely narrow (a pulse with a time duration of zero seconds) and yet is comprised of non-zero finite energy. Such a theoretical signal has a theoretically infinite bandwidth. The impulse radios described, for example, in Grisham are practical implementations with ultra-narrow pulses and thus ultra-wide bandwidths. One advantage the use of UWB signals offers is the ability to propagate through materials that would block conventional narrow-band signals: “Impulse radio technology is well suited for subway (underground) applications because this technology can effectively transmit and receive impulse radio signals through the ground.” Grisham, 25:54-57.

76. Grisham's system includes "transmitting" and "receiving" impulse radio units. Grisham, 19:55-59 ("Basically, the danger proximity warning system 900 includes a transmitting impulse radio unit 902 . . . and a receiving impulse radio unit 904[.]") In operation, the "transmitting impulse radio unit" is "coupled to" a "locomotive" and transmits an "impulse radio signal 910 towards the receiving impulse radio unit 904," which is "attached to the second object." Grisham, 21:15-35. In the example embodiment of Figure 13 (which I have annotated below), the "second object" is an "active railroad pole 1302."

77. As the locomotive moves along the track, the transmitting impulse radio unit may "continually transmit the impulse radio signal 910." Grisham, 21:28-31. When the receiving impulse radio unit receives the impulse radio signal, it "makes sure that" any nearby person "(e.g., the person operating a vehicle 1308) is alerted . . . about the potentially dangerous situation" (i.e., the situation created by the approaching locomotive). Grisham, 21:36-42. Additionally, the receiving impulse radio unit can "communicate with the transmitting impulse radio unit 902 to inform (step 1414) a person about the dangerous situation such as [by] informing a person on the locomotive 1102 about the disabled vehicle 1308." Grisham, 21:59-64.

78. Additionally, the receiving impulse radio unit can "determine the distance that the first object (e.g., locomotive 1102) is from the second object[.]"

Grisham, 22:44-46; 24:24-26. As Grisham explains, impulse radio units—like the ones that make up Grisham’s safety system—can use UWB signals to “measure distances to relatively fine resolution.” Grisham, 15:27-35. Specifically, a “controller 1110 within the receiving impulse unit 904 can use the revolutionary positioning capabilities of impulse radio technology” to determine the separation distance. Grisham, 22:46-48; 24:26-28. To do so, the controller can use the “time position measurement” of the impulse radio signal to “measure the propagation delay and determine the link distance between the receiving impulse radio unit 904 and the transmitting impulse radio unit 902.” Grisham, 22:64-67; 24:44-47. Based on this determination, the receiving impulse radio unit may include a “display” that will “show[] . . . information about the dangerous situation such as the direction, distance and/or speed of the oncoming locomotive.” Grisham, 22:41-44; 24:21-24.

79. Using propagation delay to determine distance between a transmitter and receiver, as described in Grisham, is otherwise known as a “time of flight” distance determination. Indeed, Grisham discusses and incorporates by reference U.S. Patent No. 6,133,876 to Fullerton et al. (“Fullerton”), which provides further description of how impulse radio systems can determine the distance between transceivers using “time of flight” measurements. *See* EX1011, 4:11-38. Like Grisham, Fullerton’s system “utilizes ultra-wideband signals,” thus providing a “relatively fast response time.” EX1011, 3:4-6.

80. The distance measurement technique described by Fullerton is well known in the art as “two-way ranging” and had its origins in radar. In its simplest form, a radar determines distance to a target by transmitting an electromagnetic pulse that reflects off the target and the reflection is later received back at the radar. The time between transmitting the original pulse and receiving the reflection (the ‘time of flight’) corresponds to twice the distance from the radar to the target. Since distance equals speed times elapsed time, then $2*d = c * \text{TOF}$ where d is the distance, c is the speed of propagation and TOF is the elapsed time (time of flight). Clearly then $d = (c * \text{TOF})/2$.

81. For so-called ‘cooperative’ targets (e.g., aircraft belonging to one’s own forces), the ranging technique was enhanced through an interrogation-reply system. Specifically, a transceiver would transmit an interrogation pulse and the cooperating target would transmit a reply pulse in return. This was first implemented in so-called identification friend-or-foe (IFF) systems in World War II and was later implemented in a civilian navigation system known as the distance measuring equipment (DME). In an interrogation-reply system, the total time of flight is determined by measuring the elapsed time from transmission of the interrogation to receipt of the reply and subtracting off the time needed for the second unit (‘target’) to generate and transmit a reply to the interrogation.

82. Fullerton describes the application of this known two-way ranging technique to UWB ('impulse') radio systems: "The time of flight is given by $(t_4 - t_1) - (t_3 - t_2)$, where $(t_3 - t_2)$ is the delay encountered at the impulse radio 1108." EX1011, 12:7-9.

83. Additionally, although Grisham describes the separation-distance calculation being performed by the receiving impulse unit that is attached to a "second object" (e.g., railroad pole, work vehicle, etc.) in its example embodiments, I understand Grisham to disclose that the separation-distance calculation can be performed by any impulse radio unit that is capable of receiving impulse radio signals. Grisham's discussion of "distance measurement and positioning" capabilities of impulse systems refers to "impulse systems" and "impulse radio technology" generally, without limitation. Furthermore, Grisham teaches that the components associated with the "locomotive" in Grisham's system can include the "same equipment as . . . other objects 908" in the system, such as railroad poles, work vehicles, etc. Grisham, 25:45-50, 19:62-65.

84. As discussed above, Grisham discloses an example embodiment in which the transmission of an impulse radio signal from a locomotive-based radio unit to a receiving unit at a railroad pole causes the railroad pole to activate an alert to inform nearby persons/objects of the approaching locomotive. Grisham additionally discloses that a "warning signal can be conveyed continuously (or

periodically) when the danger proximity warning system is placed in an activate[d] state (i.e., turned on). Alternatively, the danger proximity warning system may monitor conditions and convey a warning signal whenever one or more conditions meet established alert status criteria.” Grisham, 26:15-21. To that end, Grisham describes a specific example in which a person working near machinery (specifically, “mine personnel” working near “mining equipment”) can be “equipped with headsets that provide . . . a UWB communications link to a UWB radio associated with the [machinery].” Grisham, 26:21-25. The worker can then be “provided a first type of audio warning whenever [the machinery] is operating in the vicinity of the person.” Grisham, 26:26-28.

85. Grisham also discloses that the “warning/alert signals may be conveyed using UWB communications between mobile objects, fixed objects, or combinations of mobile and fixed objects in order to warn a person of a potentially dangerous situation.” Grisham, 26:39-43. The “signal conveying an alert status may only include enough information to activate or deactivate a warning device, for example, turning on (or off) a warning light or a siren.” Grisham, 26:51-54. In other instances, the signal “may include information describing the potentially dangerous situation, . . . which could be conveyed to a person . . . via a visual display and/or an audio device/voice synthesizer.” Grisham, 26:54-58. Moreover, the signal may “include information intended to assist the person in assessing

and/or avoiding the potentially dangerous situation,” such as “the location of the potentially dangerous situation . . . and/or the distance to the dangerous situation.” Grisham, 26:62-27:1.

86. Additionally, while Grisham’s safety warning system may involve generating alerts for drivers of vehicles (Grisham, 27:8-39), the system “can also involve an UWB-enabled device that is carried on or by a person.” Grisham, 27:40-42. For example, the UWB device may be a “watch, phone, helmet, or computing device” that can “receive warnings from UWB radios associated with vehicles.” Grisham, 27:42-45. These worker-based UWB devices can also “enable warnings to be conveyed directly between people,” such that a worker receiving an alert indication can “send warning messages directly to other workers.” Grisham, 27:46-54.

87. Grisham also teaches that the impulse radio technology “could be used in subway (underground) applications the same way it is used in railroad applications,” noting that the technology is “well suited for subway (underground applications) because [the] technology can effectively transmit and receive impulse radio signals through the ground.” Grisham, 25:51-57.

4. The Meyer-Grisham Combination

88. In my opinion, POSAs would have had reasons to use Grisham’s impulse radio units in Meyer’s worker protection system.

89. First, Meyer and Grisham describe systems that are independently similar to one another in terms of their purpose and overall system configuration. Both disclosures are directed to determining when there is a risk of a moving train (or, rail-bound vehicle or locomotive) colliding with persons or objects located on or near the train's track. Moreover, both systems include a radio communication device that is attached to a train, which communicates wirelessly with radio communications devices attached to persons or objects on or near the train's path. In Meyer's system, this device is a trackside mobile unit (Meyer, ¶¶37-38); in Grisham's system, this device is an impulse radio that may be attached to a railroad pole, a work vehicle, a passenger vehicle, a worker, or any other "object" in a scalable proximity warning system (Grisham, 19:63-65, 27:40-54, Fig. 23). This overall structural similarity between the systems would have provided POSAs with a reason to consider the potential benefits of combining aspects of the two systems.

90. Additionally, both systems use the exchange of wireless signals to determine when there is a dangerous situation and to trigger alerts based on the determination. In Meyer, the train-based stationary unit includes a "transmission unit" to send information related to the train's location (specifically, "travel information") via wireless signals. Meyer, ¶¶36-39. The mobile unit receives these signals, extracts the travel information, and uses this information to determine whether there is a risk of collision between the approaching rail vehicle and any

personnel working on or near the tracks. Meyer, ¶39. If so, the mobile unit activates a warning signal and/or emits a near-range signal that will trigger a warning signal at worker-based transponders. Meyer, ¶¶39, 41. Grisham operates in a very similar manner. The train-based impulse radio unit transmits an impulse radio (or, “UWB”) signal. *See, e.g.*, Grisham, 4:47-53, 5:4-20, 19:66-20:4. This signal is received by a receiving impulse radio that uses the transmitted signal to determine that there is a potentially dangerous situation and, based on this determination, alerts any nearby persons or objects of the dangerous situation by generating an alarm. *See, e.g.*, Grisham, 20:4-13, 20:35-47, 21:36-48.

91. Given this similarity between both the structure and operation of Meyer’s and Grisham’s alert-generating systems, a POSA would have understood the components of these systems to be readily combinable, if not interchangeable. For example, POSAs would have understood that the impulse radio units described in Grisham could have been combined with (or substituted for) any of the three companion devices in Meyer because the impulse radio units, like Meyer’s devices, were capable of sending/receiving wireless signals and using those signals to trigger alerts.

92. Beyond these systems being structurally and operationally similar, POSAs would have been further motivated to use Grisham’s impulse radio units in

Meyer's worker protection system to realize the benefits of impulse radio (or, UWB) technology.

93. Meyer does not disclose a specific type of wireless communication used to send travel information from the stationary unit to the mobile unit, but instead generically refers to using "radio signals." Accordingly, a POSA reading Meyer would have the option of choosing any particular type of wireless radio signal to use to transmit information between the stationary and mobile unit in Meyer's system. In choosing this particular wireless-transmission technology, a POSA would have been motivated by Grisham's disclosure, as well as the POSA's background knowledge of the state of the art, to utilize impulse radio (or, UWB) technology for these transmissions, as disclosed in Grisham.

94. Grisham describes many benefits of using impulse radio technology in a worker protection system. Most notably, Grisham specifically teaches that impulse radio technology is well suited for use in subway applications because it is possible to "effectively transmit and receive impulse radio signals through the ground." Grisham, 25:51-57. A POSA would have been keenly aware of the importance of being able to transmit signals through the ground in a subway application, where the use of non-UWB signals would make it more difficult to effectively communicate between devices that are separated by, e.g., walls, turns, tunnels, the ground, etc. Thus, a POSA would have appreciated that, by using

Grisham's impulse radio technology, it would be possible to improve Meyer's system by making it more certain that a signal transmitted by the stationary unit would actually be received by the mobile unit, even when there are obstacles in between the two units.

95. Additionally, Grisham teaches that impulse radio signals are "highly resistant to interference," a property that is "desirable since impulse radio systems must share the energy spectrum with conventional radio systems and with other impulse radio systems." Grisham, 12:1-8. A POSA would have understood the importance of ensuring that signals sent between the stationary unit and mobile unit were resistant to interference and, therefore, would have been further motivated to use Grisham's impulse radio units in Meyer's worker protection system. For example, a POSA would have appreciated that a railway environment is likely to feature a high prevalence of wireless signals, such as LTE, WiFi, and UHF/VHF communication channels being used by the train system and/or by the passengers on the train. Thus, by using Grisham's impulse radio units, a POSA would have been able to increase the reliability of Meyer's system by decreasing the likelihood that any signal between the stationary unit and mobile unit would be subject to interference.

96. Additionally, beyond making information transmission more reliable in the manner described above, a POSA would have been motivated to implement

Grisham's impulse radio units in Meyer's system to realize the benefits relating to positioning. Indeed, both Meyer and Grisham disclose systems in which alarms/alerts are generated based on a determination that there is a risk of collision between a moving train and one or more persons or objects in its path. In both systems, this determination is made at least in part based on information about the location of the train and the location of the one or more objects/persons. Thus, a POSA would have understood that either of these systems could be improved by improving the accuracy and reliability of its location-determination capability. In particular, as relevant here, a POSA would have understood that using Grisham's impulse radio units in Meyer's system would improve the accuracy and reliability of the train's location information that is used to determine the risk of collision. Accordingly, a POSA would have been further motivated to make this combination.

97. In Meyer's system, the stationary unit and mobile unit are each equipped with GNSS sensors to determine their respective positions. This position information may then be (i) included in the "travel information" sent from the stationary unit to the mobile unit and (ii) used by the mobile unit to determine whether the train is approaching and/or in the vicinity of the mobile unit.

98. However, a POSA would have recognized significant drawbacks and risks arising from the approach described in Meyer. For instance, a POSA would

have recognized that these GNSS sensors are only able to determine a device's location with relatively low precision, such as on the order of 5 meters.

Additionally, these GNSS sensors may not be able to function in areas with limited GNSS coverage, such as in tunnels, underground, or urban canyons.

99. In light of these drawbacks, a POSA would have been further motivated to incorporate Grisham's impulse radio units in Meyer's system not only for the transmission of data (or, information) between the stationary unit and mobile unit, but also to improve the system's ability to determine the location of each system component (i.e., train unit, wayside unit, and worker unit) relative to the other system components and, in turn, to assess the risk of collision between the train and the personnel on or near the track. Whereas GNSS sensors provide a device's location with relatively low precision, the impulse radio units described in Grisham are able to determine link distance between units to a "high degree of precision," in some cases with "centimeter distance resolution." Grisham, 15:38-42. Additionally, because impulse radio signals are resistant to interference and can be transmitted through the ground or other obstacles, using Grisham's impulse radio units in Meyer's worker protections system would not only make the system more accurate but also more reliable as compared to using GNSS sensors alone.

100. POSAs would have had a reasonable expectation of success in the above-described Meyer-Grisham combination because Grisham expressly teaches

that its impulse radio systems can be used in variety of proximity determination applications, including in railway or subway environments of the type contemplated in Meyer. *See* Grisham, 29:34-41, Fig. 23. In particular, Grisham describes a system in which “[e]ach of the vehicles, poles, people, etc.” in the system “have associated with them a UWB-enabled radio” and in which the UWB radios communicate with one another and, based on those communications, generate warnings, such as warnings relating to a “train approaching a railroad crossing.” Grisham, 29:34-41. These UWB devices may include a “UWB-enabled device that is carried on or by a person,” such as a “watch, phone, helmet or computing device.” Grisham, 27:40-44.

101. It would have required only ordinary skill for POSAs to utilize Grisham’s impulse radio units in Meyer’s system because the use of these impulse radio devices was commonplace at the time of the ’709 patent and because these impulse radios are small and easily configurable for worker-protection and proximity-detection applications, as evidenced by Grisham’s extensive disclosure.

102. Additionally, a POSA would have been further motivated to modify Meyer to include Grisham’s “control box” to, e.g., detect the presence of an approaching train.

103. In an example embodiment, Grisham discloses that its proximity detection system may also include a “control box” that “is located at a monitoring

location such as next to railroad tracks.” Grisham, 23:12-16. The control box “us[es] a sensor 1506 (e.g., electromagnetic sensor, motion detector, percussion sensor) to sense the presence of a third object (e.g., locomotive 1102).” Grisham, 23:14-16. When the sensor detects “a dangerous situation such as the presence of a locomotive,” an impulse radio associated with the sensor may “transmit” a signal that triggers a warning that the locomotive is approaching. *See* Grisham, 23:25-35.

104. A POSA would have been motivated to implement the Meyer-Grisham system by combining Grisham’s wayside “sensor” with Meyer’s wayside mobile unit. In the Cross-Grisham system described herein, Meyer’s stationary unit, mobile unit, and worker transponders would communicate wirelessly about the location/position of trains using Grisham’s impulse radio units. However, a POSA would have recognized the benefits of having an additional failsafe method to determine whether a train is approaching a warning area in which workers are present. Thus, a POSA would have been motivated to utilize Grisham’s wayside “sensor” to provide an additional layer of protection to ensure that the system would be able to detect an approaching train despite any malfunction in the UWB communication equipment. Thus, in the Meyer-Grisham system, a POSA would have included a sensor in the wayside mobile unit and would have used the sensor to determine whether a train is approaching and, if so, to generate a UWB signal to any nearby worker transponders to trigger an alert mode. This use of the wayside

sensors is consistent with their use in Grisham, where a UWB signal is generated based on the wayside sensor detecting that a train is approaching. *See* Grisham, 23:4-35.

105. A POSA would have had a reasonable expectation of success in implementing this modification of the Meyer-Grisham system, as the sensors of the type described in Grisham are conventional equipment and are small, low-powered, and highly adaptable devices that could be placed at any point on the train's track.

5. Independent Claim 1

a. 1[pre]: “A system for worker protection, the system comprises:”

106. If the preamble of claim 1 is a limitation of the claim, it is taught by Meyer-Grisham. Meyer discloses “a railway collision warning system to warn of a collision risk between the rail-bound vehicle and [] at least one person,” including “construction crews.” Meyer, Abs, ¶ 15.

107. Thus, Meyer-Grisham discloses a system for worker protection, as claimed.

b. 1[A]: “a train-mounted unit for use on a train”

108. Meyer's system includes a “stationary unit” that is “installed on a rail-bound vehicle.” Meyer, ¶17.

109. Thus, Meyer-Grisham discloses a train-mounted unit, as claimed.

- c. **1[B]: “wherein the train-mounted unit comprises: a communication component, comprising one or more antennas, configured to transmit and/or receive wireless signals”**

110. Meyer’s stationary unit includes a “transmission unit” and/or “has a connection to such a transmission unit.” Meyer, ¶17. The stationary unit uses this transmission unit to “transmit[] corresponding radio signals” to other components in the system. Meyer, ¶17. The stationary unit also includes a “receiving unit” for receiving a “return message” (i.e., responsive radio signals) from other components in the system. Meyer, ¶27.

111. In the combined Meyer-Grisham system, Meyer’s stationary unit would maintain a “transmission unit” and “receiving unit,” but these units would be implemented using Grisham’s impulse radio technology. To implement impulse radios in the Meyer-Grisham system, the transmission unit would include a “transmit antenna 624” to transmit an “emitted signal” by generating “propagating electromagnetic pulses.” Grisham, 17:25-40. Similarly, the receiving unit would include a “receive antenna 704 for receiving a propagated impulse radio signal 706.” Grisham, 17:46-47.

112. Thus, Meyer-Grisham’s stationary unit includes a communication component comprising antennas to transmit and/or receive wireless signals, as claimed.

d. 1[C]: “wherein the signals comprise ultra-wideband (UWB) signals”

113. In the combined Meyer-Grisham system, Meyer’s transmission unit and receiving unit would be implemented using Grisham’s impulse radio technology. In particular, Meyer’s stationary unit, mobile unit, and worker transponders would have each included an impulse radio of the type described in Grisham and would have used these impulse radios to send (transmit) and receive wireless UWB signals. These wireless UWB signals would have been used to communicate data of the type described in Meyer, such as information about the train’s location and movement.

114. Grisham’s impulse radio units “utilize impulse radio technology to effectively warn a person when there is a...locomotive in their vicinity.” Grisham, 2:27-31. Grisham states, and POSAs would have understood, that a system using impulse radios of the type disclosed is the same as an “ultra-wideband system, or ultra-wideband communication systems.” Grisham, 5:8-13. Accordingly, in Grisham’s “preferred embodiment, the emitted signal is wide-band or ultrawide-band.” Grisham, 17:34-35.

115. Therefore, in Cross-Grisham, the wireless signals transmitted and/or received by the VCU are UWB signals, as claimed.

- e. **1[D]: “and one or more circuits configured to process signals and data, and perform one or more applications or functions relating to operations of the train-mounted unit”**

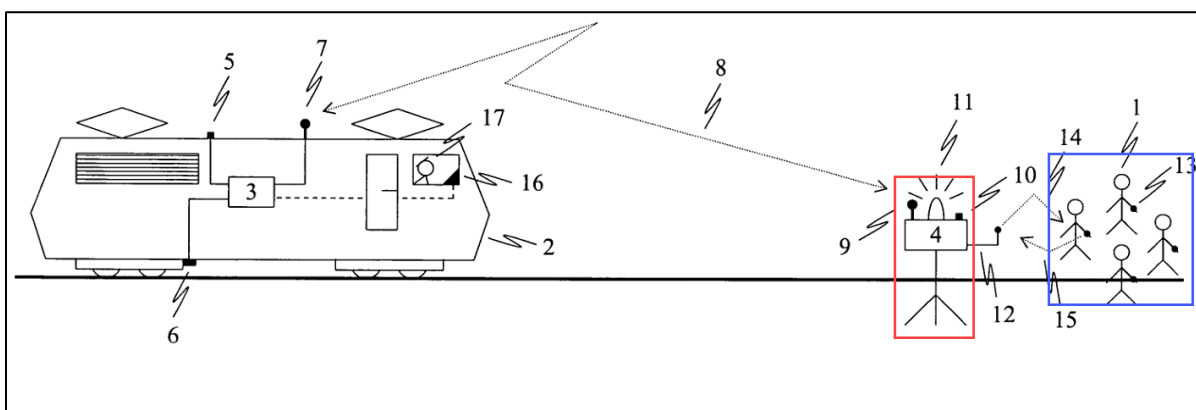
116. Meyer’s stationary unit may be “connected to the internal electronics of the rail-bound vehicle.” Meyer, ¶45. The stationary unit may also be capable of “continuously determin[ing] corresponding travel information of the rail-bound vehicle” and may be “connected to the corresponding data bus of the rail-bound vehicle such that the required travel information can be read.” Meyer, ¶17. Based on these (and other) determinations, the stationary unit may “automatically slow down the rail-based vehicle.” Meyer, ¶45. Thus, Meyer’s stationary unit is capable of processing signals and data and performing operations of the train-mounted unit.

117. A POSA would have understood that the conventional way to connect the stationary unit to the train’s internal electronics and to enable the unit to perform the above-described functions would have been to include, in the stationary unit, a computer with processing capabilities. A POSA would have further understood that any such computer/processor would utilize electronic circuits to perform these processing functions—specifically, by using the circuits to process signals and data. *See* EX1001, 1:63-2:4 (defining “circuit” as “physical electronic components,” *e.g.*, a “processor and memory,” and “software” associated with, executed by, or which configures those components).

118. Thus, a POSA would have understood Meyer-Grisham to disclose and/or render obvious the inclusion of circuits in the stationary unit to process signals or data and perform functions of the stationary unit, as claimed.

- f. **1[E]: “and wherein the train-mounted unit is configured to operate cooperatively with one or more wayside units, configured for placement on or near a track traversed by the train, to provide alerts to one or more workers operating on or near the track, based on communication of the UWB signals with at least one of the one or more wayside units.”**

119. As discussed, the Meyer-Grisham system would not only include Meyer’s train-mounted unit, but also Meyer’s “mobile unit,” which is “set up in the proximity of [a] track section and [a] construction crew.” Meyer, ¶35. Thus, the mobile unit is configured for placement on or near the train’s track, as claimed. In the figure below, I have annotated the mobile unit in red and the nearby construction crew in blue:



120. Additionally, the mobile unit includes a “receiving unit for receiving radio signals transmitted by the stationary unit.” Meyer, ¶18. In the Meyer-

Grisham combination, this receiving unit would be a receiving impulse radio unit, as described in Grisham. Accordingly, the mobile unit would receive UWB signals communicated by the stationary unit's corresponding transmitting impulse radio unit, as claimed.

121. In operation, the stationary unit and mobile unit operate cooperatively to provide alerts to the workers operating on or near the track (e.g., the construction crew annotated in blue in the figure above). In particular, as the train and the stationary unit “approaches the position of the mobile unit 4 or that of the personnel 1 to be warned, the radio signal 8 transmitted by the rail-bound vehicle 2 is received by the mobile unit 4.” Meyer, ¶39. The mobile unit then “determine[s] a collision risk” based on the received signal and, if a collision risk is identified, generates a warning signal for the nearby personnel. Meyer, ¶39. The mobile unit may generate a “warning signal,” such as a “light signal” that “can be perceived such that the personnel 1 becomes aware that a rail-bound vehicle 2 is approaching their position.” Meyer, ¶¶ 38-39. Or, the mobile unit may use its “near range transmission and receiving unit” to “transmit a near-range warning signal” to nearby “mobile transponder[s]” that are carried by or attached to the workers. Meyer, ¶¶40-41. The mobile transponders “can, for example, be worn on the wrist” of the workers and, based on receiving a near-range warning signal from the mobile unit, will generate an “acoustic, optical or haptic signal” to alert the

workers of the collision risk. Meyer, ¶¶40-41. In Meyer-Grisham, the radio signal transmitted from the stationary unit to the mobile unit is an ultra-wideband signal transmitted by Grisham's impulse radio unit.

122. Thus, Meyer-Grisham's stationary unit is configured to operate cooperatively with a mobile unit placed on or near the track to provide alerts to nearby workers based on the communication of UWB signal(s), as claimed.

6. Dependent Claims 2-5, 7, 10-16, and 19-20

a. Claim 2: "The system of claim 1, wherein the train-mounted unit is configured to broadcast alert triggering signals."

123. As discussed in connection with Claim 1, Meyer-Grisham's stationary unit transmits an impulse radio signal that is received by the wayside mobile unit and causes the activation of alert(s) to nearby workers. The mobile unit receives the signal from the stationary unit and generates a "warning signal . . . so that the personnel 1 can clear the hazard zone," Meyer, ¶39, either by directly causing the mobile unit to generate an alert or by causing the mobile unit to send a near-range warning signal that causes worker transponder(s) to generate alert(s). Accordingly, the impulse radio signal sent by the stationary unit is an alert-triggering signal, as claimed.

124. Meyer-Grisham's alert-triggering impulse radio signal is broadcast by the stationary unit, as claimed. The '709 patent does not provide a special

definition of broadcast. In the ordinary sense the patent uses the term, a POSA would understand “broadcast” in its ordinary sense to be the transmission of a signal to multiple devices simultaneously using a one-to-many model of transmission, rather than a one-to-one or targeted model of transmission. For example, the website www.freedictionary.com defines “broadcast” as “[t]o *communicate or transmit* (a signal, a message, or content, such as audio or video programming) *to numerous recipients simultaneously* over a communication network,” which in my opinion is consistent with the plain meaning of “broadcast” in the ’595 patent at the time of the alleged invention. (Emphasis added). Similarly, Newton's Telecom Dictionary (2013) defines broadcast as “[t]o send information to two or more received devices simultaneously....” EX1022, 227; *see also* EX1023, 54 (“to send a message to all recipients”); EX1024, 73 (“Sent to more than one recipient.”).

125. Consistent with this interpretation, Meyer expressly teaches that its stationary unit “transmits corresponding radio signals . . . using the broadcast method such that [the signal] can be received in a certain radius by the corresponding receiving units.” Meyer, ¶17. In the combined Meyer-Grisham system, the impulse radio units would have broadcast the impulse radio signals in the manner described in Meyer to ensure that the impulse radio signal would be received by any nearby mobile units, both known and unknown to the stationary

unit. Indeed, the conventional technique for a single transmitting device (like the stationary) to send wireless radio signals simultaneously to multiple receiving devices (e.g., multiple mobile units) was to “broadcast” the signal, i.e., transmit the data packet to a plurality of devices in the network simultaneously.

126. Corroborating my opinion that broadcasting was a well-known way to communicate with multiple devices at a time, EX1013 at [0003]-[0004] teaches as background information that “[b]roadcasting allows stations to transmit information to a large number of end devices efficiently” so that “all people within a broadcast area receive the broadcast signals.” As further corroboration of my opinion that a POSA had reason to broadcast Meyer’s radio signal, EX1017 at [0005] taught as background information that “[i]t may be desirable to efficiently send and receive broadcast alert messages” rather than “unicast messages sent to individual users.”

- b. Claim 3: “The system of claim 1, wherein the train-mounted unit is configured to generate data relating to alerts and/or to other devices or objects in a path of the train, based on the communication of the UWB signals with at least one of the one or more wayside units.”**

127. In Meyer-Grisham, the impulse radio units implemented as part of the stationary unit and mobile unit would enable these units to generate data relating to alerts or other devices or objects in the train’s path based on the exchange of UWB signals.

128. When implemented using Grisham's impulse radio technology, Meyer's stationary unit would be able to determine the distance between itself and another impulse radio unit, such as an impulse radio unit associated with the wayside mobile unit. Grisham, 20:55-65, 22:44-48, 24:24-28 (impulse radio unit is able to "determine the distance that the first object (e.g., first locomotive 1102) is from the second object"). Grisham touts the "revolutionary positioning capabilities of impulse radio technology," noting that impulse radio units can generate a "time position measurement" that "can be used by the [unit] to measure the propagation delay and determine the link distance between" a transmitting and a receiving impulse radio. Grisham, 25:16-45.

129. In Meyer-Grisham, the stationary unit, implemented with this impulse radio technology, would be able to determine the distance between it and the mobile unit using these "positioning capabilities." The determined distance would constitute data relating to the devices or objects in the path of the train based on the communication of the UWB signals. Thus, the Meyer-Grisham stationary unit is configured to generate such data, as claimed.

- c. **Claim 4: “The system of claim 1, wherein the train-mounted unit is configured to generate feedback information for outputting to an operator of the train, based on the communication of the UWB signals with at least one of the one or more wayside units.”**

130. In Meyer-Grisham, after an alert has been triggered at/by a wayside mobile unit, the mobile unit can transmit a “radio signal” to the stationary unit indicating “that the hazard zone is not yet clear of personnel.” Meyer, ¶44. Based on receiving this signal, the stationary unit can cause a “display unit 16 in the operator cab of the vehicle operator 17” to “display to the [operator] that there is an imminent collision risk with personnel.” Meyer, ¶44. The indication that there is an imminent risk of collision is feedback information for outputting to an operator of the train.

131. The stationary unit generates this feedback information based on the communication of UWB signals with the mobile unit. In the Meyer-Grisham system, the stationary unit and mobile unit include impulse radio units to send and receive radio signals, including alert-triggering signals sent by the stationary unit. Accordingly, the generation and display of feedback information is based on the communication of UWB signals between the stationary unit and the mobile unit insofar as the indication is displayed in response to the triggering of an alert at/by the mobile unit, which is itself triggered by the UWB signal communicated from the stationary unit to the mobile unit. Additionally, the generation and display of

feedback information is based on UWB communication insofar as it is based on the communication of a “radio signal” from the mobile unit to the stationary unit indicating “that the hazard zone is not yet clear of personnel.” Meyer, ¶44.

- d. Claim 5: “The system of claim 1, wherein the train-mounted unit is configured to: receive a signal indicating an acknowledgment of a safety alert by a worker of the one or more workers, in response to broadcasted alert triggering signals; and provide an indication of the acknowledgement to an operator of the train.”**

132. In Meyer-Grisham, the mobile unit sends a “near-range warning signal” to nearby worker transponders based on determining that there is a risk of collision presented by an approaching train. Meyer, ¶41. When these transponders receive the warning signal, the transponders generate an “acoustic, optical or haptic signal” to alert the workers of the collision risk. Meyer, ¶40-41. The workers are then able to press an “actuation button” on the transponders to acknowledge that the “warning signal was received by the mobile transponders.” Meyer, ¶42. When the actuation is pressed, a “near-range acknowledgment signal 15 is sent to the mobile unit 4.” Meyer, ¶42.

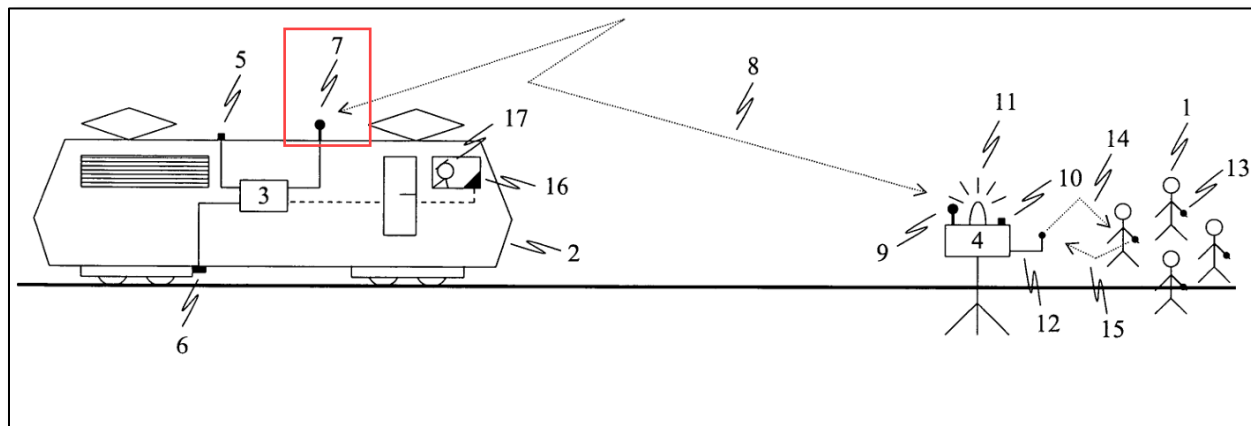
133. Based on the received acknowledgement signal(s), the mobile unit sends a “radio signal” to the stationary unit relating to the number of acknowledgments received by the nearby workers. Meyer, ¶44. This radio signal may “notify” the stationary unit that “the hazard zone is not yet clear of personnel”

if the number of acknowledgments received is “less than the predetermined number of personnel” working nearby. Meyer, ¶¶43-44. The stationary unit can then use the “display unit 16 in the operator cab of the vehicle operator 17 to display to the [operator] that there is an imminent collision risk with personnel.” Meyer, ¶44.

134. The signal received from the mobile unit is a signal indicating acknowledgement insofar as it indicates that some but not all of the nearby workers have acknowledged the warning signal. However, to the extent this signal is not the claimed signal indicating an acknowledgment, a POSA would have been motivated to include such information in the signal sent by the mobile unit to the stationary unit. For example, a POSA would have had reason to send a signal indicating that all of the nearby workers acknowledged receipt of the warning signal and/or a signal indicating the specific number of nearby workers that have acknowledged receipt. Either of these implementations would have been a routine and conventional approach to sending a signal from the mobile unit to the stationary unit relating to the number of acknowledgements received from nearby workers.

- e. **Claim 10: “The system of claim 1, wherein the train-mounted unit is arranged into a plurality of separate physical units that comprises at least a broadcast unit comprising at least the communication component, and wherein the broadcast unit is configured for deployment external to the train.”**

135. In Meyer-Grisham, the stationary unit comprises multiple units, including a broadcast unit configured for deployment external to the train. Meyer’s stationary unit includes and/or is operatively connected to multiple distinct components, including a “transmission unit” and a “travel detection unit.” Meyer, ¶¶ 35-36. The transmission unit is responsible for “transmit[ting] . . . radio signals . . . using the broadcast method.” Meyer, ¶¶ 17, 36. Meyer depicts the transmission unit being deployed external to the train, as shown in the figure below, in which I have annotated the transmission unit in red:



136. Additionally, a POSA would have had reason to configure the stationary unit’s antenna for attachment external to the vehicle, as claimed. In general, there would have been only two locations to mount the antenna: inside or

outside the vehicle. By 2015, it would have been conventional to a POSA to locate an antenna(s) on top of a vehicle because mounting antennas externally would have improved line-of-sight thereby reducing interference for wireless communications to and from the antenna.

137. My opinion that it would have been conventional (and beneficial) to mount the antenna on top of the vehicle is corroborated by EX1014, which discloses (at [0006]) that “[m]ounting an antenna **outside of the vehicle lessens interference...** and a roof-mounted outdoor antenna is less likely to receive reflected ghost signals” and “increases the amount of direct signal it [the antenna] can receive from a transmitter.” My opinion is further corroborated by EX1015 which discloses (at 1:30-42) that “the higher the mobile antenna is located on [a] vehicle, the better the useful communications range.”

- f. **Claim 7: “The system of claim 1, wherein the train-mounted unit comprises one or more input/output (I/O) components, for receiving input from an operator of the train and/or for providing output to the operator of the train.”**
- g. **Claim 11: “The system of claim 10, wherein the plurality of separate physical units comprises an operator unit comprising at least the one or more I/O components, and wherein the operator unit is configured for use by an operator of the train.”**

138. As I discussed in connection with Claim 5, Meyer-Grisham’s stationary unit includes and/or is operatively connected to a “display unit 16 in the

operator cab of the vehicle operator 17.” Meyer, ¶44, FIG. 2. This display unit provides output to the operator of the train, such as by providing an indication “that there is an imminent collision risk with personnel.” Meyer, ¶44.

139. Moreover, in the Meyer-Grisham combination, Meyer’s disclosure of a “display unit” associated with its stationary unit is consistent with Grisham’s disclosure of a “display” associated with its impulse radio units. In operation, this “display” can be used to output an alert of a potentially dangerous situation and can also receive inputs to “communicate with” another impulse radio unit in the system. Grisham, 25:4-19, 45-50. Additionally, the display can “show[],” (or, output) “information about [a] dangerous situation such as the direction, distance and/or speed of the oncoming ... locomotive.” Grisham, 25:16-19.

140. Thus, Meyer-Grisham discloses input/output components for providing output to the operator of the train, which are configured for use by an operator of the train, as claimed.

7. Independent Claim 12

a. 12[pre]: “A system for worker protection, the system comprises:”

141. As I discussed in connection with Claim 1[pre] (§ VII.A.5.a), Meyer-Grisham discloses a system for worker protection.

b. 12[A]: “one or more wayside units configured for placement on or near a track;”

142. As I discussed in connection with Claim 1[E] (§ VII.A.5.f), Meyer-Grisham discloses mobile units that are configured for placement on or near a track, as claimed.

c. 12[B]: “wherein each wayside unit comprises: a communication component, comprising one or more antennas, configured to transmit and/or receive wireless signals,”

143. Meyer-Grisham’s mobile unit includes a “receiving unit 9 to receive the radio signal 8 transmitted by the stationary unit 3 using the transmission unit 7 when the mobile unit 4 is located in the transmission radius of the rail-bound vehicle 2.” Meyer, ¶37. Additionally, the mobile unit includes a “near range transmission and receiving unit 12” that can “transmit a near-range warning signal 14 that can be received by the mobile transponders 13.” Meyer, ¶40-41. The receiving unit and near-range transmission and receiving unit are, individually and collectively, communications components configured to transmit and/or receive wireless signals.

144. Although Meyer does not expressly state that these communications components include one or more antennas, a POSA would have understood that the conventional way to transmit and receive these wireless signals would have been to use one or more antennas.

145. Additionally, in the Meyer-Grisham system, the mobile units would have been implemented using Grisham's impulse radio units, as described above. Thus, in this combination, Meyer's mobile unit would have included a "transmit antenna" to generate an "emitted signal" (Grisham, 17:26-36) and a "receive antenna 704 for receiving a propagated impulse radio signal" (Grisham, 17:46-47).

d. 12[C]: "wherein the signals comprise ultra-wideband (UWB) signals;"

146. In the combined Meyer-Grisham system described above (§§ VII.A.4, VII.A.5.d), the stationary unit, mobile unit, and worker transponder would each include an impulse radio unit of the type described in Grisham to send and receive data. Grisham states, and POSAs would have understood, that a system using impulse radios of the type disclosed is the same as an "ultra-wideband system, or ultra-wideband communication systems." Grisham, 5:8-13. Accordingly, in Grisham's "preferred embodiment, the emitted signal is wide-band or ultrawide-band." Grisham, 17:34-35.

147. Therefore, in the Meyer-Grisham combination, the wireless signals sent and received by the wayside priority detector would comprise ultra-wideband signals, as claimed.

- e. **12[D]: “and one or more circuits configured to process signals and data, and perform one or more applications or functions relating to operations of the wayside detection unit;”**

148. In Meyer-Grisham, the mobile unit determines whether there is a risk of collision between an approaching train and nearby workers based on “travel information” extracted from the radio signal received from the stationary unit. Meyer, ¶39. If it determines that there is a collision risk, it generates a “warning signal” and/or transmits a “near-range warning signal” to nearby “mobile transponders” associated with workers. Meyer, ¶39-41. Thus, the mobile unit processes signals and data and performs applications or functions relating to the operation of the mobile unit, as claimed.

149. A POSA would have understood that the conventional way to enable the mobile unit to perform the above-described functions would have been to include, in the mobile unit, a computer with processing capabilities. A POSA would have further understood that any such computer/processor would utilize electronic circuits to perform these processing functions—specifically, by using the circuits to process signals and data, as claimed.

150. Additionally, the Meyer-Grisham mobile unit would include Grisham’s impulse radio technology. An impulse radio unit includes, among other things, circuitry to generate an impulse radio signal, transmit and receive impulse radio signals. *See, e.g.,* Grisham, 17:1-18:35. In operation, the Meyer-Grisham

mobile unit includes an impulse radio unit, which sends and receives signals and data as part of its performance of applications or functions relating to operations of the mobile unit, as claimed.

151. Thus, a POSA would have understood Meyer-Grisham to disclose and/or render obvious the inclusion of circuits in the mobile unit to process signals or data and perform functions of the mobile unit, as claimed.

- f. **12[E]: “and wherein the one or more wayside units are configured to operate cooperatively with any train-mounted unit deployed on a train traversing the track, to provide alerts to one or more workers operating on or near the track, based on communication of the UWB signals between at least one of the one or more wayside units and the train-mounted unit.”**

152. In Meyer-Grisham, the stationary unit and mobile unit operate cooperatively to provide alerts to the workers operating on or near the track (e.g., the construction crew annotated in blue in the figure above). In particular, as the train and the stationary unit “approaches the position of the mobile unit 4 or that of the personnel 1 to be warned, the radio signal 8 transmitted by the rail-bound vehicle 2 is received by the mobile unit 4.” Meyer, ¶39. The mobile unit then “determine[s] a collision risk” based on the received signal and, if a collision risk is identified, generates a warning signal for the nearby personnel. Meyer, ¶39. The mobile unit may generate a “warning signal,” such as a “light signal” that “can be perceived such that the personnel 1 becomes aware that a rail-bound vehicle 2 is

approaching their position.” Meyer, ¶¶ 38-39. Or, the mobile unit may use its “near range transmission and receiving unit” to “transmit a near-range warning signal” to nearby “mobile transponder[s]” that are carried by or attached to the workers. Meyer, ¶¶40-41. The mobile transponders “can, for example, be worn on the wrist” of the workers and, based on receiving a near-range warning signal from the mobile unit, will generate an “acoustic, optical or haptic signal” to alert the workers of the collision risk. Meyer, ¶¶40-41. In Meyer-Grisham, the radio signal transmitted from the stationary unit to the mobile unit is an ultra-wideband signal transmitted by Grisham’s impulse radio unit.

153. Thus, Meyer-Grisham’s mobile unit is configured to operate cooperatively with the train-mounted stationary unit to provide alerts to nearby workers based on the communication of UWB signal(s), as claimed.

8. Dependent Claims 13-16 and 19

a. Claim 13: “The system of claim 12, wherein each wayside unit comprises a power supply for powering components of the wayside unit.”

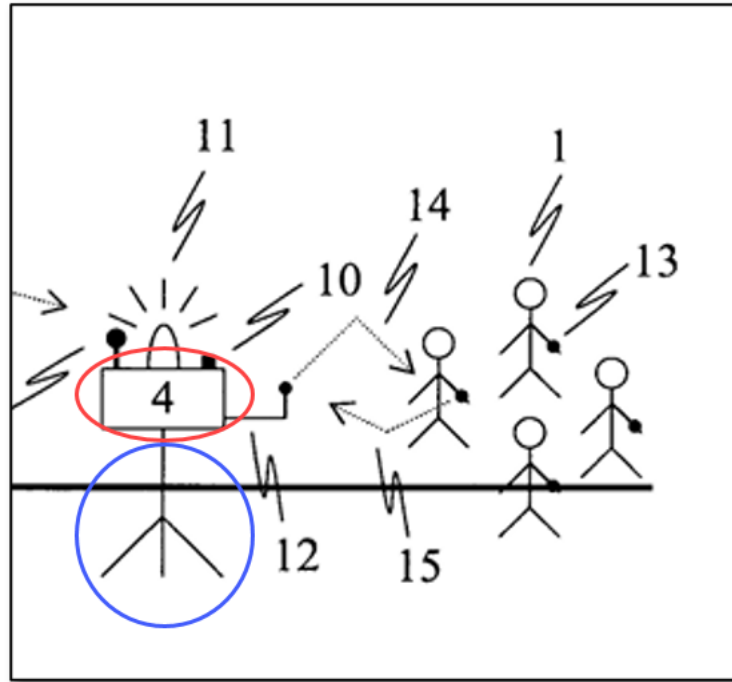
154. In Meyer-Grisham, the mobile unit “advantageously has an autonomous power supply.” Meyer, ¶18.

- b. **Claim 14: “The system of claim 12, wherein each wayside unit comprises a housing for enclosing components of the wayside unit.”**

Claim 15: “The system of claim 12, wherein each wayside unit comprises a support structure for holding and supporting the wayside unit when placed on or near the track.”

155. In Meyer-Grisham the mobile unit is “portable” and can, therefore, be “set up in the proximity of the track section and the construction crew such that any light and audio warnings from the mobile unit 4 can be perceived by the personnel 1 to be warned.” Meyer, ¶¶ 18, 35.

156. Meyer further discloses that the portable mobile unit includes a housing and a support structure, as claimed. In the annotated figure below, Meyer depicts the mobile unit, which includes a housing (red) atop a support structure (blue):



157. Additionally, beyond this disclosure in Meyer, a POSA would have understood that enclosing the electronic components of the mobile unit within a housing would have been a conventional design choice. If the electronics were not enclosed in any housing, they would be exposed to the natural elements, making damage highly likely, especially in the type of environment in which the Meyer-Grisham would have been implemented (e.g., underground subway). Providing a support structure to support the mobile unit would have been a conventional design choice for similar reasons. For instance, providing a support structure would avoid the mobile unit being placed on the ground, where the mobile unit would be more likely to experience damage from the natural elements (e.g., water, dirt, etc.) Additionally, Meyer discloses that the mobile unit may provide an alert to workers by activating a “light signal facility” (e.g., an “omni-directional light”) that “can be

perceived such that the personnel 1 becomes aware that a rail-bound vehicle 2 is approaching their position.” Meyer, ¶ 38. A POSA would have understood that such a light signal facility would more effectively alert nearby personnel if it were raised from the ground, as depicted in Meyer.

158. Thus, a POSA would have understood Meyer-Grisham to disclose and/or render obvious enclosing the mobile unit in a housing and supporting the mobile unit with a support structure, as claimed.

c. Claim 16: “The system of claim 12, wherein at least one wayside unit is configured to broadcast alert related signals, relating to the train when approaching the wayside unit.”

159. The ’709 patent does not provide a special definition of broadcast. In the ordinary sense the patent uses the term, a POSA would understand “broadcast” in its ordinary sense to be the transmission of a signal to multiple devices simultaneously using a one-to-many model of transmission, rather than a one-to-one or targeted model of transmission.

160. In Meyer-Grisham, when the mobile unit determines that there is a risk of collision caused by an approaching train, the mobile unit “transmit[s] a near-range warning signal 14 that can be received by [] mobile transponders 13” that are associated with (e.g., carried by or worn on) nearby workers. Meyer, ¶40-41. When the worker transponder receives this warning signal, it generates an “acoustic, optical, or haptic signal” “to warn the personnel 1 about an imminent

collision with a rail-bound vehicle.” Meyer, ¶41. The conventional technique for a single transmitting device (like the mobile unit) to send wireless data packets simultaneously to a “plurality” of receiving devices (like worker transponders) was to “broadcast” the signal, i.e., transmit the signal to a plurality of devices simultaneously.

161. Indeed, Meyer discloses that its stationary unit “transmits corresponding radio signals . . . using the broadcast method such that [the signal] can be received in a certain radius by the corresponding receiving units.” Meyer, ¶17. A POSA would have recognized the benefit of implementing the mobile unit in the same manner as the stationary unit because both devices are sending signals to all companion devices in wireless communication range.

162. Corroborating my opinion that broadcasting was a well-known way to communicate with multiple devices at a time, EX1013 at [0003]-[0004] teaches as background information that “[b]roadcasting allows stations to transmit information to a large number of end devices efficiently” so that “all people within a broadcast area receive the broadcast signals.” As further corroboration of my opinion that a POSA had reason to broadcast Meyer’s radio signal, EX1017 at [0005] taught as background information that “[i]t may be desirable to efficiently send and receive broadcast alert messages” rather than “unicast messages sent to individual users.”

- d. **Claim 19: “The system of claim 12, wherein at least one wayside unit comprises one or more sensory components, for detecting, monitoring, and/or tracking trains, and wherein the at least one wayside unit configured to determine, based on sensory data obtained from the one or more sensors, when the train is approaching the wayside unit.”**

163. As discussed above (§ VII.A.4), the Meyer-Grisham system would not only utilize Grisham’s impulse radio units for wireless communication between Meyer’s stationary unit, mobile unit, and worker transponders, but would also utilize Grisham’s wayside “sensor” in conjunction with Meyer’s mobile unit to detect an approaching train.

164. In this combined system, the wayside priority detector would therefore use a “sensor 1506 (e.g., electromagnetic sensor, motion detector, percussion sensor) to sense the presence of a[n] object,” as taught in Grisham. Grisham, 23:14-16. In particular, the sensor would detect when a train/vehicle is approaching the mobile unit; when detected, an impulse radio associated with the mobile unit would then “transmit” a signal to any worker transponders in the area around the priority detector, which would cause the worker transponders to generate an alarm signal, as taught in Meyer. *See* Grisham, 23:25-35.

165. Thus, in the Meyer-Grisham system, the mobile unit (a “wayside unit”) would include a sensor (“sensory components”) that would detect (i.e.,

“determine”) that a train is approaching the mobile unit based on the sensor inputs, as claimed.

9. Independent Claim 20

a. 20[pre]: “A system for protecting workers near railroad tracks, comprising:”

166. If the preamble of claim 20 is a limitation of the claim, it is taught by Meyer-Grisham. Meyer discloses “a railway collision warning system to warn of a collision risk between the rail-bound vehicle and [] at least one person,” including “construction crews.” Meyer, Abs, ¶ 15.

167. Thus, Meyer-Grisham discloses a for protecting workers near railroad tracks, as claimed.

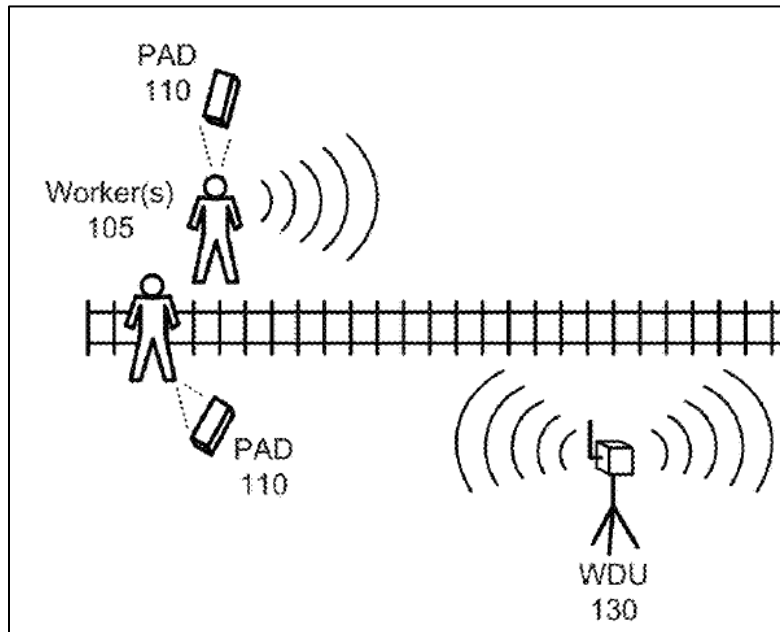
b. 20[A]: “one or more UWB radios at pre-determined locations along the railroad tracks;”

168. The ’709 patent does not provide a special definition of pre-determined locations. In the ordinary sense the patent uses the term, a POSA would understand a “pre-determined” location to be a location determined at some point prior to operation of the device/system. Thus, although a pre-determined location could be a fixed, unchanging location, it could also be a location set prior to operation but subject to change at various times between operation depending on the specific circumstances of operation.

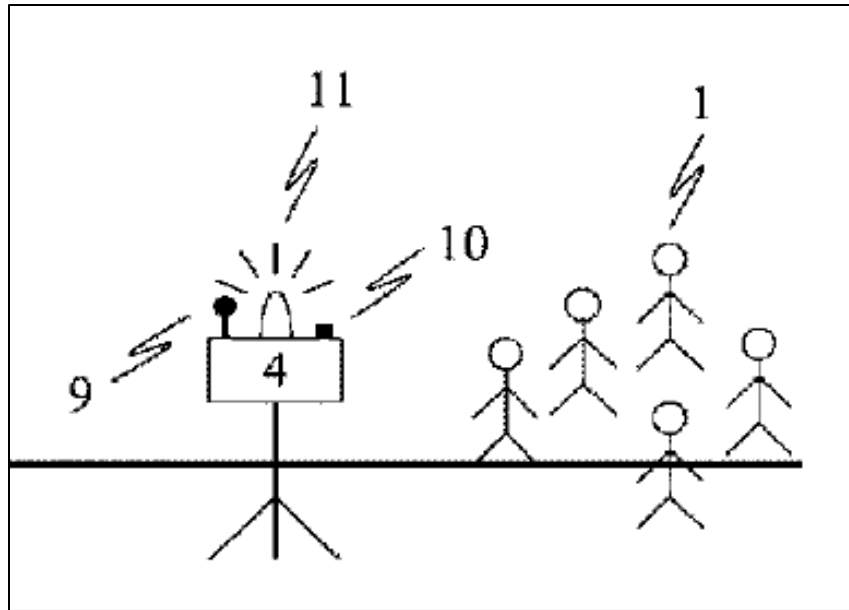
169. This interpretation finds support in the ’709 patent, which teaches that its WDU “may be attached to placement component (e.g., a tripod)” and may be

“temporarily placed near the track...at or in advance of each end of a work zone.”

EX1001, 3:59-66. Indeed, the '709 patent depicts its WDU having such a tripod structure and demonstrating that the WDU can be temporarily placed at a predetermined location in which workers will be present for a period of time:



170. Consistent with this interpretation, Meyer-Grisham’s mobile units are located at pre-determined locations along the railroad tracks. The mobile unit is “set up in the proximity of the personnel.” Meyer, ¶37. Thus, the mobile unit is placed at a predetermined location in which the personnel will be working during a period of time, with the mobile unit remaining in that location during operation. Like the '709 patent, Meyer depicts its mobile unit having a support structure that allows the mobile unit to be temporarily placed at a predetermined location in which workers will be present for a period of time:



171. Even if Claim 20's use of "pre-determined location" were interpreted to require placement at a fixed, unchanging location, Meyer-Grisham would still disclose this claim element because Grisham discloses such placement and a POSA would have recognized the possibility (and potentially benefits) of implementing the Meyer-Grisham in this manner. Grisham discloses an impulse radio unit that is attached to "an active railroad pole" placed on or near the track. Grisham, 21:15-23. A POSA would have recognized that in certain areas of the track, it may be beneficial to implement the Meyer-Grisham system using a permanent, fixed wayside device, such as high-traffic areas in which workers or other persons are commonly working or present. In such a circumstance, placement of a permanent wayside device would provide constant protection to on- and near-track personnel, thus reducing what would otherwise be a high risk of collision at the high-traffic

area. *See Cross*, [049] (corroborating my opinion that placement of devices at high-traffic areas would be obvious to reduce heightened risk of collision in those areas).

172. Thus, Meyer-Grisham teaches placing radio communication devices at pre-determined locations along the railroad track, as claimed.

173. Additionally, in Meyer-Grisham, each of the stationary unit, mobile unit, and worker transponder would be implemented using Grisham's impulse radio units to send and receive impulse radio signals. As discussed (§ VII.A.4), these impulse radio signals are ultra-wideband signals, and these impulse radio units are therefore ultra-wideband radios, as claimed.

c. 20[B]: “one or more worker UWB radios associated with one or more workers on or near the railroad tracks;”

174. Meyer-Grisham's worker transponders are “arranged on or attached to the personnel to be warned.” Meyer, ¶23. These “personnel” include “construction crew performing work on the track section.” Meyer, ¶35. And the worker transponders can receive “near-range warning signal[s],” such as those transmitted by a trackside mobile unit. Meyer, ¶41. Thus, Meyer-Grisham discloses radio communication devices that are associated with workers on or near the railroad tracks.

175. Additionally, in Meyer-Grisham, these worker transponders would send and receive impulse radio (or, ultra-wideband) signals to and from other components in the system. § VII.A.4. In particular, the Meyer-Grisham system would implement worker-associated UWB radio devices such as those described in Grisham, which discloses a “UWB-enabled device that is carried on or by a person,” such as a “watch, phone, helmet or computing device.” Grisham, 27:40-44. Accordingly, the Meyer-Grisham worker transponders are UWB radios, as claimed.

d. 20[C]: “a vehicle UWB radio associated with a vehicle on the railroad track;”

176. Meyer-Grisham’s stationary unit is “arranged on [a] railbound vehicle” (e.g., a train). Meyer, ¶¶16-17, 35. The stationary unit includes or is associated with a “transmission unit” that broadcasts a radio signal received by other system components. Meyer, ¶¶36-39. Thus, Meyer-Grisham discloses a radio communications device associated with a vehicle on the railroad track, as claimed.

177. Additionally, in Meyer-Grisham, these train-based devices would send and receive impulse radio (or, ultra-wideband) signals to and from other components in the system. § VII.A.4. In particular, the Meyer-Grisham system would implement worker-associated UWB radio devices such as those described in Grisham, which discloses a “transmitting impulse radio unit” is “coupled ... to” a “locomotive” and transmits an “impulse radio signal 910 ... towards the receiving

impulse radio unit 904,” which is “attached to the second object.” Grisham, 21:15-35. Accordingly, the Meyer-Grisham stationary units are UWB radios, as claimed.

e. 20[D]: “wherein: the vehicle UWB radio is in communication with a processor,”

178. Meyer-Grisham’s stationary unit is “connected to the internal electronics of the rail-bound vehicle” and is “equipped to automatically slow down the rail-based vehicle” to prevent a risk of collision with on- or near-track personnel. Meyer, ¶45. In Meyer-Grisham, the stationary unit would further include an impulse radio unit, which includes a “controller” that is able to “measure the propagation delay and determine the link distance between the receiving impulse radio unit 904 and the transmitting impulse radio unit 902.” Grisham, 22:41-23:3, 24:21-49, 25:45-50.

179. A POSA would have understood that the conventional way to connect the stationary unit to the train’s internal electronics and to enable the unit’s controller to perform the above-described functions would have been to include, in the stationary unit, a computer with processing capabilities.

180. Thus, a POSA would have understood Meyer-Grisham to disclose and/or render obvious to put the stationary unit in communication with a processor, as claimed.

- f. **20[E]: “wherein: the processor determines a position of the vehicle based on time of flight measurements obtained based on communication between the vehicle UWB radio and at least one of the one or more UWB radios that are located at pre-determined locations;”**
- 20[F]: “the processor determines a location in which the one or more workers are working based on time of flight information obtained based on communication with at least one of the one or more worker UWB radios;”**

181. In operation, Meyer-Grisham’s stationary unit sends wireless signals to other system components, such as the wayside mobile unit, which, as discussed (§§ VII.A.4, VII.A.9.b), is a device located at a pre-determined location. *See* Meyer, ¶¶ 36-39 (stationary unit’s “transmission unit” broadcasts a radio signal that is received by the mobile unit’s “receiving unit”). Meyer-Grisham’s stationary unit also receives wireless communications from other system components, including the wayside mobile unit. Meyer, ¶44 (mobile unit “transmit[s] a radio signal to the rail-bound vehicle 2 to notify the latter that the hazard zone is not yet clear of personnel 1”). Thus, Meyer-Grisham discloses communication between the vehicle unit and units at pre-determined locations, as claimed.

182. Moreover, as discussed, the Meyer-Grisham combination utilizes Grisham’s impulse radio communication technology (i.e., UWB radio communications) to perform wireless communication between system components.

Thus, Meyer-Grisham discloses UWB communication between a vehicle UWB radio and a UWB radio at a pre-determined location, as claimed.

183. In addition to using Grisham's impulse radio technology to send and receive wireless signals, a POSA would have implemented Grisham's impulse radio technology in the Meyer-Grisham system to utilize the "positioning capabilities of impulse radio technology." Grisham, 25:16-45. Thus, in operation, each of the impulse radio units implemented in the Meyer-Grisham system would process signals that "can be used by the controller" "to measure the propagation delay and determine the link distance between" the impulse radios. Grisham, 22:64-67, 24:44-47, 25:16-45.

184. Using Grisham's impulse radio units to measure propagation delay and determine the link distance between impulse radios in the manner described in Grisham would have constituted using time of flight information to determine the position/location of the respective impulse radio units, as claimed. Specifically, a POSA would have understood that the "propagation delay" of a wireless signal is the same as the "time of flight" of that signal and, therefore, would have understood that determining link distance based on propagation delay is the same as determining the distance between impulse radios based on time of flight information.

185. My opinion that Grisham discloses time-of-flight determinations is corroborated by Grisham's incorporation by reference of U.S. Patent No. 6,133,876 to Fullerton et al. ("Fullerton"), which issued on October 17, 2000 and is titled "System and Method for Position Determination by Impulse Radio." Grisham, 15:40-48. Fullerton provides further description of how impulse radio systems can determine the distance between transceivers, expressly describing these determinations as "time of flight measurements." *See* EX1011, 4:11-38. Like Grisham, Fullerton's system "utilizes ultra-wideband signals," thus providing a "relatively fast response time." EX1011, 3:4-6.

186. Thus, Meyer-Grisham discloses the use of time of flight measurements obtained based on communication between UWB radios in the worker protection system, as claimed.

187. Moreover, in the Meyer-Grisham system, these time of flight measurements would have been used to determine the position of the vehicle and the location of the workers, as claimed. Meyer's stationary unit includes a "travel detection unit 6 to determine the current travel information and the position of the rail-bound vehicle, the vehicle speed, the current direction of travel, and the track occupied by the rail-bound vehicle 2." (36). Similarly, the mobile unit includes components to "autonomously determine the current position of the mobile unit 4." (37). Although Meyer discloses that these components of the stationary unit and

mobile unit use “GNSS satellite signals” to determine to their respective locations, a POSA would have recognized the benefits of using Grisham’s impulse radio units either to replace or supplement the GNSS positioning information.

188. Specifically, a POSA would have used the impulse radio units to measure propagation delay and determine link distance between the stationary unit and the wayside mobile unit. Using Grisham’s impulse radio units in this manner would have enabled Meyer’s stationary unit to determine additional “travel information” that could be shared with the wayside mobile unit to improve the mobile unit’s ability to determine a risk of collision. For example, Meyer’s mobile unit uses its own GNSS-based position and the received GNSS-based train position to “compare” the respective locations and determine a collision risk. A POSA would have understood that using the impulse radio signals to determine link distance between the radio units would have been an equally feasible method to obtain the same information—that is, the position of the two units relative to one another.

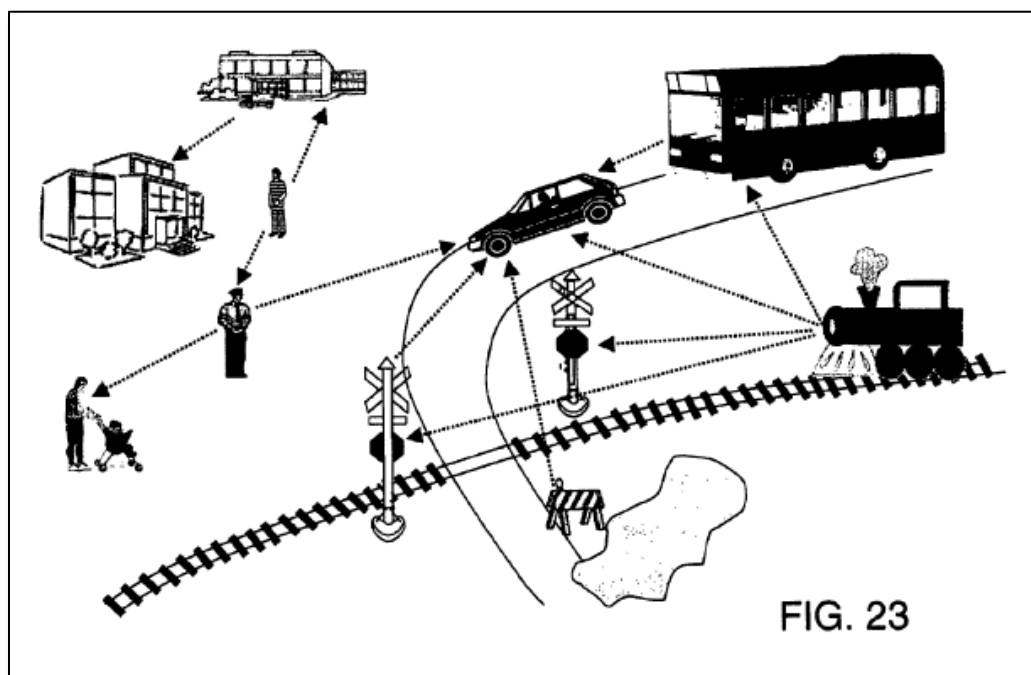
189. Moreover, a POSA would have recognized that using the impulse radios to determine link distance would have presented advantages as compared to using the GNSS signals for location information. For instance, as discussed (§ VII.A.4), Grisham’s impulse radio units are able to determine link distance between units to a “high degree of precision,” in some cases with “centimeter

distance resolution.” Grisham, 15:38-42. Additionally, because impulse radio signals are resistant to interference and can be transmitted through the ground or other obstacles, using Grisham’s impulse radio units in Meyer’s worker protections system would not only make the system more accurate but also more reliable as compared to using GNSS sensors alone.

190. A POSA would have been further motivated to implement Meyer-Grisham in this manner by Grisham’s disclosure, which describes a highly similar implementation. Grisham describes systems in which the impulse radio units determine the distance between a train-mounted unit and other units (e.g., wayside units) and use this information to determine whether an approaching train creates a potentially dangerous situation. Grisham, 20:52-21:14; 22:41-23:3; 24:21-49; 25:16-45. From this disclosure, a POSA would have understood that any impulse radio unit—whether coupled to the locomotive or associated with another component in the system—could use a received impulse radio signal to determine the link distance between the sending and receiving radio unit. Grisham, 25:45-50 (teaching that transmitting and receiving impulse radio units can contain the “same equipment”).

191. Accordingly, a POSA would have implemented Meyer-Grisham to not only enable determination of distance between the stationary unit and mobile unit, but also to use the same functionality to determine the distance between the

stationary unit and worker-based transponder(s). Although Meyer does not expressly describe direct train-to-worker communications, Grisham teaches that its impulse radio units can be implemented in a scalable worker protection system in which impulse radio units are associated with a number of different persons/objects and in which the units communicate with multiple components in the system. Grisham also expressly teaches that this system can include a “UWB-enabled device that is carried on or by a person,” such as a “watch, phone, helmet or computing device.” Grisham, 27:40-44. One such scalable system is depicted in Figure 23(below):



192. A POSA would have viewed this description in Grisham as suggesting that Meyer-Grisham could be implemented using the impulse radio units to communicate between each of the system components (i.e., stationary unit, mobile

unit, worker transponder). Beyond Grisham's suggestion to use its impulse radio units in this way, a POSA would have independently recognized the benefits of such an implementation. For instance, a POSA would have appreciated that enabling the stationary unit to determine its position relative to both the wayside mobile unit and the worker-carried mobile transponders would provide the train operator with multiple sources of information that would be relevant to determining whether there is a risk of a collision and, if so, what steps need to be taken (e.g., braking the train) to avoid such a collision.

193. Additionally, A POSA would have understood that implementing Meyer-Grisham to allow for communications—and a distance determination—between the stationary unit and worker transponder(s) would have advanced the overall system goal of worker protection. A POSA would have appreciated that there may be some scenarios in which it would be more beneficial for the train operator to know the location of the workers than the distance to the wayside unit, such as when a worker is working on a section of the track that is closer to the approaching train than the wayside unit. Additionally, there may be other scenarios in which it would be more beneficial for the train operator to know the distance to the wayside unit than the location of the workers, such as when workers are present on a section of the track that is further from the approaching train than the wayside unit, but in which the workers' equipment, a work vehicle, or some other worker-

related obstacle is present near the wayside unit. In each of these scenarios, determining the location of the worker transponders relative to the train would provide improved worker protection as compared to only determining the location of the train relative to a wayside unit.

194. The '709 patent does not provide a special definition of "location" or "position." In the ordinary sense the patent uses the term, a POSA would understand position and location of an object/person in its ordinary sense to encompass either the absolute position/location of the object/person or the position/location of that object/person relative to some other object/person. In the Meyer-Grisham implementation described above, the stationary unit would use the propagation delay between the stationary unit, mobile unit, and worker transponders to determine, among other things, the distance between the stationary unit and each other system component within radio transmission range. The distance between the stationary unit and mobile unit reflects the position of the train relative to the wayside mobile unit. Similarly, the distance between the stationary unit and a worker transponder reflects the location of that worker transponder relative to the train. Accordingly, Meyer-Grisham determines the position of the vehicle and the location of workers based on the impulse radio communications between the respective devices, as claimed.

195. Additionally, even if the '709 patent were interpreted to require a determination of the absolute location of the train and/or the worker transponders, a POSA would have appreciated that such a determination would be possible using the GNSS sensor data already available to the train and to the mobile unit. For instance, Meyer discloses that each of the stationary unit and mobile unit can use GNSS data to determine its position. A POSA would understand this GNSS-based position to be an absolute position of the mobile unit. A POSA would further understand that an absolute position of the stationary unit and/or worker transponders could be determined using the GNSS-based position of the mobile unit (as disclosed in Meyer), the UWB-based link distance determination (as disclosed in Grisham), and a directional (or, "direction finding") antenna (as disclosed in Grisham/Fullerton). *See* Meyer, ¶ 37; Grisham, 15:27-56; EX1011, 11:20-12:23. For example, Fullerton teaches that the "position (x2, y2) of [an] object" can be determined using the "distance" of the object from a first impulse radio at a known location and using the "angular direction" of the first impulse radio relative to the object. EX1011, 11:20-12:23.

196. Thus, applying these techniques, Meyer-Grisham's stationary unit could use the GNSS-based position of the mobile unit with the UWB-based link distance between the stationary unit and mobile unit and the angular direction of the mobile unit relative to the stationary unit to determine the absolute position of

the stationary unit. Similarly, the stationary unit could use the GNSS-based position of the stationary unit with the UWB-based link distance between the stationary unit and worker transponder and the angular direction of the worker transponder unit relative to the stationary unit to determine the absolute position of the worker transponder. Accordingly, Meyer-Grisham determines the position of the vehicle and the location of workers based on the impulse radio communications between the respective devices even under a more narrow interpretation of these limitations.

g. 20[G]: “and the processor generates an alert to an operator of the vehicle based on the determined location of the one or more workers;”

197. Meyer-Grisham’s stationary unit is “connected to a display unit 16 in the operator cab of the vehicle operator 17 to display to the latter that there is an imminent collision risk with personnel.” Meyer, ¶44.

198. A POSA would have implemented Meyer-Grisham to determine a risk of collision with personnel based at least in part on determinations of the link distance between the stationary unit and the worker transponders, each of which is an impulse radio unit as described in Grisham. Accordingly, if the stationary unit were to detect an “imminent collision risk with personnel” based on the determined distance between the stationary unit and worker transponders, the “display unit” would alert the operator to this risk, as described in Meyer. This implementation is

consistent with Grisham, which discloses that impulse radio units can be “incorporated within or coupled to an after-market display,” which provide “information about the potentially dangerous situation,” such as the “distance that the first object (e.g., locomotive 1102) is from the second object.” Grisham, 22:24-45; 24:4-25.

- h. 20[H]: “and at least one worker UWB radio communicates time of flight information between the at least one worker UWB radio and the vehicle UWB radio to a processor in communication with the at least one worker UWB radio,”**

199. Meyer-Grisham’s impulse radios include a “controller” that can be used to “determine the distance that the first object (e.g., locomotive 1102) is from the second object.” Grisham, 20:55-59, 22:44-48; 24:24-28. The controller determines the distance between these objects (or, more accurately, between the impulse radio units associated with these objects) by “measur[ing] the propagation delay and determin[ing] the link distance between” the impulse radio units. Grisham, 24:44-47.

200. A POSA would have understood that the conventional way to send and receive these signals and to enable the unit’s controller to perform the above-described functions would have been to include, in each respective impulse radio unit, a computer with processing capabilities.

201. Thus, a POSA would have understood Meyer-Grisham to disclose and/or render obvious a processor in communication with each worker transponder impulse radio, as claimed.

202. Moreover, a POSA would implement Meyer-Grisham to enable each UWB radio in the system (i.e., stationary unit, mobile unit, and worker transponder) to receive a UWB signal from any other system component, determine the “propagation delay” of that signal, and use that information to determine the distance between itself and the other system component. This implementation is consistent with and supported by Grisham’s teaching that the display associated with an impulse radio is “capable of showing...information about the dangerous situation such as the direction, distance and/or speed of the oncoming locomotive.” Grisham, 22:41-44; 24:21-24. Furthermore, a POSA would have recognized that enabling the worker transponder impulse radio unit to determine the link distance to other system components—in particular, between itself and the stationary unit—would improve the Meyer-Grisham system. Specifically, it would make the system more robust to the failure of any one system component by enabling multiple components to determine the distance between the train and the worker(s). Thus, even if the operator of the train were unable to take responsive action to prevent a collision with workers on or near the track (e.g., by braking the train), the workers themselves would be aware of the collision risk and

would be enabled to take any necessary steps to reduce or eliminate the risk of harm (e.g., by leaving the track).

203. Accordingly, a POSA would have understood Meyer-Grisham to disclose and/or render obvious communicating time of flight information to a processor associated with the worker transponder, as claimed.

- i. **20[I]: “wherein the processor generates alerts to a worker associated with the at least one worker UWB radio based on one or more of: a determined distance to the vehicle UWB radio, an estimated time of closest approach of the vehicle UWB radio to a location of the at least one worker UWB radio, and an approach speed of the vehicle UWB radio.”**

204. Meyer-Grisham’s worker transponders are configured to generate alerts to workers when it is determined that there is a risk of collision. Meyer, ¶41. Additionally, as discussed in connection with Claim 20[H] (§ VII.A.9.h), a POSA would have implemented Meyer-Grisham by enabling the worker transponders to determine/receive the propagation delay between stationary unit and worker transponder and to use this information to determine the distance between the worker and an oncoming train. Thus, as Meyer discloses, the transponders would be able to generate an alert to workers if this determination indicated a risk of collision. Meyer, ¶40-41. This implementation is consistent with Grisham, which discloses that an alert may be generated by a receiving UWB radio when the

distance between radios falls below a “predetermined distance.” *See* Grisham, 2:35-41, Claim 2.

205. Thus, a POSA would have understood Meyer-Grisham to disclose and/or render obvious using the worker transponder’s processor to generate an alert to the worker based a determination of the distance to the stationary unit, as claimed.

B. Ground 2: Claims 1-4, 6-12, and 17-19 Would Have Been Obvious over Cross in view of Grisham

1. Overview of Ground 2

206. For the reasons I discuss below in §§ VII.B.2-7, it is my opinion that claims 1-4, 6-12, and 17-19 would have been obvious over Cross (EX1010) in view of Grisham.

2. Cross (EX1010): PCT Application Publication No. WO 2013/056244 A1

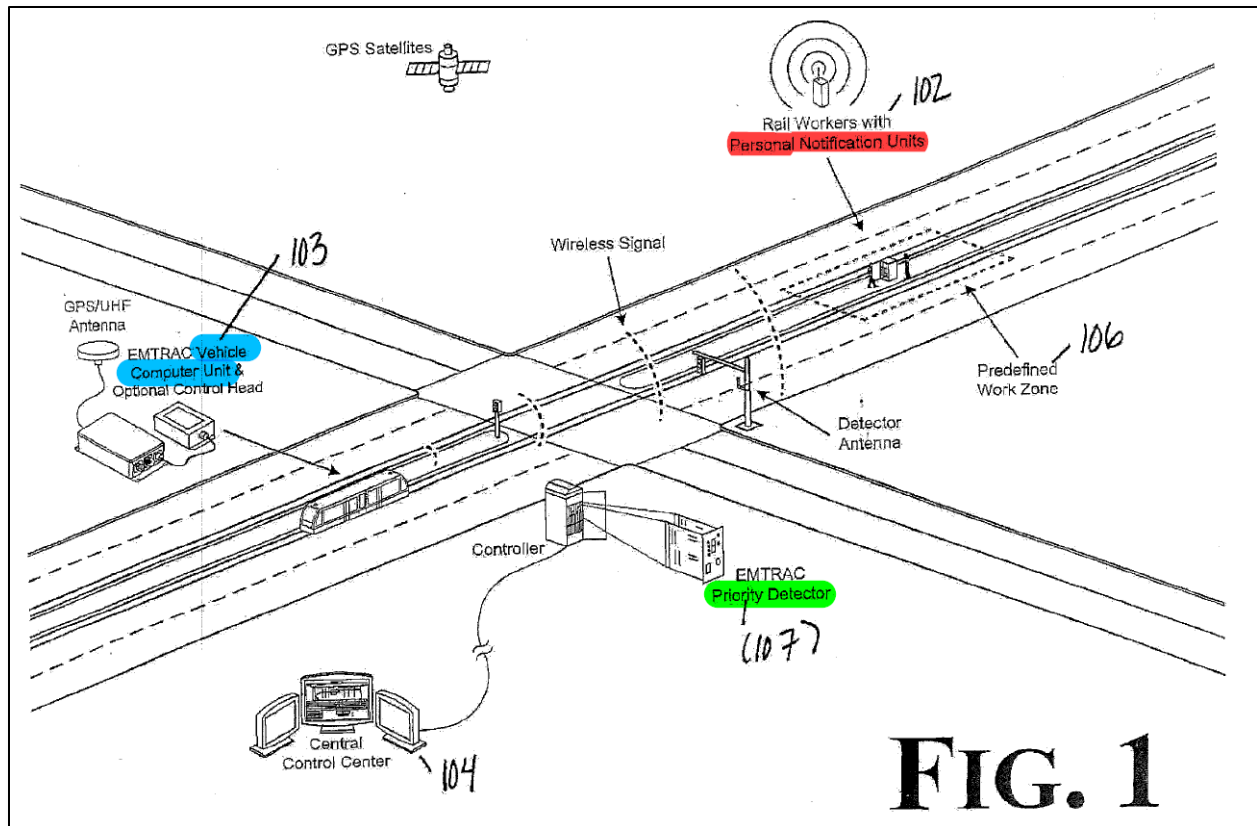
207. According to the face of the document, Cross is an international application published under the patent cooperation treaty (PCT) that published on April 18, 2013 (code (43)), titled “Mass Transit Safety Notification System and Device” (code (54)). Because Cross was published in 2013, I understand that Cross qualifies as prior art even if the challenged claims were entitled to the March 23, 2015 filing date of Provisional Application No. 62/177,683 (*see* ’709 patent, code (60)). I understand that Cross was not cited during prosecution of the ’709 patent. *See* ’709 patent, code (56) (references cited).

208. Like the '709 patent, Cross discloses “a safety notification system and device” for workers in a mass transit system. Cross, Abstract-[001] – Cross-Summary, [026].¹ In Cross’s system, maintenance worker are warned of approaching trains and train-operators are warned of nearby workers. Cross’s “safety notification system and device (101)” can also be “integrated into existing systems known to those of ordinary skill in the art which monitor and control the operation of the mass transit systems.” Cross, [026]. “[A]pplicable mass transit system include, but are not limited to, rapid transit,... subway..., metropolitan railway, light rail,... dedicated bus and trains” (all referred to as “trains” in Cross for simplicity). Cross, [026]. The functionality of Cross’s safety system generally includes “1) alert[ing] mass transit, train, and road maintenance workers of an approaching mass transit vehicle; 2) alert[ing] train and mass transit vehicle operators when they are approaching an area where workers are located; and 3) inform[ing] administrators of the location of vehicles and workers within a traffic grid in real-time, among other safety functions ... for workers.” Cross-Summary, [001].

¹ I note that the paragraphs that are in the first two sections of Cross – Cross Reference to Related Application(s) and Background of the Invention – are numbered paragraphs [001] to [005] and then Cross’s Summary of the Invention Section restarts the paragraph numbering to [001]. That is, Cross’s “Background” (pp. 1-2) and “Summary of the Invention” (pp. 3-7) each include paragraphs [001]-[005]. To avoid confusion, I have included either “Background” or “Summary” to paragraph [001]-[005] citations, e.g., [001]-Background or [001]-Summary.

209. Cross’s Figure 1 (below) illustrates “a perspective view of a diagram of the rail-maintenance safety notification system and device (101) in use with warning zones.” Cross, [021]. Like the system of the ’709 patent, Cross’s system relies on three companion devices: (1) “worker equipment unit, also known as the personal notification unit (PNU) (102)” (Cross, [029]); (2) “at least one mass transit equipment unit, also known as the vehicle computer unit (VCU) (103)” (Cross, [029]); and (3) “a plurality of priority detectors (107),” which “are wayside devices” (Cross, [049]).

210. Figure 1 (which I have annotated below) depicts an exemplary implementation of Cross’s system with all three companion devices in Cross’s system – (1) a PNU; (2) a VCU; and (3) a wayside priority detector:



211. The PNUs and VCU's "are comprised of at least a receiver, a transmitter, a computer and a navigation system" (e.g., GPS). Cross, [031]. In operation, the PNUs and VCU's are "consistently sending and receiving location-based packaged data over the network." Cross, [030]; *see also* Cross, [029] (noting that the disclosed devices are "communicatively attached to each other over a network"). "Based upon this exchanged location-based data" and other information (e.g., "route and bearing" of "vehicles in the grid" and/or the location of vehicles or PNUs "relative to a designated warning area or route"), an alert mode is triggered by the PNUs, the VCU's, or the "central control server." Cross, [030]. For example, when "an alert mode is triggered" by one or more devices, an

“alert signal[] will be set off” to “notify a worker equipped with a PNU (102), a vehicle operator, or an administrator of a potentially dangerous interaction between an equipped worker and a vehicle.” Cross, [030].

212. The PNU is “a simple hardware device” that attaches to a worker using “[a] clip.” Cross, [045]. “The PNU (102) is generally a small, portable device capable of receiving GPS and transmitting its location data and storing detailed activity and alert logs, among other functions.” Cross, [041]. Cross’s Figure 2 (below) “provides a perspective view of an embodiment of a portable handheld PNU (102).” Cross, [022].



The PNU shown in Figure 2 is “a simple hardware device that can be carried by or attached to an individual rail-maintenance worker by a method known to” a POSA.

Cross, [045]. The PNU can be “integrated into safety equipment worn by a rail maintenance worker including, but not limited to, helmets, belts and safety vests” or “in alternate embodiments, may simply be temporarily attached to the safety equipment by a pocket, clip or other applicable attachment modality known to” a POSA. Cross, [045].

213. The PNU “contains a power source,” which “include, but are not limited to” various known and rechargeable “batteries” and/or “self-contained power sources such as solar power, movement-based power generation, and energy harvesting,” which power the device and recharge the batteries without wires to an external power source. Cross, [042]. The batteries can also be recharged at “PNU (102) charging stations.” Cross, [047].

214. The PNU also comprises a computer (Cross, [031]), which Cross describes broadly as “inclusive of all computational devices including, but not limited to, processing devices or processors, personal computers...portable computers, and hand held computers.” Cross, [032]. The PNU’s computer has “four main functions”:

(1) “transmit[ting]... the location data of the worker equipped with the PNU (102) to the VCU (103), central control server (104), other PNUs (102), a plurality of signal controllers, a plurality of priority detectors (105), and/or other components of the network”;

- (2) “receiv[ing] communications and information” (e.g., AVL packets, which I discuss in § VII.B.4 below) from these other devices (e.g., from VCUs, other PNUs and priority detectors);
- (3) “identify[ing] alert mode conditions” “based upon the location data received from the plurality of VCUs (103) in the system, the location of warning areas (106), the bearing of VCUs on pre-defined routes, and the location-data of the PNU (102), amongst other information transmitted over the system”; and
- (4) “transmit[ing] audible, movement or visual warnings to a worker when it determines an alert condition exists or when it receives an alert signal” from another device in the system. Example “audio, movement and visual alert signals include, but are not limited to, ultra bright LEDs, vibrations and high volume speakers,” whose “strength... can vary depending on the risk posed.”

Cross, [043]. For example, when the PNU “determines that an alert condition is present, the PNU (102) will go into alert mode,” wherein the PNU will “send[] out an alert signal” and “transmit a special high alert packet into the network and [to] each of the components of the network to notify them of the alert situation.”

Cross, [044].

215. As noted above, another component of Cross's system are vehicle-mounted VCUs 103 (illustrated in FIG. 1 above as comprised of three separate components). Each VCU "is generally an onboard unit" that can be "integrated with a PTC [positive train control] system, that tracks real-time vehicle location, transmits approaching-vehicle alerts, receives signals from other components in the system (such as alert signals from PNUs), controls or has the ability to alter vehicle function, and stores activity logs." Cross, [034]. The VCU's are installed in vehicles "either permanent[ly], by direct integration into the mass transit vehicle—particularly into the PTC (102) of the particular mass transit unit and the overall grid—or temporar[ily], through a mobile receiver that can be taken into and removed from the vehicle." Cross, [035]. The VCUs are "generally capable of sending communications to and receiving communications from" the other devices in the system (e.g., PNUs (102), signal light controllers, and priority detectors (107)). Cross, [034]. For example, as I discuss below, the VCU (like the PNU) receives information (e.g., alert signals) from other devices in the system (e.g., PNUs), and also transmits its own "automatic vehicle location (AVL) packets" to those other devices. Cross, [036]-[038].

216. The VCUs also comprise a computer ([036]) that executes similar functionality as the PNUs. The VCU's computer "functions to send safety signals to and receive safety signals from PNUs in the network, the vehicle operator, and

operators at the central control server (106) monitoring the overall grid.” Cross, [036]. Based on “the inputs received” from other devices (e.g., PNUs) and “knowledge of the route” and grid (e.g., location of “warning areas (106)”), the VCU’s computer “functions to send safety signals to and receive safety signals from PNUs in the network, the vehicle operator, and operators at the central control server (106) monitoring the overall grid.” Cross, [036]. For example, “when... workers equipped with a PNU (102) are within a certain location, time, bearing, distance or velocity of a vehicle,” “an alert signal will be sent to an approaching vehicle.” Cross, [036]. The VCU’s computer can then “instruct the train to gradually slow down.” Cross, [037].

217. Alerts may also be triggered when the VCU “send[s] automatic vehicle location (AVL) packets to the other components of the network, in particular to the plurality of PNUs (102).” Cross, [038]. The AVL “signal includes, but is not limited to, location-based information about the vehicle (e.g., its velocity, acceleration, direction, route, bearing, etc.).” Cross, [038].

Information conveyed in AVL packets can be determined from “a GPS receiver (or other contemplated positioning system”). Cross, [035]. The AVL packets can be sent “automatically” or “in response to an event (such as the VCU receiving a signal from a PNU in the system)” and are “transmitted through the network to the plurality of PNUs (102).” Cross, [038]. The VCU’s computer also includes

“monitor software which allows for the real-time monitoring and display of worker activity and locations on a user interface,” via an input/output (I/O) component that “can be located in the vehicle” or “via a mobile interface known to” POSAs, “such as a tablet computer or smart phone.” Cross, [039]. The VCU’s computer also includes “the capability to create detailed logs and reports which show worker location and alert histories along the route.” Cross, [039]. The VCU’s computer can also function to provide “PNU warning,” whereby “a signal is sent to a given PNU (102), warning of an impending mass transit vehicle.” Cross, [040].

218. The priority detectors are “wayside devices capable of receiving radio frequency (RF) signals and forwarding the received data through the network to a plurality of signal controllers, a plurality of VCUs, a plurality of PNUs, the centralized control server and other known and contemplated components of the network.” Cross, [049]. The priority detectors are “located at various locations along a particular vehicle’s route.” Cross, [055]. Cross discloses that “one common location for priority detectors (107) will be at or in close proximity to intersection” (Cross, [055]), though Cross does not limit the priority detectors to intersection. The priority detectors generally “function as intermediaries in the overall system (101)” by “receiving signals from” devices (e.g., PNUs and VCUs) and “forwarding the real-time vehicle and worker activity and alert notifications received in these signals to” devices (e.g., PNUs and VCUs). Cross, [049].

3. Cross-Grisham Combination

219. In my opinion, POSAs would have had reasons to use Grisham's impulse radio units in Cross's worker protection system. Specifically, POSAs would have had reasons to use Grisham's impulse radio units to accomplish the sending and receiving of wireless signals by Cross's VCU, PNU, and priority detectors.

220. First, Cross and Grisham describe systems that are independently similar to one another in terms of their purpose and overall system configuration. Both disclosures are directed to determining when there is a risk of a moving vehicle (e.g., a train) colliding with persons or objects located on or near the train's track. Moreover, both systems include a radio communication device that is attached to the train/vehicle, which sends and receives wireless signals to/from devices attached to persons or objects on or near the train's path. Cross, [035], [040], [041], [047] (describing Cross's VCU and its sending/receiving wireless signals); Grisham, 20:17-22, 21:18-23 (describing Grisham's impulse radio "coupled ... to" a "locomotive"), 20:59-65, 21:18-35 (describing sending/receiving UWB signals).

221. In Cross's system, the VCU sends/receives signals to/from wayside priority detectors and worker-based PNUs (Cross, [035], [041]); in Grisham's system, the train-based impulse radio sends/receives signals to/from a second

impulse radio that can be attached to a railroad pole, a work vehicle, a passenger vehicle, a worker, or any other “object” in a scalable proximity warning system (Grisham, 19:63-65, 27:40-54, Fig. 23). This overall structural similarity between the systems would have provided POSAs with a reason to consider the potential benefits of combining aspects of the two systems.

222. Additionally, both systems use the exchange of wireless signals to determine when there is a dangerous situation and to trigger alerts based on the determination. In Cross, the VCU includes a “transmitter” to send information related to the train’s location (e.g., AVL packets) via wireless signals and a “receiver” to receive “information” from PNUs and/or wayside priority detectors. Cross, [041, 043]. The worker-based PNUs receive AVL signals sent by the VCU and use the location-related information contained therein to determine whether to enter an “alert mode,” which, if activated, causes the worker (and other components/persons in the system) to be alerted to the risk of a collision. Cross, [049]-[050], [062]-[063]. Grisham’s impulse radio units operate in a very similar manner within Grisham’s proximity-detection system. The train-based impulse radio unit transmits an impulse radio (or, “UWB”) signal. Grisham, 17:1-40 (describing exemplary transmitter operation), 21:15-35, 23:20-29, 23:56-24:3 (describing transmitting operations of radio unit in example embodiments involving moving locomotive). This signal is received by a receiving impulse

radio. Grisham, 17:41-18:35 (describing exemplary receiver operation). Based on the received signal, the receiving unit “makes sure a person associated with the second object 908 is informed (step 1010) about the potentially dangerous situation” by, for example, triggering a warning light or activating a display that is capable of alerting a person by generating an alarm or voice message. Grisham, 20:4-8; 21:36-52, 23:30-45, 24:4-20.

223. Given this similarity between both the structure and operation of Cross’s and Grisham’s alert-generating systems, a POSA would have understood the components of these systems to be readily combinable. For example, POSAs would have understood that the impulse radio units described in Grisham could have been combined with any of the three companion devices in Cross because Grisham’s impulse radio units, like Cross’s components, were capable of sending/receiving wireless signals and using those signals to trigger alerts. *Compare* Cross, [030]-[031] (Cross’s components “consistently send[] and receiv[e] location-based packaged data,” which may trigger an “alert mode” and “alert signals”) *with* Grisham, 23:64-24:16 (Grisham’s impulse radio “continually transmit[s] . . . an impulse radio signal,” which may trigger an “alarm” or “voice message”).

224. Beyond these systems being structurally and operationally similar, POSAs would have been further motivated to use Grisham’s impulse radio units in

Cross's worker protection system to realize the benefits of impulse radio (or, UWB) technology.

225. Cross describes a "preferred embodiment" in which the "receivers and transmitters of the system . . . operate on a secure ultra-high frequency (UHF) hopping spread spectrum." Cross, [033]. However, Cross also makes clear that "operation on this frequency is not determinative as it is contemplated that the disclosed system (101) could also operate on a fixed-frequency transmission range or any other transmission range or spectrum as well as any communication protocol known to those of skill in the art." Cross, [033]. To that end, Cross discloses that its use of the term "transmitter" should be "understood to encompass any electronics device which produces radio waves, or other known communication modalities, for the communication of information over a distance known to those of skill in the art." Cross, [031]. Similarly, Cross's "receiver" should be "understood to encompass an electronic circuit known to those of skill in the art that is capable of receiving radio signal inputs, separating the wanted radio signal from all other picked-up radio signals, amplifying the signal to a level suitable for further processing and converting the signal through demodulation and decoding into usable form." Cross, [031].

226. Accordingly, a POSA reading Cross would have the option of using any known radio frequency and/or communication protocol to use to transmit

information between the transmitters and receivers in Cross's system. In choosing this particular wireless-transmission technology, a POSA would have been motivated by Grisham's disclosure, as well as the POSA's background knowledge of the state of the art, to utilize impulse radio (or, UWB) technology for these transmissions, as disclosed in Grisham.

227. Grisham describes many benefits of using impulse radio technology in a worker protection system. Most notably, Grisham specifically teaches that impulse radio technology is well suited for use in subway applications because it is possible to "effectively transmit and receive impulse radio signals through the ground." Grisham, 25:51-57. A POSA would have been keenly aware of the importance of being able to transmit signals through the ground in a subway application, where the use of non-UWB signals would make it more difficult to effectively communicate between devices that are separated by, e.g., walls, turns, tunnels, the ground, etc. Indeed, Cross specifically discloses that its system is meant to be used in "underground" and "subway" mass transit systems. Cross, [026]. Thus, a POSA implementing Cross's system in such an underground/subway environment would have appreciated that, by using Grisham's impulse radio technology, it would be possible to improve Cross's system by making it more certain that a signal transmitted by the stationary unit

would actually be received by the mobile unit, even when there are obstacles in between the two units.

228. Additionally, Grisham teaches that impulse radio signals are “highly resistant to interference,” a property that is “desirable since impulse radio systems must share the energy spectrum with conventional radio systems and with other impulse radio systems.” Grisham, 12:1-8. A POSA would have understood the importance of ensuring that signals sent between VCUs, PNUs, and priority detectors were resistant to interference and, therefore, would have been further motivated to use Grisham’s impulse radio units in Cross’s safety notification system. For example, a POSA would have appreciated that a mass transit environment is likely to feature a high prevalence of wireless signals, such as LTE, WiFi, and UHF/VHF communication channels being used by the train system and/or by the passengers on the train. Thus, by using Grisham’s impulse radio units, a POSA would have been able to increase the reliability of Cross’s system by decreasing the likelihood that any signal between the VCUs, PNUs, and/or priority detectors would be subject to interference.

229. Additionally, beyond making information transmission more reliable in the manner described above, a POSA would have been motivated to implement Grisham’s impulse radio units in Cross’s system to realize the benefits relating to positioning. Indeed, both Cross and Grisham disclose systems in which

alarms/alerts are generated based on a determination that there is a risk of collision between a moving train and one or more persons or objects in its path. In both systems, this determination is made at least in part based on information about the location of the train. Thus, a POSA would have understood that either of these systems could be improved by improving the accuracy and reliability of its location-determination capability. In particular, as relevant here, a POSA would have understood that using Grisham's impulse radio units in Cross's system would improve the accuracy and reliability of the train's location information that is used to determine whether to enter an alert mode at the PNU. Accordingly, a POSA would have been further motivated to make this combination.

230. In Cross's system, the VCU is equipped with a "GPS receiver" to "determine the mass transit vehicle's position [.]" Cross, [035]. This location information can be used to generate an "AVL signal" that includes "location-based information about the vehicle" and which is transmitted—either directly or indirectly via priority detectors—to PNUs. Cross, [038]. Based on the received AVL packet, the PNU enters an alert mode, such as when the "Vehicle reaches a certain predefined . . . distance from the warning area," in which the PNU is located. Cross, [056].

231. However, a POSA would have recognized drawbacks and risks arising from the approach described in Cross. For instance, a POSA would have

recognized that these GPS sensors are only able to determine a device's location with relatively low precision, such as on the order of 5 meters. Additionally, these GPS sensors may not be able to function in areas with limited GPS coverage, such as in tunnels, underground, or urban canyons.

232. In light of these drawbacks a POSA would have been further motivated to incorporate Grisham's impulse radio units in Cross's system not only for the transmission of data (or, information) between the stationary unit and mobile unit, but also to improve the system's ability to determine the location of the train relative to the mobile unit and, in turn, to assess the risk of collision between the train and the personnel on or near the track. Whereas GPS sensors provide a device's location with relatively low precision, the impulse radio units described in Grisham are able to determine link distance between units to a "high degree of precision," in some cases with "centimeter distance resolution." Grisham, 15:38-42. Additionally, because impulse radio signals are resistant to interference and can be transmitted through the ground or other obstacles, using Grisham's impulse radio units in Cross's worker protections system would not only make the system more accurate but also more reliable as compared to using GPS sensors alone.

233. POSAs would have had a reasonable expectation of success in the above-described Cross-Grisham combination because Grisham expressly teaches

that its impulse radio systems can be used in variety of proximity determination applications, including in railway or subway environments of the type contemplated in Cross. It would have required only ordinary skill for POSAs to utilize Grisham's impulse radio units in Cross's system because these impulse radios are small and easily configurable for worker-protection and proximity-detection applications, as evidenced by Grisham's extensive disclosure.

234. Additionally, a POSA would have been further motivated to modify Cross to include Grisham's "control box" to, e.g., detect the presence of an approaching train.

235. In an example embodiment, Grisham discloses that its proximity detection system may also include a "control box" that "is located at a monitoring location such as next to railroad tracks." Grisham, 23:12-16. The control box "us[es] a sensor 1560 (e.g., electromagnetic sensor, motion detector, percussion sensor) to sense the presence of a third object (e.g., locomotive 1102)." Grisham, 23:14-16. When the sensor detects "a dangerous situation such as the presence of a locomotive," an impulse radio associated with the sensor may "transmit" a signal that triggers a warning that the locomotive is approaching. *See* Grisham, 23:25-35.

236. A POSA would have been motivated to implement the Cross-Grisham system by combining Grisham's wayside "sensor" with Cross's wayside priority detector. In the Cross-Grisham system described herein, Cross's VCU, PNU, and

wayside priority detectors would communicate wirelessly about the location/position of trains using Grisham's impulse radio units. However, a POSA would have recognized the benefits of having an additional failsafe method to determine whether a train is approaching a warning area in which workers are present. Thus, a POSA would have been motivated to utilize Grisham's wayside "sensor" to provide an additional layer of protection to ensure that the system would be able to detect an approaching train despite any malfunction in the train's UWB communication equipment. Thus, in the Cross-Grisham system, a POSA would have included a sensor in the wayside priority detector and would have used the sensor to determine whether a train is approaching and, if so, to generate a UWB signal to any nearby PNUs to trigger an alert mode. This use of the wayside sensors is consistent with their use in Grisham, where a UWB signal is generated based on the wayside sensor detecting that a train is approaching. *See Grisham, 23:4-35.*

237. A POSA would have had a reasonable expectation of success in implementing this modification of the Cross-Grisham system, as the sensors of the type described in Grisham are conventional equipment and are small, low-powered, and highly adaptable devices that could be placed at any point on the train's track.

4. Independent Claim 1

a. 1[pre]: “A system for worker protection, the system comprises:”

238. If the preamble of claim 1 is a limitation of the claim, it is taught by Cross-Grisham. Cross discloses “a safety notification system” for protecting “maintenance workers” and workers on trains from being injured from collisions. Cross-Summary, [001]. Worker protection occurs by, for example, “notify[ing] roadway maintenance workers of an approaching mass transit vehicle and, conversely, [] notify[ing] the operators ... of mass transit vehicles of roadway maintenance workers within the vicinity of an approaching section of track.” Cross-Background, [002] (Background of the Invention). *See also* Cross, [046] (disclosing that PNU works with other devices “to identify potentially unsafe conditions and also alert maintenance, construction, and first-response personal when potentially unsafe conditions exist”), Cross, [049] (disclosing that wayside priority detectors forward “real-time vehicle and worker activity and alert notifications”).

239. Thus, Cross-Grisham discloses a system for worker protection, as claimed.

b. 1[A]: “a train-mounted unit for use on a train”

240. Cross’s system includes a “vehicle computer unit (VCU)” (Cross, [029]) that is an “onboard unit” (Cross, [034]). As I discuss below (§ VII.B.4.f),

the VCU is an alert device that transmits alerts, alert-triggering signals, and generates alerts for workers operating the vehicle. Cross discloses that the VCU is installed “into [a] mass transit vehicle,” where the installation can be “either permanent—by direct integration into the [] vehicle”—“or temporary, through a mobile receiver that can be taken into and removed from the vehicle.” Cross, [029], [034]-[035]. In either implementation, Cross’s VCU is a train-mounted unit for use on a train, as claimed.

c. 1[B]: “wherein the train-mounted unit comprises: a communication component, comprising one or more antennas, configured to transmit and/or receive wireless signals”

241. As Cross’s Figure 1 (annotated above) illustrates, Cross’s VCU has an “Antenna” (which I annotated in green above), which is configured to transmit and receive wireless signals. The VCU also has a transmitter and receiver (or transceiver). Cross, [037]. The VCU’s receiver is an “electronic circuit,” which performs “processing and converting [of] the [received] signal...into usable form” (Cross, [031]) for use in VCU functions like “track[ing] real-time vehicle location, transmit[ing] approaching vehicle-alerts, ...alter[ing] vehicle function, and stor[ing] activity logs” (Cross, [034]).

242. A POSA would understand the transmitter and receiver (or transceiver) use its antenna to “produce” (i.e., transmit) and “receiv[e]” radio

signals. And, in the Cross-Grisham combination described above, these radio signals would include ultra-wideband radio signals.

243. A POSA would have understood that the signals transmitted by the VCU are wireless signals. Cross, [031], [033]. For example, Figure 1 above illustrates several “Wireless Signal[s]” emanating from the vehicle. Thus, at least the VCU’s antenna is a communication component comprising one or more antennas configured transmit and/or receive wireless signals, as claimed.

d. 1[C]: “wherein the signals comprise ultra-wideband (UWB) signals”

244. As discussed, a POSA would implement the Cross-Grisham system using Grisham’s impulse radio units for wireless communications between Cross’s components. In particular, Cross’s train-mounted VCU, wayside priority detector, and worker-based PNU(s) would have each included an impulse radio of the type described in Grisham and would have used these impulse radios to send (transmit) and receive wireless UWB signals. These wireless UWB signals would have been used to communicate data of the type described in Cross, such as AVL packets and other location- or route-based information.

245. Grisham’s impulse radio units “utilize impulse radio technology to effectively warn a person when there is a...locomotive in their vicinity.” Grisham, 2:27-31. Grisham states, and POSAs would have understood, that a system using impulse radios of the type disclosed is the same as an “ultra-wideband system, or

ultra-wideband communication systems.” Grisham, 5:8-13. Accordingly, in Grisham’s “preferred embodiment, the emitted signal is wide-band or ultrawide-band.” Grisham, 17:34-35.

246. Therefore, in Cross-Grisham, the wireless signals transmitted and/or received by the VCU are UWB signals, as claimed.

- e. **1[D]: “and one or more circuits configured to process signals and data, and perform one or more applications or functions relating to operations of the train-mounted unit”**

247. The VCU includes a “computer” (Cross, [031]), which Cross broadly defines as a device that is “inclusive of all computational devices,” including “processing devices or processors” (Cross, [032]). Cross’s “computer,” (which has a “processor”) is a circuit as defined by the ’709 patent (EX1001, 1:63-2:4). A POSA also understood that computational devices like processing devices or processors comprise many circuits operable to process signals and data, as claimed.

248. The VCU’s computer “serves four main functions.” Cross, [043]. The VCU’s computer performs these functions by processing various signals and data. For example, the VCU’s computer processes “inputs received” from PNUs, which are signals conveying data from the PNU to VCU, and other data regarding the vehicle (e.g., the “current velocity of the vehicle”). Cross. [036]. The inputs received from the PNUs and various other data are processed by the VCU’s processor to perform various functions relating to the VCU’s operation including

- (i) “send[ing] safety signals to and receiv[ing] safety signals from PNUs” and
- (ii) “instruct[ing] the train to gradually slow down.” Cross, [036]-[037].

249. The VCU’s receiver is explicitly described in Cross as an “electronic circuit” that performs “processing and converting [of] the [received] signal...into usable form” (Cross, [031]), e.g., demodulating received wireless signals to facilitate conversion to digital data. The radio signals processed into usable form by the receiver are used to perform functions of the VCU, like “track[ing] real-time vehicle location, transmit[ing] approaching vehicle-alerts, ...alter[ing] vehicle function, and stor[ing] activity logs.” Cross, [034].

250. Thus, Cross’s VCU comprises one or more circuits operable to process signals and data (e.g., a computer and associated processor and a receiver), and to perform one or more applications or functions relating to operations of the train-mounted unit (e.g., like transmitting and reacting to alert signals), as claimed.

- f. **1[E]: “and wherein the train-mounted unit is configured to operate cooperatively with one or more wayside units, configured for placement on or near a track traversed by the train, to provide alerts to one or more workers operating on or near the track, based on communication of the UWB signals with at least one of the one or more wayside units.”**

251. Cross’s VCUs are “generally capable of sending communications to and receiving communications from” the other devices in the system (e.g., PNUs (102), signal light controllers, and priority detectors (107)). Cross, [034]. And, as

discussed above, the wayside priority detectors “are wayside devices.” Cross, [049].

252. The VCU “send[s] automatic vehicle location (AVL) packets to the other components of the network[.]” Cross, [038]. The AVL “signal includes, but is not limited to, location-based information about the vehicle (e.g., its velocity, acceleration, direction, route, bearing, etc.).” Cross, [038]. Information conveyed in AVL packets can be determined from “a GPS receiver (or other contemplated positioning system”). Cross, [035].

253. These AVL packets (and/or other wireless signals generated by the VCUs) may be received directly from the VCU or may be sent by wayside priority detectors/units. Cross teaches that the wayside priority detectors may “function as intermediaries..., receiving signals [communicated] from VCUs (103) and PNUs (102) and forwarding the real-time vehicle and worker activity and alert notifications...to...VCUs (103), or PNUs (102).” Cross, [049], [0055], [0062], [0067]. Therefore, the VCU and the wayside priority detectors/units operate cooperatively to transmit AVL packets to the PNUs.

254. Cross discloses that the PNU takes certain actions in response to “receiv[ing] communications and information” from companion alert devices, such as AVL packets comprising information about (e.g., location of) approaching vehicles. Cross, [043]-[044], [050].

255. Based on the AVL packets received from VCUs and/or priority detectors, the PNU's computer "can identify alert mode conditions" (Cross, [043]) and if such a condition exists, the PNU "will go into alert mode" (Cross, [0044]). *See also* Cross, [056] (disclosing that the PNU processes received AVL packets to "determine[] whether to enter an alert mode"). The PNU processes the signals it receives from these companion devices to "determine[] whether to enter an alert mode." Cross, [056] (disclosing that a PNU determines whether to enter an alert mode in a warning area based on processing an "(AVL) from an approaching vehicle"); *see also* Cross, [061] (PNU "determined whether or not an alert mode needs to be triggered" based "[u]pon the exchange of" information received in wireless signals from other devices).

256. Once the PNU "determines an alert condition exists" and has entered alert mode, the PNU's computer outputs "audio, movement and visual alert signals" via its indicator components, the PNU's "LEDs, vibration[al components] and...speakers." Cross, [043]. Determining whether an alert mode condition is based on the safety alert generated by the PNU. *See* Cross, [056] (PNU "will trigger a warning call, as discussed previously, to notify the equipped worker of the high risk event"), Cross, [061] ("Upon activation of the alert mode, the PNU (102) will trigger an alert signal and notify the worker, via audio, movement, visual or

other signals”). Thus, the physical alert indications output by the indicator components are based on the existence of an “alert mode.”

257. When the VCU sends AVL packets that are forwarded to PNU(s) by the wayside priority detector acting as an intermediary, the VCU is operating cooperatively with the wayside priority detector, as claimed. Additionally, because the reception of these wireless signals at the PNU(s) results in the PNU(s) entering an alert mode, the VCU and wayside priority detectors operative cooperatively to provide alerts to the workers operating on or near the track, as claimed.

Furthermore, because the PNU(s) determine whether an alert mode exists based on the AVL packets that are sent by the VCU and/or forwarded by the wayside priority detectors, alerts are provided to the workers based on communication of wireless signals between the train-mounted VCU and the wayside priority detectors, as claimed.

258. As discussed above (§ VII.B.3), the Cross-Grisham combined system would utilize Grisham’s UWB radio technology to transmit UWB signals between the VCU(s), PNU(s), and wayside priority detector(s). In the combined system, the AVL packets sent by VCUs would be sent using UWB signals. These UWB signals would be received by wayside priority detectors and “forwarded” to PNU(s) as UWB signals. Accordingly, in the Cross-Grisham system, the train-

mounted VCU and wayside priority detectors would operate cooperatively to provide alerts to workers based on the communication of UWB signals, as claimed.

5. Dependent Claims 2-4, 6-12, and 17-19

a. Claim 2: “The system of claim 1, wherein the train-mounted unit is configured to broadcast alert triggering signals.”

259. The ’709 patent does not provide a special definition of broadcast. In the ordinary sense the patent uses the term, a POSA would understand “broadcast” in its ordinary sense to be the transmission of a signal to multiple devices simultaneously using a one-to-many model of transmission, rather than a one-to-one or targeted model of transmission.

260. As discussed above (§ VII.B.3), in the combined Cross-Grisham system, the VCU’s transmitter would transmits signals using an ultra-wideband (UWB) transmission spectrum. Cross, [033]. For example, the VCU’s transmitter “send[s] automatic vehicle location (AVL) packets to the other components of the networks, in particular to the plurality of PNU’s (102) in the network.” Cross, [038]. Cross repeatedly discloses that VCUs transmit signals to a “plurality of PNU’s.” See Cross, [034] (explaining VCU sends communications to “a plurality of PNU’s”), Cross, [035] (VCU’s “transmitter functions to transmit information and radio signals to a plurality of PNU’s”), Cross, [043]-[044]. The conventional technique for a single transmitting device (like the VCU) to send wireless data

packets simultaneously to a “plurality” of receiving devices (like PNUs), including when using a UWB-based wireless communication network, was to “broadcast” the data packet, i.e., transmit the data packet to a plurality of devices in the network simultaneously.

261. POSAs would have also recognized the benefit of implementing the VCU such that it did broadcast its AVL packets to all companion devices in wireless communication range (e.g., all nearby PNUs). POSAs would have recognized the benefit of broadcasting, rather than narrow casting, because doing so would ensure that all companion devices within wireless communication range of the VCU’s transmitter—both known and unknown to the VCU—received the AVL packets. A VCU may not be aware of all PNUs within communication range and a POSA would have recognized safety to workers would be increased by having PNUs receive AVL packets from the VCU without having to wait for the VCU to first identify the PNU.

262. Corroborating my opinion that broadcasting was a well-known way to communicate with multiple devices at a time, Meyer teaches transmitting alerts from a vehicle “using the broadcast method such that it can be received in a certain radius by the corresponding receiving units.” Meyer, ¶17, ¶36. Similarly, EX1013 at [0003]-[0004] teaches as background information that “[b]roadcasting allows stations to transmit information to a large number of end devices efficiently” so

that “all people within a broadcast area receive the broadcast signals.” As further corroboration of my opinion that a POSA had reason to broadcast Cross’s AVL packets, EX1017 at [0005] taught as background information that “[i]t may be desirable to efficiently send and receive broadcast alert messages” rather than “unicast messages sent to individual users.”

263. In Cross’s system, the AVL packets broadcast by the VCU are alert-triggering signals. Cross discloses that “an alert mode is triggered by” PNUs based on receiving AVL packets, which are processed by the PNU’s computer to determine a vehicle’s “route and bearing” and/or “location.” Cross, [030]. Cross at [043] similarly explains that PNUs “can identify alert mode conditions” based in part on “location data received from the plurality of VCUs” (i.e., the AVL packets broadcast by VCUs). Cross at [056]-[057] similarly discloses that “alert mode is triggered by the PNU...based on the AVL packet received by [sic: from] the approaching vehicle.” Thus, AVL packets broadcast by VCUs are alert triggering signals, as claimed.

- b. Claim 3: “The system of claim 1, wherein the train-mounted unit is configured to generate data relating to alerts and/or to other devices or objects in a path of the train, based on the communication of the UWB signals with at least one of the one or more wayside units.”**

264. When a PNU identifies an alert mode condition exists based on the AVL packet received from an approaching vehicle, the PNU “transmits a special

high alert packet into the network and [to] each of the components of the network to notify them of the alert situation.” Cross, [044]. Cross explains that “[t]his special alert mode packet notifies the other components of the system [] of the high risk event.” Cross, [056]. By receiving the alert mode packet from the PNU, the VCU is thus notified of the alert that its AVL packet triggered in the PNU.

265. This alert mode packet may be received by the wayside priority detector and forwarded to the VCU. Cross, [055]. Based on receiving the alert mode packet forwarded by the wayside priority detector, the VCU’s computer generates data relating to the alert and/or other devices in the path of the vehicle. For example, the VCU computer “create[s] detailed logs and reports which show worker location and alert histories along the route.” Cross, [039]. Additionally, when an alert mode is activated in the system, the VCU generates data that is used to initiate the “alert signals” that are produced by the VCU’s output components to “notify...a vehicle operator...of a potentially dangerous interaction between an equipped worker and a vehicle within the grid.” Cross, [030], [052]. As another example of data generated by the VCU that relates to the alerts and devices in the path of the vehicle (e.g., PNUs), the VCU “upon receiving the alert mode, will slow down [the vehicle] to a speed that will allow it to stop, if needed, before encountering the PNU-equipped worker.” Cross, [062]; *see also* Cross, [037]

(VCU's computer "through the PTC" (positive train control) "will instruct the train to gradually slow down").

266. Thus, Cross's VCU is configured in the several ways discussed above to generate data relating to alerts and/or to other devices or objects in a path of the train, as claimed.

267. In the Cross-Grisham combined system, all communications would be UWB. This would include communications between the VCU and wayside priority detectors, such as the "signals" that are (a) sent by the VCU and forwarded by the priority detector to the PNUs or (b) sent by the PNU(s) and forwarded by the priority detector to the VCU. Cross, [055].

268. Thus, the VCU's generation of the data relating to alerts would be based on the communication of the UWB signals with at least one of the one or more wayside units, as claimed.

- c. **Claim 4: "The system of claim 1, wherein the train-mounted unit is configured to generate feedback information for outputting to an operator of the train, based on the communication of the UWB signals with at least one of the one or more wayside units."**

269. The VCU includes several input/output components. For example, the VCU includes "monitor software" that "allows for the real-time monitoring and display of worker activity and locations on a user interface." Cross, [039].

270. Based on the data generated by the VCU that I discussed for Claim 3 (§ VII.B.5.b), the VCU outputs various feedback information to the operator via the VCU's I/O components, like the VCU's display, speakers and/or LED lights. For example, the VCU outputs "detailed logs and reports which show worker location and alert histories along the route." Cross, [039]. These logs and reports show (i.e., display) the worker location and alert histories to network "administrators or other interested individuals," e.g., the vehicle operator, who uses knowledge of worker location to make decision about how to operate the vehicle. Cross, [039]. Similarly, the VCU outputs "alert signals" that "notify" the vehicle operator of an impending dangerous situation (e.g., sounds or displayed text to warn of a potential collision). Cross, [030], [052]. These alert signals are generated when the VCU receives a special alert mode packet (e.g., from a PNU or wayside priority detector), which is generated by a PNU based on the UWB communication received from the VCU (e.g., based on a received AVL packet). Cross, [043]-[044]. These alerts are also a form of "feedback" to the operator that is generated via the VCU's I/O components (e.g., speakers and display). As another example, when the VCU causes the vehicle to slow down, the VCU's display of the vehicle's speed will reflect the changing vehicle speed. The slowing down of the vehicle and the reduced speed that would show on the display of speed

are also feedback information to the operator, telling the operator that the VCU determined a collision is possible.

271. Thus, Cross's VCU is configured in the several ways described above to generate based on the data that meets Claim 3 feedback information that is output to the operator, as claimed.

d. Claim 6: "The system of claim 1, wherein the train-mounted unit is configured to log data relating to alerts triggered in response to movement of the train."

272. Cross discloses that the VCU's computer is operable "to create detailed logs and reports which show...alert histories along the route." Cross, [034], [039]. The alert histories are the alerts that I discussed above (Claims 1, 3), which are triggered in response to movement of the train. For example, alerts that are logged that are based on vehicle-movement information conveyed in AVL packets (e.g. the vehicle's AVL packet indicates to the PNU that has moved closer to a PNU device) and/or when the vehicle approaches PNUs or enters a "warning zone." Cross, [027], [034]-[036], [038], [051], [061], FIGS. 3-4.

273. Thus, Cross's VCU is operable to log data relating to alerts triggered in response to movement of the train, as claimed.

- e. **Claim 7: “The system of claim 1, wherein the train-mounted unit comprises one or more input/output (I/O) components, for receiving input from an operator of the train and/or for providing output to the operator of the train.”**

274. The VCU includes several input/output components. For example, the VCU includes “monitor software” that “allows for the real-time monitoring and display of worker activity and locations on a *user interface*.” Cross, [039]. This vehicle “user interface” can take the form of a “tablet computer.” Cross, [039]. When the user interface is implemented as a tablet computer, the tablet is a user interface that comprises input/output (I/O) components. The ’709 patent at 11:16-46 itself discloses that exemplary I/O components include a “display” with a “touch screen,” which would have conventionally been part of a tablet computer.

275. Through its user interface (e.g., tablet), the VCU produces outputs to the operator of the vehicle. For example, the VCU’s user interface “displays the location” of VCUs and PNUs in the system “in real time.” Cross, [012]. Likewise, the VCU’s “interface will display worker locations on or near the rail line or route on geographics maps.” Cross, [039].

276. Through its user interface (e.g., tablet), the VCU also receives inputs from the operator of the vehicle and/or it would have been obvious to implement the VCU such that it received input via its user interface. For example, Cross discloses that a train operator can “manually” instruct the VCU to issue an AVL

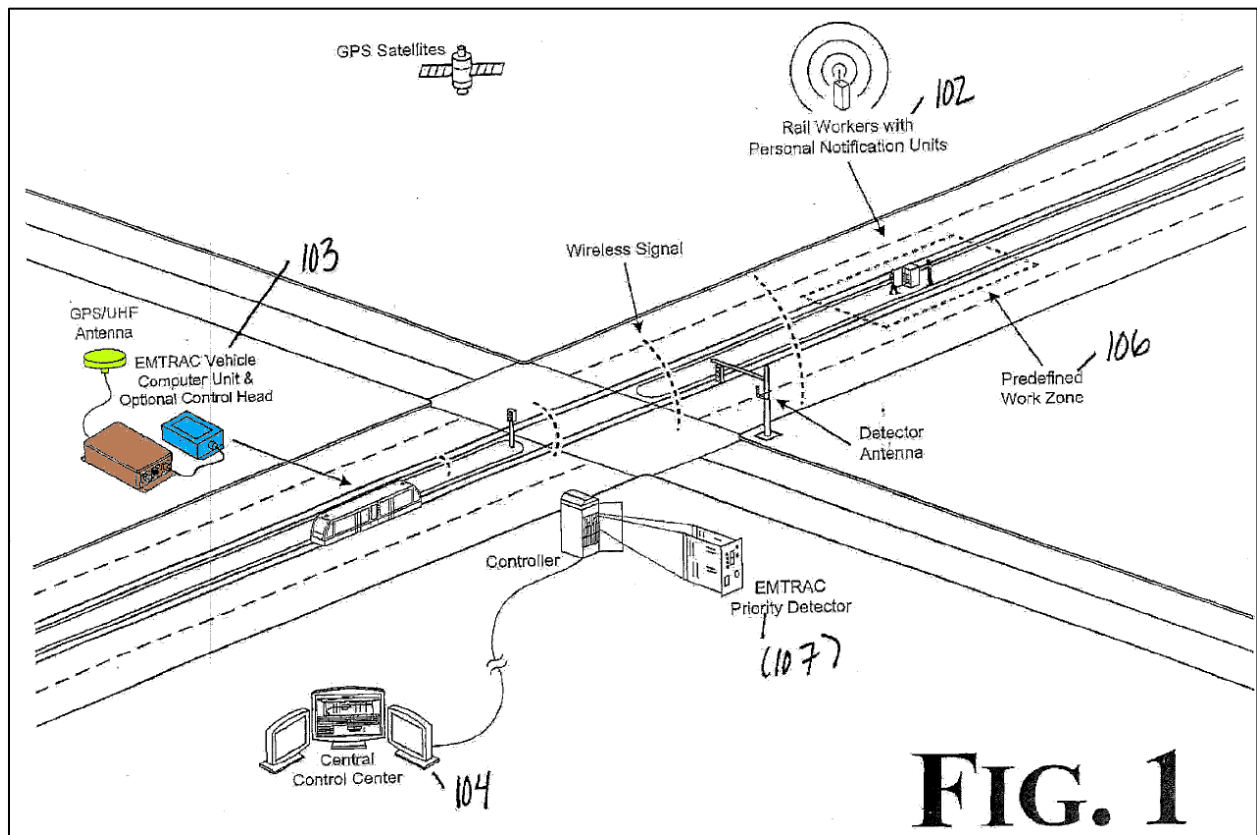
packet into the network. Cross, [038]. It would have also been obvious to configure the VCU so that the operator could issue this instruction through the VCU's user interface (e.g., by touching a physical or "soft button" on the tablet). Similarly, Cross discloses that the VCU can "set up and adjust" how PNUs respond to alert signals. Cross, [055]. The VCU can also be used to "create[], modify[], delete[] or otherwise control[]" warning areas. Cross, [055]. POSAs would have understood that the operator caused the VCU to perform these system adjustments via inputs to a user interface

277. If Cross is found not to disclose that operators input instructions or other commands to the VCU via its user interface (e.g., the tablet), then POSAs would have had reason to implement Cross such that its user interface, e.g., tablet, received the operator's inputs because electronic devices—like the VCU—conventionally received inputs from their I/O component, like the tablet that could be used as the VCU's interface.

278. Thus, Cross's VCU comprises input/output (I/O) components for receiving input from an operator of the train and for providing output to the operator of the train, as claimed.

f. **Claim 8: “The system of claim 1, wherein the train-mounted unit comprises housing for enclosing components of the train-mounted unit.”**

279. The VCU includes several components like “a receiver, a transmitter, a computer and a navigation system.” Cross, [031]-[032]. As illustrated in FIG. 1, VCU components are enclosed in several housings, which I have annotated below. The VCU’s includes a housing for a “mobile receiver that can be taken into and removed from the vehicle.” Cross, [035]. The ability to take the receiver into and the vehicle and remove it from the vehicle reinforces that there is a housing enclosing the components of the receiver to allow it to be carried into and removed from the vehicle.



280. The VCU can also be “permanent[ly]” installed in a vehicle. Cross, [035]. It would have been conventional for a permanently installed computing system, like the VCU, to include a housing for its electronic components (whether using housings the ones shown in FIG. 1 or using another conventional housing).

281. Thus, Cross’s vehicle-mounted VCU comprises a housing for enclosing components of the device, as claimed.

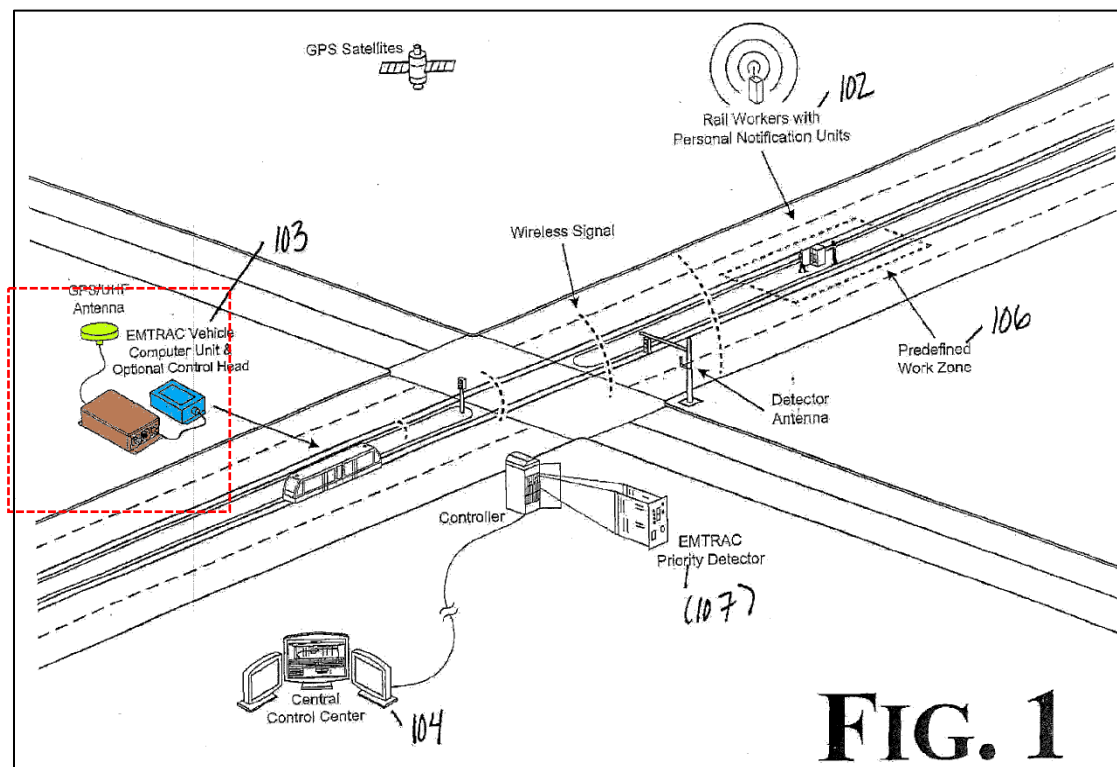
g. Claim 9: “The system of claim 1, wherein the train-mounted unit is configured, at least in part, as portable, detachable and moveable from the train.”

282. Cross teaches that the VCU (train-mounted alert device) is configurable as a “temporar[ily]” installed “mobile receiver that can be taken into and removed from the vehicle,” and thus the VCU device is portable, detachable and movable from the train, as claimed. Cross, [035], FIG. 1. Cross also discloses that the VCU’s user interface can be implemented as a tablet (Cross, [039]). A tablet implementation of the VCU’s user interface also meets claim 9 because a POSA would understand that a conventional tablet is a device that is portable, detachable and movable. Additionally, even if Cross’s VCU were not detachable, implementing the VCU to be attachable and detachable would have been a conventional design choice to ensure that the VCU’s components were secure within the train. The user interface implemented as a tablet (Cross, [039]) would have also been portable, detachable, and movable from the train, as claimed.

283. Thus, Cross's VCU is a device that is configured, at least in part, as portable, detachable and movable from the train, as claimed.

- h. Claim 10: "The system of claim 1, wherein the train-mounted unit is arranged into a plurality of separate physical units that comprises at least a broadcast unit comprising at least the communication component, and wherein the broadcast unit is configured for deployment external to the train."**

284. Cross's Figure 1 (which I annotated below) illustrates that the VCU 103 comprises three separate physical units: (1) "onboard vehicle computer unit"; (2) GPS/UHF antenna; and (3) "optional control head." The physical separation of the VCU's computer from its antenna (and optional control head) is consistent with the '709 patent's description of a vehicle alert device. EX1001, 3:42-58.



285. The antenna (which I have annotated green above) is a broadcast unit that includes the VCU's communication component—i.e., the antenna itself, which is a communication component as I discussed above in § VII.B.4.c.

286. Though Cross's text does not explicitly state where each VCU's antenna is mounted on the train, a POSA would have had reason to configure the VCU's antenna for attachment external to the vehicle, as claimed. In general, there would have been only two locations to mount the antenna: inside or outside the vehicle. By 2015, it would have been conventional to a POSA to locate an antenna(s) on top of a vehicle because mounting antennas externally would have improved line-of-sight thereby reducing interference for wireless communications to and from the antenna.

287. My opinion that it would have been conventional (and beneficial) to mount the antenna on top of the vehicle is corroborated by EX1014, which discloses (at [0006]) that “[m]ounting an antenna **outside of the vehicle lessens interference** from electronics and a roof-mounted outdoor antenna is less likely to receive reflected ghost signals” and “increases the amount of direct signal it [the antenna] can receive from a transmitter.” (emphasis added.) As another example, EX1020 (at [0056]) discloses installing various communication components of a vehicle-mounted unit, including a UWB transmitter/receiver of the type described in Grisham, “on the upper extremity of a vehicle.”

288. As further evidence of the obviousness of mounting Cross’s antenna external to the train, another prior art patent application filed by Cross’s first-named inventor disclose mounting an antenna for a similar VCU “*on top of the [// vehicle.*” EX1021, [0039]; FIGS. 1-2.

289. Accordingly, based on a POS’s general knowledge of conventional antenna placement and disclosures by the Cross-inventor, POSAs had reason to implement Cross-Grisham such that its UWB antenna(s) are configured for attachment external to the VCU, as claimed.

- i. **Claim 11: “The system of claim 10, wherein the plurality of separate physical units comprises an operator unit comprising at least the one or more I/O components, and wherein the operator unit is configured for use by an operator of the train.”**

290. As I discussed above (§ VII.B.5.e), each VCU includes a “user interface” (an operator unit, as claimed) that comprises I/O components. The I/O components are separate physical units—like a “tablet” and/or a separate “display” device (Cross, [039])—as claimed.

291. These user interfaces are configured for use by the operator to receive inputs and/or provide outputs, as I discussed above (§§ VII.B.5.e). Cross, [039].

6. Independent Claim 12

- a. **12[pre]: “A system for worker protection, the system comprises:”**

292. Cross discloses a system for worker protection, as I discussed above for limitation 1[pre] (§ VII.B.4.a). *See* Cross, [001]-[002], [046], [050].

- b. **12[A]: “one or more wayside units configured for placement on or near a track;”**

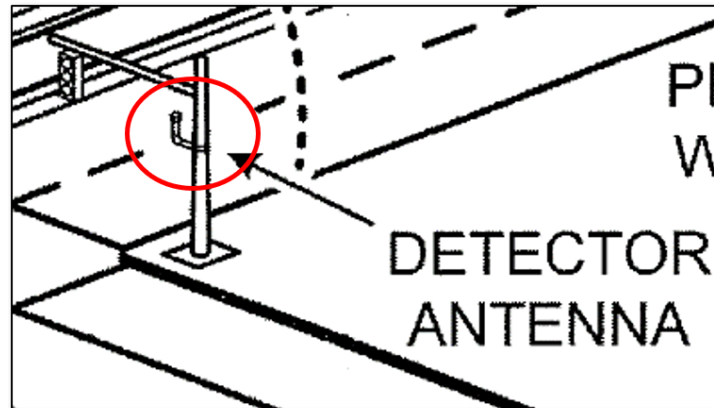
293. The Cross-Grisham combination that I described above (§ VII.B.3) includes Cross’s “priority detectors,” which “are wayside devices” “located at various locations along a particular vehicle’s route.” Cross, [049], FIG. 1. These priority detectors are, therefore, configured for placement on or near a track, as claimed.

- c. **12[B]: “wherein each wayside unit comprises: a communication component, comprising one or more antennas, configured to transmit and/or receive wireless signals,”**

294. The Cross-Grisham wayside priority detectors would have included a “communication component” having an antenna for transmitting/receiving wireless signals. In the Cross-Grisham system, these wireless signals would have been UWB signals, which is a specific type of radio (RF) signal. As Cross explains, its priority detectors are “capable of receiving radio frequency (RF) signals and forwarding the received data” to companion devices like Cross’s PNUs or VCUs. Cross, [049]. More specifically, the Cross-Grisham detector would (1) “receiv[e]”

wireless signals from components in the system such as a Cross's VCUs, PNUs and other detectors (*see* §§ VII.B.2-3), and (2) "forward[]," i.e., transmit, wireless alert notification signals to those same components, in order to increase the safety and reliability of the system. Cross, [049].

295. To receive and forward the data through the network, Cross's wayside priority detectors use an antenna, such as the antenna depicted in the annotated Figure 1, below:



296. When Cross's priority detector is implemented using Grisham's impulse radio units in the Cross-Grisham combination, the priority detector would have maintained an antenna for sending and receiving UWB signals. Grisham's impulse radio unit includes a "transmit antenna" that is capable of generating an "emitted signal" that is "wide-band or ultrawide-band." Grisham, 17:26-36. To receive signals, the unit also includes a "receive antenna 704 for receiving a propagated impulse radio signal." Grisham, 17:46-47.

297. Accordingly, in the Cross-Grisham combination that I described above in § VII.B.3 the wayside priority detector would have included a communication component comprising an antenna along with related circuitry for processing wireless RF signals—which together are a “communication component,” as claimed.

d. 12[C]: “wherein the signals comprise ultra-wideband (UWB) signals;”

298. In the combined Cross-Grisham system described above (§ VII.B.3), the VCU, PNU, and wayside priority detector would each include an impulse radio unit of the type described in Grisham to send and receive data. Grisham states, and POSAs would have understood, that a system using impulse radios of the type disclosed is the same as an “ultra-wideband system, or ultra-wideband communication systems.” Grisham, 5:8-13. Accordingly, in Grisham’s “preferred embodiment, the emitted signal is wide-band or ultrawide-band.” Grisham, 17:34-35.

299. Therefore, in the Cross-Grisham combination, the wireless signals sent and received by the wayside priority detector would comprise ultra-wideband signals, as claimed.

- e. **12[D]: “and one or more circuits configured to process signals and data, and perform one or more applications or functions relating to operations of the wayside detection unit;”**

300. In the Cross-Grisham combination, the portable priority detectors would have included electronic circuits operable to process received wireless signals (and the data contained in those signals), like “real-time vehicle and worker activity and alert notifications,” and to transmit the signals (and associated data) to other components in the system, consistent with Cross’s teachings. Cross, [049]. As Cross at [031] teaches, “receivers...encompass an electronic circuit” and a POSA would understand that transmitters and/or transceivers do as well. These receiving and transmitting functions by the priority detector are operations of the wayside priority detectors and relate to operations of the wayside priority detectors (e.g., they relate to the detectors’ relaying of data functionality).

- f. **12[E]: “and wherein the one or more wayside units are configured to operate cooperatively with any train-mounted unit deployed on a train traversing the track, to provide alerts to one or more workers operating on or near the track, based on communication of the UWB signals between at least one of the one or more wayside units and the train-mounted unit.”**

301. Cross’s VCU is an “onboard unit” (Cross, [034]) that is installed “into [a] mass transit vehicle,” where the installation can be “either permanent—by direct integration into the [] vehicle”—“or temporary, through a mobile receiver

that can be taken into and removed from the vehicle.” Cross, [029], [034]-[035]. Thus, Cross’s VCUs are train-mounted units deployed on a train traversing the track, as claimed.

302. Cross’s wayside priority detectors, which are “wayside devices,” “function as intermediaries..., receiving signals [communicated] from VCUs (103) and PNU’s (102) and forwarding the real-time vehicle and worker activity and alert notifications...to...VCUs (103), or PNU’s (102).” Cross, [049], [0055], [0062], [0067]. Thus, Cross’s wayside priority detectors are wayside units configured to operate cooperatively with Cross’s VCU (e.g., by forwarding signals communicated to or from the VCU), as claimed.

303. By sending, receiving, and forwarding these signals, Cross’s VCU and wayside priority detector operate cooperatively to provide alerts to workers operating on or near the track. In particular, as discussed, Cross’s VCU “send[s] automatic vehicle location (AVL) packets to the other components of the network[.]” Cross, [038]. The AVL “signal includes, but is not limited to, location-based information about the vehicle (e.g., its velocity, acceleration, direction, route, bearing, etc.).” Cross, [038]. Information conveyed in AVL packets can be determined from “a GPS receiver (or other contemplated positioning system”). Cross, [035].

304. The PNU “receive[s] communications and information” from companion alert devices, such as AVL packets comprising information about (e.g., location of) approaching vehicles. Cross, [043]-[044], [050].

305. Based on the AVL packets received from VCUs and/or priority detectors, the PNU’s computer “can identify alert mode conditions” (Cross, [043]) and if such a condition exists, the PNU “will go into alert mode” (Cross, [0044]). *See also* Cross, [056] (disclosing that the PNU processes received AVL packets to “determine[] whether to enter an alert mode”). The PNU processes the signals it receives from these companion devices to “determine[] whether to enter an alert mode.” Cross, [056] (disclosing that a PNU determines whether to enter an alert mode in a warning area based on processing an “(AVL) from an approaching vehicle”); *see also* Cross, [061] (PNU “determines whether or not an alert mode needs to be triggered” based “[u]pon the exchange of” information received in wireless signals from other devices).

306. Once the PNU “determines an alert condition exists” and has entered alert mode, the PNU’s computer outputs “audio, movement and visual alert signals” via its indicator components, the PNU’s “LEDs, vibration[al components] and...speakers.” Cross, [043]. Determining whether an alert mode condition is based on the safety alert generated by the PNU. *See* Cross, [056] (PNU “will trigger a warning call, as discussed previously, to notify the equipped worker of the

high risk event”), Cross, [061] (“Upon activation of the alert mode, the PNU (102) will trigger an alert signal and notify the worker, via audio, movement, visual or other signals”). Thus, the physical alert indications output by the indicator components are based on the existence of an “alert mode.”

307. When the wayside priority detector forwards AVL packets sent by the VCU to the PNU(s), the wayside priority detector is operating cooperatively with the VCU, as claimed. Additionally, because the reception of these wireless signals at the PNU(s) results in the PNU(s) entering an alert mode, the VCU and wayside priority detectors operative cooperatively to provide alerts to the workers operating on or near the track, as claimed. Furthermore, because the PNU(s) determine whether an alert mode exists based on the AVL packets that are sent by the VCU and/or forwarded by the wayside priority detectors, alerts are provided to the workers based on communication of wireless signals between the train-mounted VCU and the wayside priority detectors, as claimed.

308. Additionally, as discussed above (§ VII.B.3), the Cross-Grisham combined system would utilize Grisham’s UWB radio technology to transmit UWB signals between the VCU(s), PNU(s), and wayside priority detector(s). In the combined system, the AVL packets sent by VCUs would be sent using UWB signals. These UWB signals would be received by wayside priority detectors and “forwarded” to PNU(s) as UWB signals. Accordingly, in the Cross-Grisham

system, the train-mounted VCU and wayside priority detectors would operate cooperatively to provide alerts to workers based on the communication of UWB signals, as claimed.

7. Dependent Claims 17-19

- a. Claim 17: “The system of claim 12, wherein at least one wayside unit is configured to forward alerts and/or alert related signals received from the train-mounted unit.”**

309. In the Cross-Grisham combination that I discussed above (§ VII.B.3), Cross-Grisham’s priority detectors apply Cross’s teaching to “function as intermediaries..., receiving signals [communicated] from VCUs (103) and PNUs (102) and forwarding the real-time vehicle and worker activity and alert notifications [and ETA information (i.e., the alerts and alert-related signals)]...to...VCUs (103), or PNUs (102).” The PNUs and VCUs receiving the forwarded signals are nearby vehicle and personal alert devices, respectively, as claimed. Cross, [049]; § VII.B.2 above (where I discuss Cross’s VCUs and PNUs).

- b. Claim 18: “The system of claim 12, wherein at least one wayside unit is configured to log data relating to alerts triggered in response to broadcasted alert related signals.”**

310. Cross teaches “stor[ing] detailed activity and alert logs” in its PNUs ([041]) and in its VCUs ([034]). As I discussed above (§ VII.B.3), Cross-Grisham’s wayside priority detectors forward signals to and from nearby

companion devices (e.g., PNUs and VCUs) to provide alerts to workers operating on or near the track via the workers' PNU(s). A POSA would have had reason to include logging functionality like that found in Cross's PNUs and VCUs in the Cross-Grisham's wayside priority detectors so that the priority detector could also log data regarding the alerts triggered based on signals forwarded by the priority detector.

311. POSAs would have recognized that giving the priority detectors the same ability to store logs that the PNUs and VCUs already had in Cross's system would have been beneficial because, in the Cross-Grisham combination, all of these devices would have operated cooperatively to trigger alerts that a system operator would have wanted to log and keep track of. For example, as Cross teaches and was known in the art, such logs beneficially "allow[] for administrators to evaluate trends and identify reoccurring safety issues and locations in the mass transit system as a whole." Cross, [063]. My opinion that logging data was conventional and beneficial is corroborated by EX1016, which teaches (at 5:19-25) that logs are "useful in cases where liability is an issue" and so the timing of alerts and/or operations of devices generating alerts in the system was important to maintain in logs. Similarly, EX1018 (at [0039]) teaches that logs permit administrators to "easily analyze and verify operation of the system."

312. For the same reasons, an administrator of the Cross-Grisham combination would have wanted to analyze and verify operation of the devices in the system, including the portable priority detectors. For instance, if the VCU were to malfunction or otherwise fail to log the alert histories, the alert histories logged by the priority detectors would provide a back-up source for obtaining this information. Having a back-up source for obtaining this information that is not associated with the train (unlike the VCU) would be particularly beneficial in the event that there is a collision involving the train, during which the VCU may be damaged or become otherwise inaccessible.

313. Additionally, POSAs would have appreciated further benefits to including data-logging functionality in Cross-Grisham's priority detectors in light of Grisham's disclosure of wayside units that are "capable of using a sensor . . . to sense the presence of a third object (e.g., locomotive 1102)." Grisham, 23:12-16. As discussed above in § VII.B.3, the Cross-Grisham system includes these wayside "sensors" to detect the presence of an oncoming locomotive, resulting in the transmission of an alert-triggering signal by the wayside unit. Because Cross-Grisham's wayside priority detectors would be equipped with these sensors and, as a result, be capable of generating alert-triggering signals independent of the VCU, POSAs would have recognized that it would have been most efficient to log these

alerts at the wayside priority detector rather than relying on a VCU or PNU to log the alert.

314. A POSA would have understood that logging data relating to the operations of the wayside device would have also been using a known technique (logging operations of wayside devices in a traffic system) to improve similar devices (wayside devices in the system) in the same way (by keeping records of operations and alerts for diagnostic and tracking purposes).

315. In my opinion, POSAs would have reasonably expected success in logging data relating to alerts in the Cross-Grisham priority detectors because Cross already teaches logging data in portable PNU devices and so it would have required only ordinary skill to include in priority detectors (1) similar instructions and/or software or firmware code to record alerts in a data log in the priority detectors and (2) conventional memory in the device to maintain the log data.

- c. **Claim 19: “The system of claim 12, wherein at least one wayside unit comprises one or more sensory components, for detecting, monitoring, and/or tracking trains, and wherein the at least one wayside unit configured to determine, based on sensory data obtained from the one or more sensors, when the train is approaching the wayside unit.”**

316. As discussed above (§ VII.B.3), the Cross-Grisham system would not only utilize Grisham’s impulse radio units for wireless communication between Cross’s VCU, PNU, and priority detectors, but would also utilize Grisham’s

wayside “sensor” in conjunction with Cross’s priority detectors to detect an approaching train.

317. In this combined system, the wayside priority detector would therefore use a “sensor 1506 (e.g., electromagnetic sensor, motion detector, percussion sensor) to sense the presence of a[n] object,” as taught in Grisham. Grisham, 23:14-16. In particular, the sensor would detect when a train/vehicle is approaching the wayside priority detector; when detected, an impulse radio associated with the priority detector would then “transmit” a signal to any PNU(s) in the area around the priority detector, which would cause the PNUs to enter an alert mode and trigger an alarm signal, as taught in Cross. *See* Grisham, 23:25-35.

318. Thus, in the Cross-Grisham system, the priority detector (a “wayside unit”) would include a sensor (“sensory components”) that would detect (i.e., “determine”) that a train is approaching the priority detector based on the sensor inputs, as claimed.

C. Ground 3: Claims 6, 8-9, and 17-18 Would Have Been Obvious over Meyer and Grisham in view of Cross

1. Overview of Ground 3

319. For the reasons I discuss below in §§ VII.C.2, it is my opinion that claims 6, 8-9, and 17-18 would have been obvious over Meyer in view of Grisham and Cross.

2. Meyer-Grisham-Cross Combination

320. Although Meyer and Cross disclose similar systems for worker protection and could have combined either of these systems independently with Grisham as disclosed above, a POSA could have also combined Meyer, Grisham, and Cross in a different manner. In particular, a POSA could have maintained the overall structure of Meyer's worker protection system, implemented the system using Grisham's impulse radio units (as discussed in Ground 1), and configured Meyer's stationary unit, mobile unit, and worker transponders to include aspects of Cross's VCU, PNU, and priority detectors. As described previously, Meyer and Grisham each include a train-based unit, a wayside unit, and a worker-based unit. Each of these devices is similar in construction and functionality, and it would have required only minor modifications to combine certain conventional functions of these respective devices. Thus, a POSA would have faced a reasonable expectation of success in making the Meyer-Grisham-Cross combination described below.

321. First, a POSA would have implemented Meyer-Grisham-Cross by configuring the stationary unit, mobile unit, and/or worker transponders to perform Cross's data-generating and data-logging operations. Cross, [028], [033], [039], [063]. A POSA would have understood the benefits of keeping track of when, where, and why alerts were triggered during operation of the system. Such

operations would allow system administrators to determine, e.g., whether train operators and/or workers responded appropriately in response to safety alerts. And, in the event of a collision, the data logs would provide insight into whether/how the collision could have been prevented.

322. Second, a POSA would have implemented Meyer-Grisham-Cross by housing Meyer's stationary unit and worker transponder in the manner disclosed in Cross. In particular, a POSA would have been motivated to enclose Meyer's stationary unit within a housing and to configure this housing as portable, detachable, and movable from the train. Cross motivates this combination by teaching that this configuration allows the unit to be "taken into and removed from the vehicle," which a POSA would understand to be a beneficial feature allowing the stationary unit to be more easily repaired, replaced, or moved between trains. Cross, [035].

323. Third, a POSA would have implemented Meyer-Grisham-Cross by configuring the mobile units to forward signals received from the stationary unit to the worker transponder and from the worker transponder to the stationary unit. Cross's wayside priority detectors "receiv[e] radio frequency (RF) signals and forward[] the received data through the network" to other devices (e.g., PNUs or VCUs). Cross, [049]. Because the mobile units already have the capability to send and receive data, it to configuring the mobile units to forward data received from

one device (e.g., the stationary unit) to other devices in the system (e.g., the worker-carried mobile transponders) would have been a routine combination of known elements.

324. More specifically, POSAs would have had reason to utilize the “intermediary” (i.e., data-forwarding) function of Cross’s wayside priority detectors in Meyer-Grisham-Cross’s mobile unit to forward the “acknowledgement signal” sent by the worker transponders to the train-based stationary unit in response to an alert being generated at the transponder. As taught in Meyer, the mobile unit receives “acknowledgement signals” sent by the worker transponders and, in response, generates a “collision status signal” that is a “function of the determined number of [acknowledgements] received.” Meyer, ¶¶24-27, 43. It then sends the status signal to the stationary unit. Meyer, ¶¶24-27, 43. POSAs would have appreciated, however, that it would have been more efficient to simply configure the mobile unit to operate as an “intermediary” and “forward” these acknowledgement signals directly to the stationary unit, as taught in Cross. This configuration would have been more efficient both in terms of data processing required at the mobile unit and in terms of total time taken for the signal to travel from worker to train.

325. For at least these reasons, POSAs would have appreciated that improving the sharing of information across the different devices in the combined

system would make the system more robust and reduce the likelihood that the failure of any one component in the system would compromise the effectiveness of the overall system.

a. Claim 6: “The system of claim 1, wherein the train-mounted unit is configured to log data relating to alerts triggered in response to movement of the train.”

326. Meyer-Grisham-Cross’s VCU is “equipped with monitor software which allows for the real-time monitoring and display of worker activity and locations on a user interface.” Cross, [039]. The VCU “create[s] detailed logs and reports which show worker location and alert histories along the route. These logs and reports may be generated and automatically e-mailed to administrators or other interested individuals.” Cross, [039]. A POSA would implement Meyer-Grisham-Cross’s stationary unit to include this data-logging functionality to create detailed logs of “alert histories,” which would include data relating to alerts triggered by the system.

327. This implementation is motivated by Cross’s teaching that “reporting and log creation function” “allows for administrators to evaluate trends and identify reoccurring safety issues and locations in the mass transit system as a whole.” Cross, [063].

- b. Claim 18: “The system of claim 12, wherein at least one wayside unit is configured to log data relating to alerts triggered in response to broadcasted alert related signals.”**

328. A POSA would have been further motivated to enable the mobile units to perform the data-logging functions described in Cross. A POSA would have understood that if the stationary unit of the system were to malfunction or otherwise fail to record the alert histories as described above, the alert histories logged by the wayside mobile unit would provide a back-up record of this information. Additionally, as discussed above, the logging of alerts at the wayside unit would have been a way to record any alerts triggered by the wayside unit (e.g., based on the use of a sensor to detect an oncoming locomotive).

- c. Claim 8: “The system of claim 1, wherein the train-mounted unit comprises housing for enclosing components of the train-mounted unit.”**

Claim 9: “The system of claim 1, wherein the train-mounted unit is configured, at least in part, as portable, detachable and moveable from the train.”

329. In Meyer-Grisham-Cross, the “[i]nstallation of the VCU” may be “temporary, through a mobile receiver that can be taken into and removed from the vehicle.” Cross, [035].

330. A POSA would have appreciated that using a portable, detachable, and movable train-mounted unit would provide greater flexibility, as it would allow the train-mounted unit to be more easily moved between trains and/or within

a train. Moreover, POSAs had reason to implement such a design to ensure that its components were secure within the train.

d. Claim 17: “The system of claim 12, wherein at least one wayside unit is configured to forward alerts and/or alert related signals received from the train-mounted unit.”

331. In Meyer-Grisham-Cross, the mobile unit “transmit[s] a near-range warning signal 14 that can be received by [] mobile transponders” that are carried by workers when it receives a signal from the stationary unit and detects a collision risk. Meyer, ¶41. A POSA would have implemented these mobile units in Meyer-Grisham-Cross to “receiv[e] radio frequency (RF) signals and forward[] the received data through the network” to nearby worker transponders, as disclosed in Cross. Cross, [049]. Cross teaches that its wayside devices “function as intermediaries in the overall system (101), receiving signals from ...VCUs (103) and PNUs (102) and forwarding the real-time vehicle and worker activity and alert notifications received in these signals to the...VCUs (103), or PNUs (102).” Cross, [049].

332. A POSA would have understood that including this functionality in Meyer-Grisham-Cross’s mobile units would have enhanced the worker safety system because a stationary unit would be able to directly send radio signals not only to mobile units within range of the stationary unit, but also to other system components within the range of the wayside mobile unit to which the radio signal

can be forwarded by the mobile unit. Additionally, including this functionality in Meyer-Grisham-Cross would have improved the communication of worker acknowledgement signals from worker transponders to the train's stationary unit by removing the unnecessary step of processing the worker acknowledgement signals at the mobile unit and instead configuring the mobile unit to function as an "intermediary" and forward the acknowledgment signal to the stationary unit.

333. 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.

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

Dated: 05 Jan 2023

A handwritten signature in black ink, reading "Michael S. Braasch". The signature is written in a cursive, flowing style.

Michael S. Braasch, Ph.D., P.E.

VIII. CLAIM LISTING

Claim 1
1[pre] A system for worker protection, the system comprises:
1[A] a train-mounted unit for use on a train
1[B] wherein the train-mounted unit comprises: a communication component, comprising one or more antennas, configured to transmit and/or receive wireless signals
1[C] wherein the signals comprise ultra-wideband (UWB) signals
1[D] and one or more circuits configured to process signals and data, and perform one or more applications or functions relating to operations of the train-mounted unit
1[E] and wherein the train-mounted unit is configured to operate cooperatively with one or more wayside units, configured for placement on or near a track traversed by the train, to provide alerts to one or more workers operating on or near the track, based on communication of the UWB signals with at least one of the one or more wayside units.
Claim 2
2. The system of claim 1, wherein the train-mounted unit is configured to broadcast alert triggering signals.
Claim 3
3. The system of claim 1, wherein the train-mounted unit is configured to generate data relating to alerts and/or to other devices or objects in a path of the train, based on the communication of the UWB signals with at least one of the one or more wayside units.
Claim 4
4. The system of claim 1, wherein the train-mounted unit is configured to generate feedback information for outputting to an operator of the train, based on the communication of the UWB signals with at least one of the one or more wayside units.
Claim 5
5. The system of claim 1, wherein the train-mounted unit is configured to: receive a signal indicating an acknowledgment of a safety alert by a worker of the one or more workers, in response to broadcasted alert triggering signals; and provide an indication of the acknowledgement to an operator of the train.
Claim 6

6. The system of claim 1, wherein the train-mounted unit is configured to log data relating to alerts triggered in response to movement of the train.
Claim 7
7. The system of claim 1, wherein the train-mounted unit comprises one or more input/output (I/O) components, for receiving input from an operator of the train and/or for providing output to the operator of the train.
Claim 8
8. The system of claim 1, wherein the train-mounted unit comprises housing for enclosing components of the train-mounted unit.
Claim 9
9. The system of claim 1, wherein the train-mounted unit is configured, at least in part, as portable, detachable and moveable from the train.
Claim 10
10. The system of claim 1, wherein the train-mounted unit is arranged into a plurality of separate physical units that comprises at least a broadcast unit comprising at least the communication component, and wherein the broadcast unit is configured for deployment external to the train.
Claim 11
11. The system of claim 10, wherein the plurality of separate physical units comprises an operator unit comprising at least the one or more I/O components, and wherein the operator unit is configured for use by an operator of the train.
Claim 12
12[pre] A system for worker protection, the system comprises:
12[A] one or more wayside units configured for placement on or near a track;
12[B] wherein each wayside unit comprises: a communication component, comprising one or more antennas, configured to transmit and/or receive wireless signals,
12[C] wherein the signals comprise ultra-wideband (UWB) signals;
12[D] and one or more circuits configured to process signals and data, and perform one or more applications or functions relating to operations of the wayside detection unit;
12[E] and wherein the one or more wayside units are configured to operate cooperatively with any train-mounted unit deployed on a train traversing the track, to provide alerts to one or more workers operating on or near the track, based on communication of the UWB signals between at least one of the one or more wayside units and the train-mounted unit.
Claim 13

13. The system of claim 12, wherein each wayside unit comprises a power supply for powering components of the wayside unit.
Claim 14
14. The system of claim 12, wherein each wayside unit comprises a housing for enclosing components of the wayside unit.
Claim 15
15. The system of claim 12, wherein each wayside unit comprises a support structure for holding and supporting the wayside unit when placed on or near the track.
Claim 16
16. The system of claim 12, wherein at least one wayside unit is configured to broadcast alert related signals, relating to the train when approaching the wayside unit.
Claim 17
17. The system of claim 12, wherein at least one wayside unit is configured to forward alerts and/or alert related signals received from the train-mounted unit.
Claim 18
18. The system of claim 12, wherein at least one wayside unit is configured to log data relating to alerts triggered in response to broadcasted alert related signals.
Claim 19
19. The system of claim 12, wherein at least one wayside unit comprises one or more sensory components, for detecting, monitoring, and/or tracking trains, and wherein the at least one wayside unit configured to determine, based on sensory data obtained from the one or more sensors, when the train is approaching the wayside unit.
Claim 20
20[pre] A system for protecting workers near railroad tracks, comprising:
20[A] one or more UWB radios at pre-determined locations along the railroad tracks;
20[B] one or more worker UWB radios associated with one or more workers on or near the railroad tracks;
20[C] a vehicle UWB radio associated with a vehicle on the railroad track;
20[D] wherein: the vehicle UWB radio is in communication with a processor,

20[E] wherein: the processor determines a position of the vehicle based on time of flight measurements obtained based on communication between the vehicle UWB radio and at least one of the one or more UWB radios that are located at pre-determined locations;
20[F] the processor determines a location in which the one or more workers are working based on time of flight information obtained based on communication with at least one of the one or more worker UWB radios;
20[G] and the processor generates an alert to an operator of the vehicle based on the determined location of the one or more workers;
20[H] and at least one worker UWB radio communicates time of flight information between the at least one worker UWB radio and the vehicle UWB radio to a processor in communication with the at least one worker UWB radio,
20[I] wherein the processor generates alerts to a worker associated with the at least one worker UWB radio based on one or more of: a determined distance to the vehicle UWB radio, an estimated time of closest approach of the vehicle UWB radio to a location of the at least one worker UWB radio, and an approach speed of the vehicle UWB radio.