

UNITED STATES PATENT AND TRADEMARK OFFICE

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BEFORE THE PATENT TRIAL AND APPEAL BOARD

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

v.

METROM RAIL, LLC  
Patent Owner.

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Case No. IPR2023-00452  
Patent No. 10,778,363

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**DECLARATION OF ARON Z. KAIN, PH.D.**

|                                                       |
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| Siemens Exhibit 1003<br>Siemens et al. v. Metrom Rail |
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I, Aron Z. Kain, declare:

1. I have been retained by counsel for Petitioners to assess claims 1-16 (the “challenged claims”) of U.S. Patent No. 10,778,363 (“the ’363 patent”). I am being compensated for my time at my standard rate of \$525.00 per hour, plus actual expenses. My compensation is not dependent in any way upon the outcome of the *inter partes* review of the ’363 patent.

## **I. PERSONAL AND PROFESSIONAL BACKGROUND**

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

3. I am a Principal and Chief Technology Officer for BH Technology, LLC, which is an engineering company that designs and develops sensors and sensing systems for a wide variety of applications. I have a B.A. degree in Physics and Computers from Yeshiva University. I also have a M.S. degree in Electrical Engineering from Columbia University. I completed my Ph.D. in Electrical Engineering at the University of California at Los Angeles.

4. In addition to my academic credentials, I also have over 30 years of hands-on experience in the areas of sensor and sensor system development. These sensors include physical parameter devices such as moisture sensors (soil, rain, ice, seawater) force, pressure, temperature, flow, torque, level, and displacement as well

as their associated communications protocols such as RFID, Wi-Fi, 802.11, RS-232, RS-485 and Ethernet. I have dealt in some fashion with every part of the sensor development and manufacturing process. I have personally conceived, designed, layed out, fabricated, assembled, prototyped, tested, and commercialized all the above sensor types using varied manufacturing technologies and topologies such as printed circuit board (PCB), multi-layer ceramic, MEMS, and silicon based integrated circuits. I have personally developed intellectual property for all the above sensors and am a named inventor on six patents.

5. Particular to the matter at hand, I have been involved with the design and development of UWB and UWB-related sensor and device development since the mid-1980's. In the mid-1980's I helped develop a 94GHz Time Domain Reflectometer (TDR) based on superconducting electronics for Hypres Inc., located in Elmsford, NY. TDR is an equivalent technology to UWB whereby TDR performs ultra-wideband measurements along a particular transmission line structure such as a high-speed cable, while UWB performs the same ranging and distance measurements in an unguided environment, such as over-the-air as associated with the matter at hand. In the mid-1990's I helped develop UWB components for the Los Angeles Light Rail system for TRW, Inc. These included amplifiers, oscillators, and filters. In the years since then I have developed, and continue to develop, UWB

ranging and distance applications used in the US military, most recently in the development of the Robotic Combat Vehicle.

## **II. MATERIALS REVIEWED AND CONSIDERED**

6. 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.

| <b>Exhibit</b> | <b>Description</b>                                   |
|----------------|------------------------------------------------------|
| <b>1001</b>    | U.S. Patent No. 10,778,363 (“the ’363 patent”)       |
| <b>1002</b>    | Prosecution History of U.S. Patent No. 10,778,363    |
| <b>1005</b>    | U.S. Patent Publication No. 2015/0329130 (“Carlson”) |
| <b>1006</b>    | U.S. Patent Publication No. 2012/0296562             |
| <b>1007</b>    | U.S. Patent Publication No. 2009/0253439 (“Gantner”) |
| <b>1008</b>    | European Patent No. 2,571,742 (“Ghaly”)              |
| <b>1009</b>    | U.S. Patent No. 7,725,252 (“Heddebaut”)              |
| <b>1010</b>    | U.S. Patent Publication No. 2016/0046308             |
| <b>1011</b>    | U.S. Patent Publication No. 2007/0293153             |

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| <b>1012</b> | Int. J. ITS Res., “Assessment of the Contribution of Time Reversal of a UWB Localization System for Railway Application”                |
| <b>1013</b> | U.S. Patent Publication No. 2013/0138276                                                                                                |
| <b>1014</b> | U.S. Patent No. 9,434,397                                                                                                               |
| <b>1016</b> | 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) |
| <b>1017</b> | The Free Dictionary.com Definition of “Broadcasting”                                                                                    |
| <b>1018</b> | ETSI Technical Report 101 538 V1.1.1 (2012-10)                                                                                          |
| <b>1019</b> | IEEE Std 802.15.4™-2011, IEEE Standard for Local and Metropolitan Area Networks: Part 15.4: Low-Rate Wireless Personal Area Networks    |
| <b>1020</b> | U.S. Patent Publication No. 2015/0097412                                                                                                |
| <b>1021</b> | U.S. Patent Publication No. 2004/0240565                                                                                                |
| <b>1022</b> | U.S. Patent Publication No. 2010/0235460                                                                                                |
| <b>1023</b> | U.S. Patent Publication No. 2010/0039978                                                                                                |
| <b>1024</b> | U.S. Patent No. 9,606,217                                                                                                               |
| <b>1025</b> | U.S. Patent No. 5,452,870                                                                                                               |
| <b>1026</b> | CCS: A Railway Corridor Control System Utilizing Ultra Wideband Radio Technology (2004)                                                 |
| <b>1027</b> | Newton’s Telecom Dictionary (27th ed 2013)                                                                                              |
| <b>1028</b> | Dictionary of Computer Science, Engineering, and Technology (2001)                                                                      |
| <b>1029</b> | Microsoft Computer Dictionary (5th Ed. 2002)                                                                                            |
| <b>1030</b> | Time Domain’s Ultra Wideband (UWB) Definition and Advantages, Time Domain (March 2011)                                                  |

|             |                                          |
|-------------|------------------------------------------|
| <b>1031</b> | U.S. Patent No. 6,631,322                |
| <b>1032</b> | U.S. Patent Publication No. 2006/0009240 |

### **III. MY UNDERSTANDING OF PATENT LAW**

7. 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:

8. 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.

9. I understand that, in this proceeding, Petitioner has the burden of proving that the challenged claims of the ’363 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.

10. 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. I have applied these standards in preparing the opinions in this declaration.

11. I understand that determining whether a particular patent or printed publication constitutes prior art to a challenged patent claim can require determining the effective filing date (also known as the priority date) to which the challenged claim is entitled. I have been told to assume that the earliest priority date for the claims of the '363 patent is August 4, 2017.

12. 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**

13. 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.

14. 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**

15. 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.

16. 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 '363 patent.

17. 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.

18. 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.

19. 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”)**

20. 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.

21. At a high-level, the ’363 patent involves wireless communications technologies used in the field of control systems. More specifically, the patent relates to the use of such wireless technologies to control functions in a railway or train system, like the Los Angeles Metro Rail.

22. I have been asked to provide my opinions as to the state of the art in this field by 2017. I use this timeframe because the face of the ’363 patent indicates an earliest claimed priority date of an August 4, 2017 filing date of a provisional application. EX1001 at (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 ’363 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 2017 timeframe, even if I do not say so specifically in each case.

23. 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.

24. In my opinion, a POSA in 2017 would have had a background in wireless electronics, including at least a bachelor's degree in electrical engineering or a related field and POSAs would have 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 '363 patent and the prior-art references discussed in this declaration.

25. By 2017, I held a Ph.D. in Electrical Engineering, and I had 20+ years of experience with wireless technologies and using those technologies in control systems. Therefore, I was a person of more than ordinary skill in the art during the relevant timeframe. However, I have supervised 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. TECHNOLOGY BACKGROUND AND OVERVIEW OF THE PATENT**

26. In Section V, I provide an overview of the relevant technology to which the '363 patent is directed as well as an overview of the patent itself.

### **A. Relevant Technology Background**

27. As discussed in more detail in Section V.B, the '363 patent relates to systems for controlling trains within a railway network. Train systems, such as the typical modern subway system, employ train control mechanisms to facilitate the safe movement of trains within the system. In Section V.A.1, I discuss conventional train-control systems that were well-known in the art prior to August 2017.

28. As discussed in more detail in Section V.B, the '363 patent also relates to the use of wireless communications to facilitate a train-control system. The primary wireless communication technology that the patent uses in its exemplary embodiments is ultra-wideband (or UWB for short) radio technology. In Section V.A.2, I discuss UWB technology and how it was known in the prior art that UWB can be used both to communicate data and/or determine a device's position by, for example, determining the distance between two UWB radios.

#### **1. Train Control Systems**

29. As of 2017, there were several known train-control systems, each with their own unique benefits and drawbacks. Three of those systems are: (1) fixed-block train-control systems, (2) communications-based train-control systems, and

(3) positive-train-control systems. These systems are not mutually exclusive: they share common aspects, and they can be used in combination with other each other and other types of train-control systems, depending on the specific needs and requirements of a given railway system.

**a. Fixed-Block and Moving-Block Train-Control Systems**

30. A fixed-block train-control system is a type of railway signaling system that controls the movement of trains within a defined section of track, known as a block. EX1010, [0004]-[0006]. The system is designed to ensure the safe and efficient operation of trains by preventing collisions and regulating the speed and movement of trains. EX1010, [0004]-[0005]. In a fixed-block system, the track is divided into a series of blocks, each of which is equipped with sensors and signals that typically communicate with a central control system (*e.g.*, a central server). See EX1010, [0006]. The central control system monitors the movement and position of trains within each block and sends signals to trains to control their speed and movement. There are several types of fixed-block systems, including traditional mechanical systems, which use mechanical signals and trackside equipment to control train movement, and modern electronic systems, which use electronic signals and computerized control systems to monitor and control train movement.

31. “An improve[ment]” over a fixed-block system was a “‘moving block’ system where the block was not geographically fixed, but each ‘block’ moved with

the train in that moving block and had a length predetermined by train speed, stopping distance, speed limits, wayside sensors and central control capabilities.” EX1010, [0007].

#### **b. Communications-Based Train-Control Systems**

32. Communications-Based Train Control (CBTC) is a train positioning and control technology based on continuous two-way communications between trains and, for example, “Zone controllers on the wayside.” EX1008, [0003]. A computer onboard the train continuously determines the location of the train using distance or speed measurements calculated onboard the train. EX1008, [0003]. Distance or speed measurements could occasionally be calibrated by using a radio frequency sensor onboard the train to scan passive transponders located on the track between the rails (*e.g.*, RFID tags). EX1008, [0003]. Calibration is necessary because distance or speed measurements made onboard the train are prone to accumulated error due to wheels slipping, sliding, or spinning, for example, in a tachometer-based measurement system. The passive transponders are located at known reference locations within the train system to periodically mitigate accumulated error. EX1008, [0003].

33. In response to receiving location reports from trains in the train system, the system controller transmits to all trains a data map that contains the topography of the tracks, speed limits, locations of wayside signal equipment, and a movement

authority limit. EX1008, [0004]. The computer onboard each train considers the movement authority limit and other information from the system controller to autonomously generate and enforce safe operation of the train. EX1008, [0004].

**c. Positive-Train-Control Systems**

34. In the United States, the “Rail Safety Improvement Act of 2008” mandated the installation of positive train control (PTC) systems. EX1010, [0008]. PTC is a type of advanced train control system that is intended to improve the safety of railway operations by reducing the risk of accidents caused by human error or other factors. PTC systems do this by automatically stopping or slowing down a train when the system on board the train detects a potential collision or other dangerous situation. PTC systems typically use a combination of technologies, including GPS, radio communications, and sensors, to monitor the movement and position of trains in real-time and to automatically initiate corrective actions when necessary, without the need for control signals from a centralized server. *See, e.g.*, EX1010, [0074] (“Overall control of positive train control unit 100, including on, off and other control of sensors 112, 114, 116, 118 and/or 122, is preferably under the control of PTC processor 120 [inside the PTC unit mounted to the train, *see* [0053]].”).

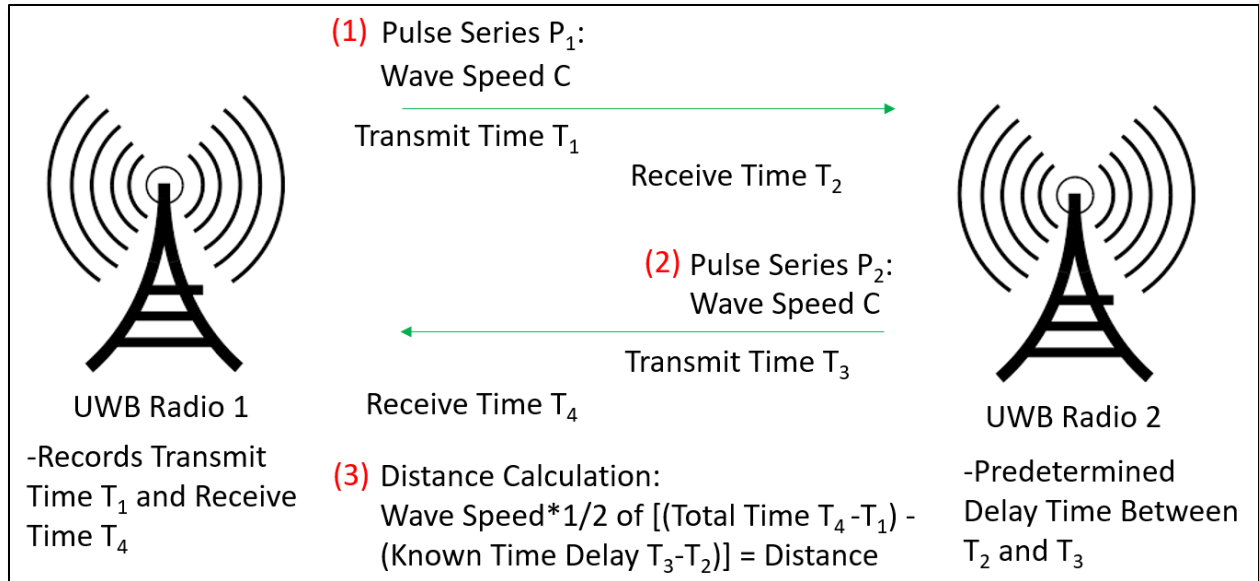
## **2. Ultra-Wideband Positioning and Sensor Technology, Including Its Use for Ranging**

35. Ultra-Wideband (UWB) technology “is a wireless technology for transmitting large amounts of data over a wide spectrum of frequency bands with very low power and for a short distance.” EX1011, [0003]. UWB signals also “have the ability to carry signals through doors and other obstacles that tend to reflect signals having more limited bandwidths and a higher power.” EX1011, [0003]. “USB communication has three main types of application:” “radar applications,” “data transmission applications,” and “location awareness applications” (*i.e.*, ranging). EX1011, [0005]. One way UWB systems can achieve high-bandwidth is by transmitting impulse-like waveforms, which have a short time profile and wide frequency profile, as opposed to traditional RF modulated sine waves, which have a long time profile and narrow frequency profile. EX1030 at p. 3. By 2007, IEEE had established a UWB standard 802.15.4a which includes use of UWB in precision-ranging applications. *See generally* EX1019; EX1011, [0009] (noting as background information that the “IEEE 802.15.4.a Task Group (TG) has been established to develop a UWB-based physical (PHY) layer standard with a precision ranging capability”).

36. UWB-based ranging techniques are used to measure the distance between two UWB radio units. One known way to perform ranging in UWB (and most wireless technologies) is based on the time it takes for a wireless signal to travel

from one radio unit to the other. See, e.g., EX1006, [0064]; EX1032, [0004] (“Several methods are known in the art for wirelessly determining the location of roaming device.”), [0006] (“Another sub-method measures the Time of Arrival (TOA) of a signal emitted by the roaming wireless device, received at least at three of the networks antennas. Knowing the location of these antennas and the TOA of the received Signal, the location of the roaming wireless device can be derived.”). For example, a first UWB radio unit may be on a fixed station on the wayside of a train track and a second UWB radio unit may be onboard a train traveling on the train track. The distance between the fixed station and the train can be measured based on the time it takes for UWB signals to be exchanged between the two UWB radio units. EX1009, FIG. 1, 6:3-9 (disclosing “[m]easuring the distance relative to a fixed reference upstream and/or downstream as ***based on the flight time of signals*** derived from pieces of geolocalised equipment and situated in upstream/downstream stations ***determines, with high degree of certainty and accuracy, the absolute position of the guided mobile***”) (emphasis added); EX1011, [0010] (incorporating by reference a 2002 IEEE-published document that disclosed “a time-of-arrival (TOA)-based ranging scheme using an ultra-wideband (UWB) radio link”).

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



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

38. UWB Radio 2 transmits a second UWB signal that is received by UWB Radio 1. Finally, the time elapsed between UWB Radio 1 transmitting the first UWB signal and receiving the second UWB signal from UWB Radio 2 is used as the basis for calculating the distance between the two radios. EX1030 at p. 11; EX1011, [0007]. For example, the distance calculation can be determined dividing the elapsed time in half (to get a one-way time-of-flight), subtracting the processing delay (*i.e.*, the time between UWB Radio 2 receiving and responding to UWB Radio 1's signal), and multiplying the result by the velocity of the UWB signals (*i.e.*, the speed of light in air). EX1011, [0008].

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

direction of movement of an object. For example, the distance between two units can be measured at regular intervals in the manner I described above. By measuring the distance between the transceivers at regular intervals, it is possible to calculate the speed and direction (if the transceivers are constrained to move along, for example, a railroad track) of movement of the object by comparing the distances between the transceivers at different points in time.

40. For example, if the distance between the transceivers increases over time, it can be inferred that the object is moving away from the receiver in a particular direction. Similarly, if the distance between the transceivers decreases over time, it can be inferred that the object is moving towards the receiver in a particular direction. The change in distance over an interval of time (typically a very short period of time such that straight line, *i.e.*, railroad track constrained, motion can be assumed) can be used to estimate the velocity over that interval (by dividing the change distance by the interval of time). *See, e.g.*, EX1026, 1 (“By co-locating such a chain of nodes along a railroad right-of-way, precise information on the location and velocity of trains could be distributed throughout the corridor.”).

41. UWB-based technology has several benefits over other common wireless technology. First, because of the wide-bandwidth / short-pulse duration of UWB signals, UWB-based signals are naturally resistant to multipath effects, improving operation in cluttered or non-line-of-sight (NLOS) environments without

the need for additional techniques to overcome multipath effects. *See, e.g.*, EX1030 at p.5; EX1006, [0064]; EX1009, [0047], EX1011, [0010]. By way of example, a UWB signal transmitted in many directions may take a direct path from a first UWB radio to a second UWB radio, and the same UWB signal may also take an indirect path from the first UWB radio to the second UWB radio by reflecting off of a wall. EX1030 at p.6; EX1006, [0064]. A narrowband (*i.e.*, long pulse) system may be unable to distinguish the direct path UWB signal from the indirect path UWB signal since they may overlap in time, resulting in multipath error. EX1030 at p. 6. In contrast, a UWB-based system uses short pulses that are more easily distinguishable in time because they are unlikely to overlap with their multipath reflections, allowing ranging to be performed using the first arriving UWB signal even if subsequent reflected versions of the same UWB signal arrive afterwards. EX1030 at pp. 6-7, 10.

42. As another advantage, UWB-based ranging provides high resolution for precise distance measurements. EX1030 at p. 4; EX1006, [0065], EX1009, [0055]. As I explained above, distance measurement is calculated based on the amount of time elapsed between transmission of a signal and its subsequent reception. EX1030 at p. 7. Since UWB signals are short and thus easily distinguishable in time, the arrival time of a UWB signal is easy to identify precisely. EX1030 at p. 7. Ambiguity in the exact arrival time can be reduced algorithmically

to provide distance measurements with precision of less than a few inches, and theoretically less than 2 mm. EX1030 at p. 7.

43. As yet another advantage, UWB-based ranging may be combined with UWB-based data communications functionality to use the same UWB signals for both ranging and (non-ranging) data communications. EX1030 at p. 13; EX1006, [0066]. That is, whereas previous systems used different technologies for ranging and data communications, needing multiple antennas, RF sections, and processors, a single UWB signal is simultaneously capable of transmitting data and used for ranging measurements. EX1030 at pp. 8-9, 13; EX1009, [0044]-[0045], [0048]-[0052].

44. Another benefit of UWB-based technology is that it requires low average operating power, making UWB efficient, unlikely to interfere with coexisting RF systems, and resistant to interception. EX1030 at p. 5; EX1006, [0066]; EX1011, [0003]-[0005]. For example, a typical UWB system transmits at power levels of only 50  $\mu$ W, and a high power UWB unit is around 10 mW. EX1030 at p. 5; EX1032, [0015] (noting that Bluetooth's power ranges from 1mW to 100mW).

#### **B. An Overview of the '363 Patent**

45. The '363 patent discloses a system for “decentralized rail signaling and positive train control.” EX1001, 1:21-25; *see also id.* at Abstract.

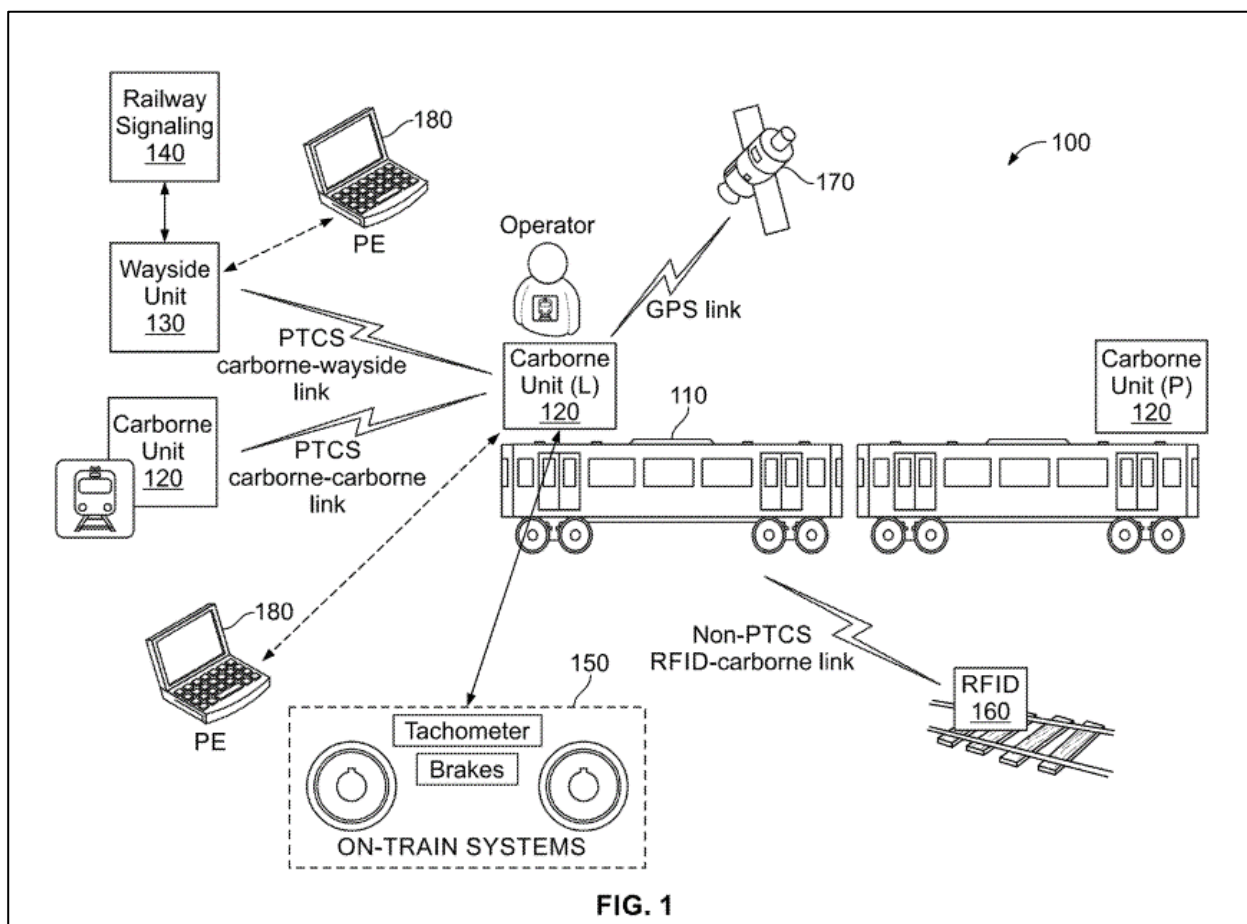
46. The patent recognizes that train-control systems were known in the art, but says that transit agencies have “few options available between the fixed block, trip stop based systems in place at many transit agencies, and available high end solutions, such as communications-based train control (CBTC) based solutions.” EX1001, 3:14-19. According to the patent, these conventional train-control systems relied on a “centralized entity” or “centralized data structure which must be hard-wired to the system” to control train signaling and movement. EX1001, 3:5-24, 4:13-24.

47. Rather than rely on a centralized entity, the '363 patent's system is purportedly “train centric,” allowing certain train-control decision-making and functionality (*e.g.*, braking) to be performed on the train itself. EX1001, 3:34-37; *see also* EX1001, 3:48-55 (listing functions that the train can perform). In other words, “most of the [train's] functions may be implemented and/or deployed within the trains rather [sic: than] in the surrounding infrastructure.” EX1001, 3:37-40. That is, the alleged invention “support[s] mostly decentralized control of trains and operations thereof.” EX1001, 3:5-9. “Such an approach,” the patent alleges, “may be advantageous due to reduced costs (*e.g.*, because the use of wireless technology may eliminate and/or reduces [sic] the amount of wayside cabling and associated maintenance; and may reduce Carborne wiring, installation effort and equipment cost), while additionally providing a modular-upgradeable signaling system which

may be easily customized and accommodate the existing transit agencies' operating rules." EX1001, 3:40-47.

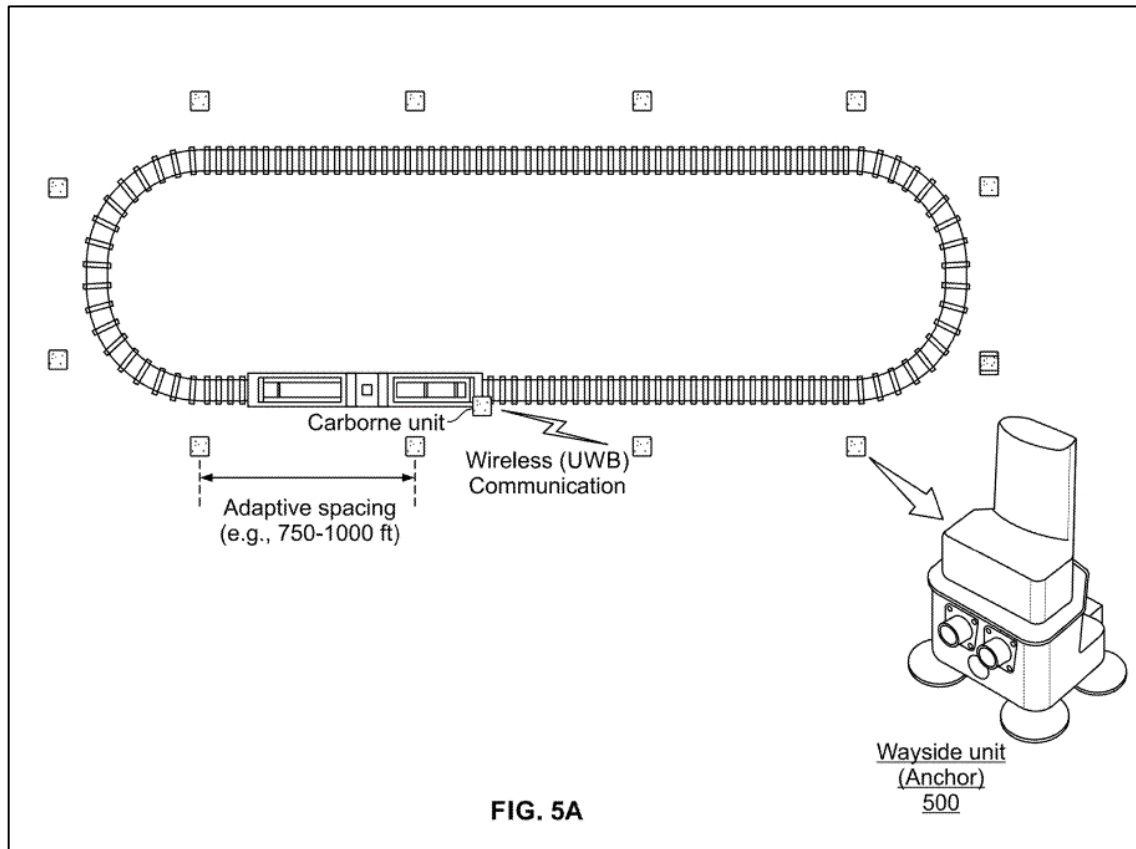
48. The patent's "train-centric" system includes train-mounted "carborne units" and "wayside units" that are installed on "structures near the tracks, such as tunnel walls [or] signal posts." EX1001, 4:25-31, 4:43-51; FIG. 1. Each unit includes a UWB radio that permits UWB-based communications between the units. EX1001, 4:19-24, 4:42-60, 6:7-24, 7:57-8:23.

49. Figure 1 (annotated below) depicts an exemplary "train-centric" system that includes carborne equipment 120 and wayside units 130:



EX1001, 4:8-11, 4:25-60.

50. Figure 5A (below) illustrates an exemplary deployment of several wayside units (or “anchors”) communicating with a carborne unit via UWB signaling:



EX1001, 1:65-67, 7:64-9:50.

51. A train determines its “position and speed” by “ranging with UWB anchors.” EX1001, 10:3-5. Consistent with my description of conventional ranging with UWB radios above, the ’363 patent explains that with UWB-based ranging, “the range [*i.e.*, distance] between a UWB transmitter and receiver [*is*] calculated as

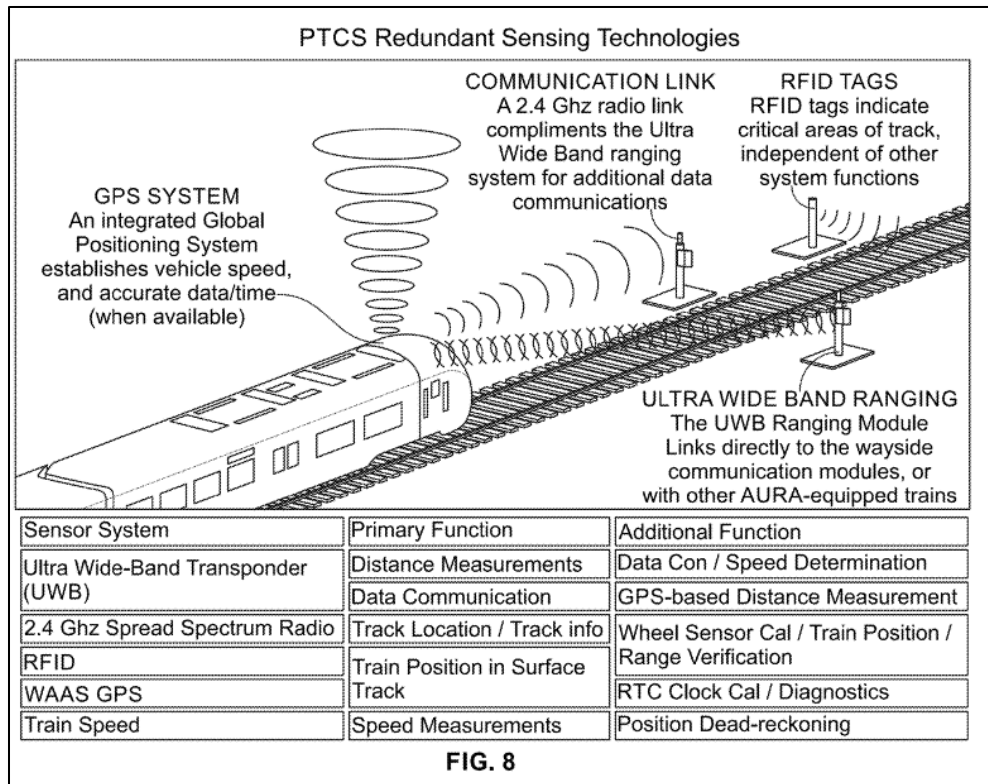
the time of flight [of UWB signals] between the transmitter and the receiver (one way) multiplied by the speed of light.” EX1001, 13:64-14:8; *see also id.*, 14:57-59 (“For example, the distance to a particular anchor may be measured using two-way time of flight timing measurements.”).

52. As the train passes a wayside-anchor, the train determines its “absolute location by the ID number of the anchor and referencing the distance to that anchor with [an] on-board track map.” EX1001, 10:3-8. The train can also determine its relative position by “collecting ranges between [it] and at least three receivers [*i.e.*, anchors]” and performing “trilateration to determine [its] relative location.” EX1001, 14:9-13; *see also id.*, 21:1-7 (discussing trilateration technique). And, if the location of the anchor(s) is known, then the trilateration technique can also “be used to determine the absolute location of the” train. EX1001, 14:13-15.

53. “The train may also determine the speed and direction of movement by measuring the UWB ranging delta separation data of the radio signal from the train to the UWB anchors.” EX1001, 10:8-11. For example, “UWB ranging may also be used for determining speed (or velocity), such as by taking multiple range calculations over a specific time period, thus allowing the distance traveled by the UWB transmitter to be determined and used to calculate the velocity of the UWB transmitter (or an object that includes that UWB transmitter).” EX1001, 14:25-30; *see also* 22:23-243 (discussing speed measurement using UWB).

54. Using its UWB-determined location, direction, and/or speed, the train's onboard computer system can implement various functions. EX1001, 19:39-53. For example, it can regulate its speed or engage an auto-braking system if the distance between it and another object (*e.g.*, another train) is too close. EX1001, 17:15-28, 17:44-48, 19:39-53.

55. In addition to using UWB signaling to determination a train's location, direction, and/or speed, the patent says that its system can use other conventional "sensing technologies," like RFID or GPS. EX1001, 5:37-65, 17:29-37, 21:43-45, FIG. 8. These systems allow the "[s]peed (or velocity) and location determination from UWB [to] be checked against, and in some cases processed with, speed and location determined via other mechanisms in order to establish vital train location, speed, and direction." EX1001, 14:30-34. Figure 8 depicts a system utilizing various "redundant sensing" technologies:



56. Although “train-centric,” the disclosed system also includes a “central server” to which the trains communicate “such information as position, speed, direction of travel, and health status.” EX1001, 14:63-65. The train can also communicate with a central “automatic train supervision (ATS) system.” EX1001, 4:48-60. The ATS can send a “movement request” or a “speed restriction message” to the train. EX1001, 19:24-30, 24:25-28; FIG. 10. In other words, while the disclosed system is “mostly” decentralized, it still supports, communicates with, and relies in part on a centralized system, *i.e.*, the train can make operating decisions like braking without a command from a centralized system. EX1001, 3:5-9 (“In accordance with the present disclosure, trains, particularly trains operating under

certain conditions—e.g., trains operating in transit systems, may be controlled in enhanced manner, particularly by allowing for and supporting **mostly** decentralized control of trains and operations thereof.”) (emphasis added), 3:37-40 (“In other words, in [the disclosed system] **most** of the functions may be implemented and/or deployed within the trains rather in the surrounding infrastructure.”) (emphasis added); *see also id.*, 11:2-11 (explaining that “work zones are centrally designated”).

## **VI. CLAIM INTERPRETATION**

57. 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.

58. For the reasons I discuss in Sections VII.A to VII.C, 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**

59. I have been asked to provide my opinion concerning whether claims 1-16 of the ’363 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 1-16 is anticipated by and/or would have been obvious to a POSA over the prior art discussed below.

60. Independent claim 1 recites a “system for providing decentralized control operations” [1PRE] including (1) “a plurality of wayside units” [1A] and (2) “one or more train-mounted units” [1B]. Each train-mounted unit communicates with other train-mounted units and/or wayside units using UWB-based signals and “generate[s] based on the [UWB] communication, control information configured for use in controlling one or more function of the train” [1C]. The claim limits the “control information” to information that “comprises or is based on obtaining ranging measurements” [1D], and further limits how the train-mounted unit obtains ranging measurements to:

1. broadcasting UWB-based signals within a wireless range of the train-mounted unit, the UWB-based signals comprising information identifying the train-mounted unit [1E1]-[1E2],
2. selecting based on received responses to the broadcast UWB-based signals, one or more of the plurality of wayside units [1E3]; and
3. determining ranging information corresponding to each of the one or more wayside units, based on UWB-based signals

communicated respectively with each of the one or more of the plurality of wayside units [1E4].

61. Some of the dependent claims further limit the claimed system to ones that also use conventional technologies like RFID or GPS. *E.g.*, claims 2, 5-8. Others limit how the train-mounted unit controls the train's functions. *E.g.*, claims 3-4. These and other conventional features in the dependent claims were in the prior art, as I discuss in more detail below.

**A. Ground 1: Claims 1-16 Are Anticipated by and/or Would Have Been Obvious Over Carlson**

**1. Overview of Ground 1**

62. As set forth in Ground 1, it is my opinion that the Carlson reference either anticipates each of claims 1-16 of the '363 patent and/or those claims would have been obvious over Carlson in view of a POSA's general knowledge.

**2. Carlson (EX1005): U.S. Patent Appl. Publ. 2015/0329130**

63. Carlson is a published U.S. patent application with a publication date of November 19, 2015. Carlson at (43). I have been told to assume that Carlson is prior art to the claims of the '363 patent.

64. Carlson discloses a "rail vehicle control system installable on a rail vehicle." Carlson, [0009]. The system includes transponders installed on rail vehicles as well as on "signal control points" located along the train track. Carlson, [0009]. Carlson's "rail vehicle control system" is a decentralized system. For

example, “[t]he vehicle-side portion of the system can operate autonomously and make internal operational decisions without requiring a central server.” Carlson, [0122].

65. Carlson’s system includes two primary components: (1) a train-mounted “vehicle mounted control system (‘VMCS’)” (Carlson, [0050]) and (2) “one or more reporting stations” located along a railroad “at strategic wayside locations” such as at a signaling station (Carlson, [0051], [0122]).

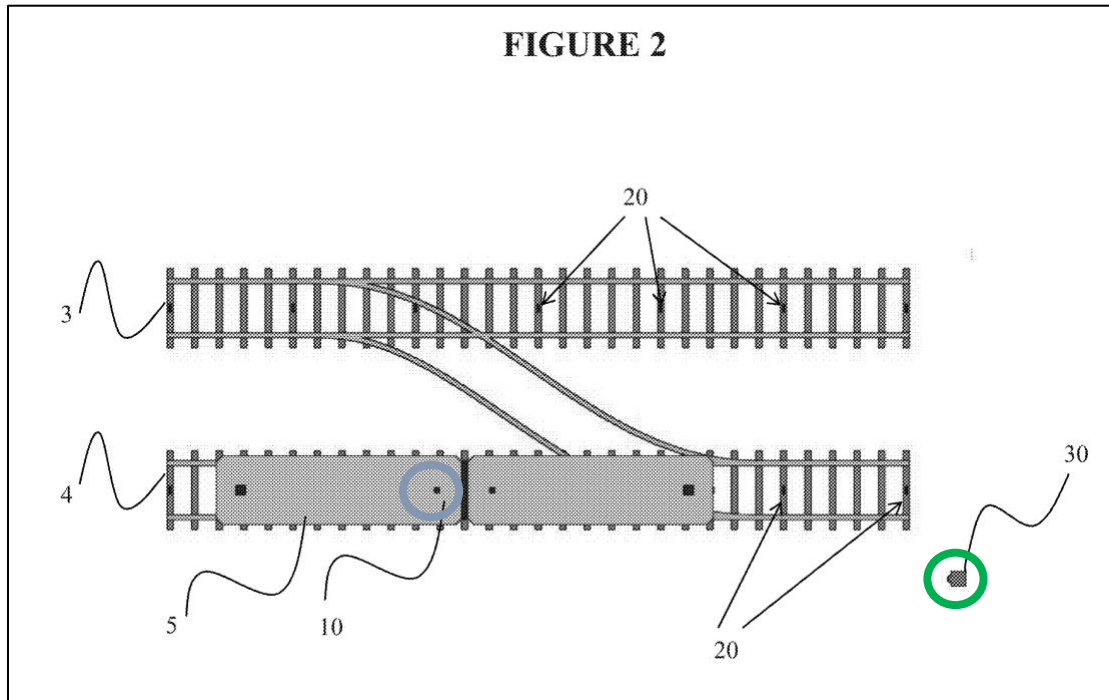
66. As Carlson explains, its system includes “multiple VMCS’s 10, mounted on several rail vehicles,” and these VMCS 10s are each “configured to communicate with one another in order to determine the speed of the vehicles, and the relative distance between the vehicles, for example.” Carlson, [0050]. The system also includes “one or more reporting stations 30 located along a railroad. The reporting stations 30 can be located at or integrated with, for example, signal control points or other objects positioned at fixed positions along a railroad track.” Carlson, [0051]. These reporting stations (or signal point stations) each include a “communication mechanism that allows” each to communicate with “the VMCS 10 installed on the rail vehicles to exchange data and information, and otherwise communicate with the reporting stations 30.” Carlson, [0051]. The reporting stations “can also communicate and exchange information with a rail network” that

“manages and maintains information relating to the speed and location of the rail vehicles connected to the network.” Carlson, [0052].

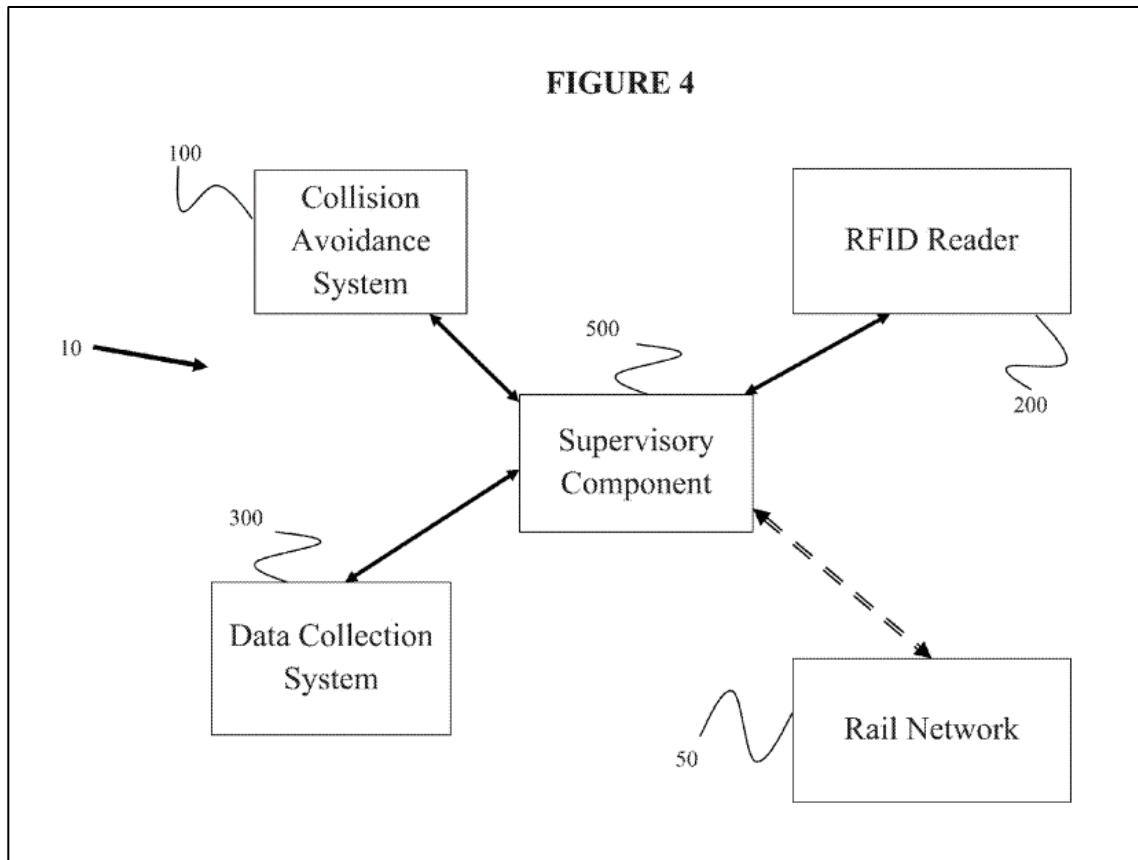
67. To communicate with one another, each VMCS 10 and reporting/signal station includes a UWB radio transponder. Carlson, Abstract (“Each of these subsystems includes an ultra-wideband (UWB) communications component. The subsystems communicate with each other through the UWB components.”). A VMCS 10 then determines the distance between itself and either another train-mounted VMCS or a wayside-located reporting/signal station “based on the time-of-flight of at least one communication between the subsystems.” Carlson, Abstract; *see also id.*, [0013] (“determine a distance between the vehicle-mounted subsystem and the control signal interface subsystem based on a time-of-flight of at least one communication between the UWB communications component of the control signal interface subsystem and the UWB communications component of the vehicle-mounted subsystem.”), [0015] (“determine a distance between the first vehicle-mounted subsystem and the second vehicle-mounted subsystem based on a time-of-flight of at least one communication between the UWB communications component of the second vehicle-mounted subsystem and the UWB communications component of the first vehicle-mounted subsystem”).

68. I have reproduced Figure 2 of Carlson below. It depicts a rail vehicle, *i.e.*, train, operating within Carlson’s control system. Carlson, [0020]. I have

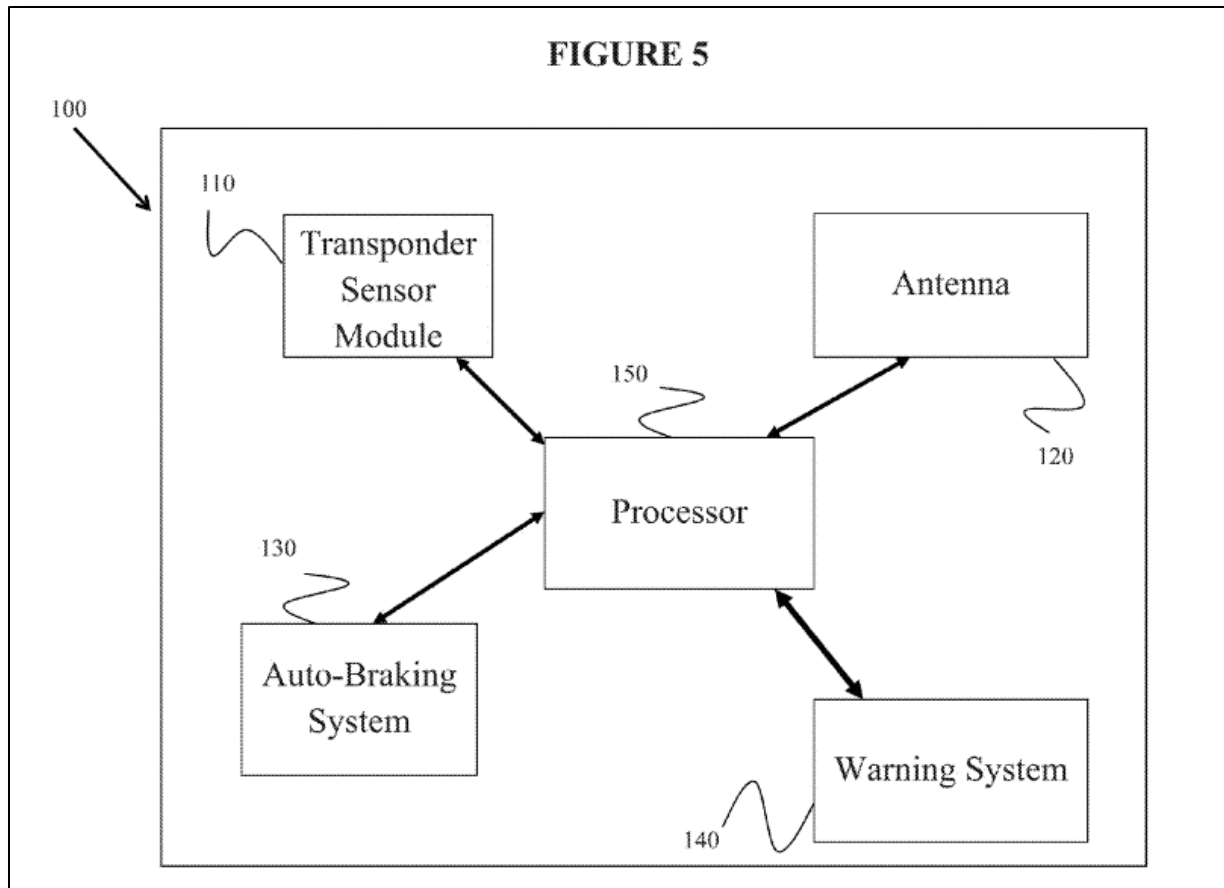
annotated Figure 2 by circling a VMCS 10 in blue and one reporting/signal station in green:



69. Carlson explains that its VMCS 10 includes four main components: a collision-avoidance system, an RFID reader, a data-collection system, and a supervisory component. Carlson, [0062]-[0063]. As Carlson explains, “the VMCS 10 can be a single module” that is “installable at a location on a rail vehicle,” or it can alternatively “comprise one or more modules” that are “installable at one or more locations on a rail vehicle.” Carlson, [0062]. Each of the VMCS 10’s four main components (as well as a separate rail network 50 with which the VMCS can communicate) are depicted below in Figure 4 of Carlson:



70. “The collision avoidance system 100,” Carlson explains, can “determine a distance between the rail line vehicle and another rail line vehicle operating on the same railroad track.” Carlson, [0064]. The collision-avoidance system is depicted in “more detail[]” in Carlson’s Figure 5, which I have reproduced below:



71. As seen above in Figure 5, the collision-avoidance system of VMCS 10 includes its own five sub-components: a transponder sensor module, an antenna, an auto-braking system, a warning system, and a processor. Carlson, [0064]-[0065]. Carlson explains that the transponder sensor module “include[s] a UWB ranging unit configured to send UWB radio waves.” Carlson, [0067]. Using that unit, the module can “communicate with other transponder sensor modules installed on proximate rail vehicles, for example, by sending radio waves/pulses outward via the antenna 120 or other transceivers associated with the transponder sensor module.” Carlson, [0067].

72. Carlson then explains how the VMCS 10 uses its transponder sensor module to calculate distance, as follows:

In this manner, a distance between the various transponder sensor modules 110 (and thus, the distance between the rail vehicles upon which the transponder sensor modules are installed) can be determined. By measuring how long it takes a wave/pulse or a signal to travel (for example by reflecting and/or bouncing, or a precisely timed response) between two transceivers, the distance between the transponder sensor modules can be accurately determined. That is, the present technology can detect the distance between two rail vehicles and/or the distance between a rail vehicle and signal/reporting station based on the time it takes a signal to travel between the transponder sensor modules. This technique may be referred to as “time of flight.” The processor 150 or another processing unit can be used to determine the distance between the vehicles based on the results of the time of flight.

Carlson, [0068]; *see also id.*, [0069]-[0070] (providing scenarios in which time-of-flight measurements are used to calculate distance between two transponders).

73. In addition to calculating the distance between two UWB transponders, Carlson explains that the “UWB time-of-flight data” can also be used to determine the speed of the train on which the VMCS 10 is mounted because “this data provides substantially continuous location information over time.” Carlson, [0072].

74. Carlson further teaches that the VMCS 10 uses other technologies to improve system accuracy and/or for redundancy. *See, e.g.*, Carlson, [0071]-[0074]. For example, Carlson explains that:

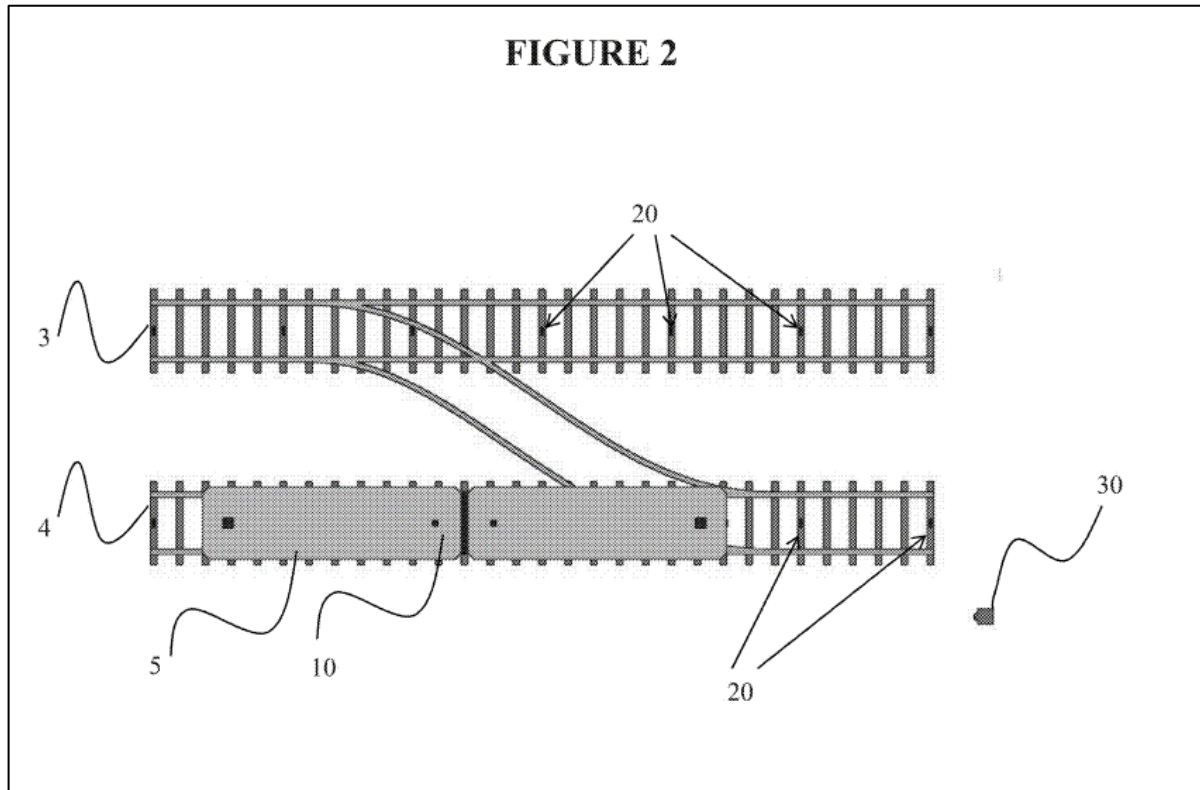
[T]he collision avoidance system 100 also includes a GPS unit that can be used in combination with (or as a component of) the

transponder sensor module to determine a position (e.g., an absolute position) of the rail vehicle. In this manner, the present technology ***can combine GPS functionality with the time of flight technology*** to determine a separation distance between rail vehicles. The GPS and/or the time of flight technology ***can serve as redundant systems*** that assure a separation distance between rail vehicles is known even when one of the systems is not effectively working. For example, the GPS unit can be used to ensure that the time of flight technology is not providing incorrect separation distance information because of reflected signals. Moreover, the time of flight technology can be used to observe separation distance in situations where the GPS unit is incapable of receiving positioning information, for example, due to issues with satellite connectivity. This can be particularly useful, for example, for rail vehicles traveling in subterranean tunnels (e.g., subways), where there is limited or no access to GPS functionality. The GPS operating frequency may be 1.575 GHz. The system may include two GPS receivers, for example, to provide redundancy. GPS information may provide speed data and the vehicle direction of travel.

Carlson, [0071]; *see also id.*, [0072] (explaining GPS can be used to determine a train's speed).

75. In addition to receiving and using information from GPS satellite signals, Carlson also teaches that the VMCS 10 receives and uses information from RFID tags “mounted on the railroad rails or the ties of the railroad” or mounted “on the wall of a tunnel, on the ground, or on poles or stakes located along the railroad track.” Carlson, [0054]. As Carlson explains, “the VMCS (which may include an RFID reader) can read the RFID tags 20 located along the railroad track to obtain information about the location, operating track, track speed limit, and/or speed of

the vehicle.” Carlson, [0054]. Figure 2 of Carlson (which I have reproduced below) depicts “RFID tags 20” mounted on “railroad ties of the track” (Carlson, [0055]):



76. As Carlson explains:

Where the RFID tags are positioned closer together and occur with greater frequency, the system can detect the location and speed of the rail vehicle 5 with greater accuracy. For example, where the RFID tags are placed close enough together so that a slower moving rail vehicle can detect several RFID tags per second, the separation control system can continually determine and calculate the location and speed of the vehicle with the passing and detection of each RFID tag. However, RFID tags that are too close together may not be distinguishable by a rail vehicle traveling at a high rate of speed, and may therefore result in a less accurate speed determination. Conversely, where the RFID tags are located farther apart, the system may be unaware of the precise location and speed of the rail vehicle 5 in between the

RFID tags, but the sufficient separation can assure that each RFID tag is properly readable and distinguishable from the others. Accordingly, in some embodiments, the RFID tags are placed sufficiently close together so as to accurately provide rail vehicle location and speed information, while also being sufficiently spaced to ensure that each RFID tag can be properly detected and distinguished by the VMCS 10 on the rail vehicle 5.

Carlson, [0056]; *see also* Carlson, [0096]-[0107] & Figure 7 (explaining how RFID tags can be scanned to determine a train's location and speed).

77. Carlson further teaches that the VMCS 10 can determine the speed of the train on which it is mounted using the UWB-based time-of-flight data and/or other sources of speed-related data (*e.g.*, GPS satellite signals or RFID tags):

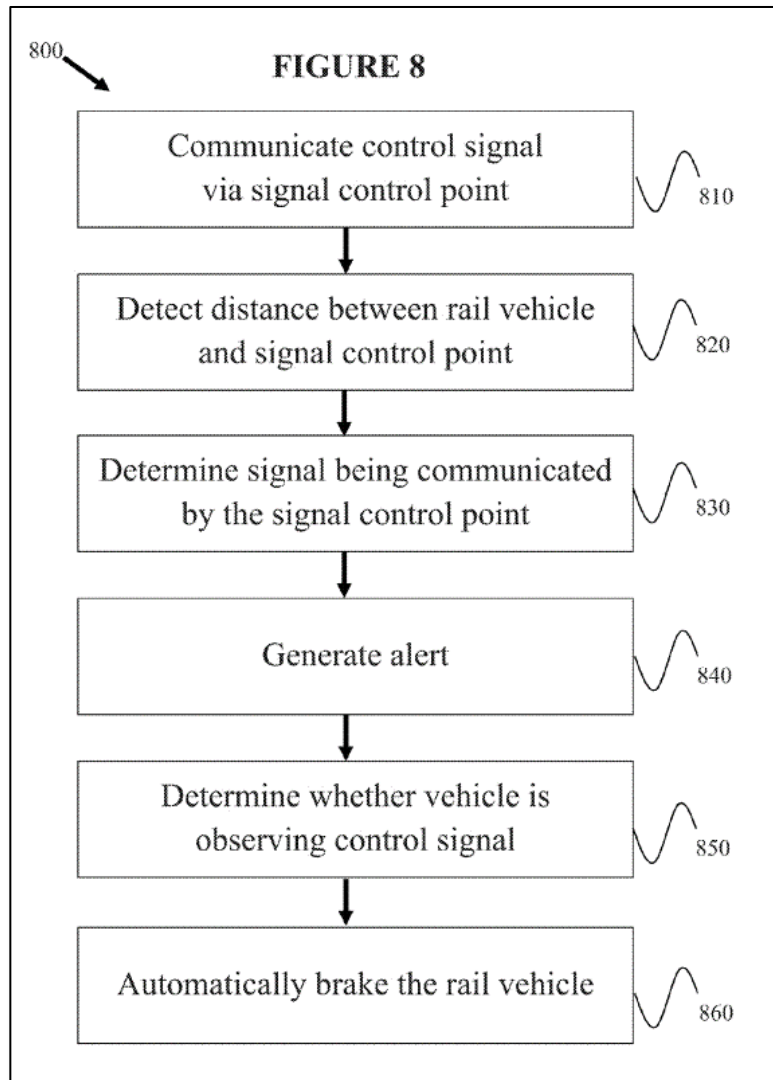
The VMCS 10 may have a speed measurement system which may be distinct from the speedometer of the vehicle (prior to installation of the VMCS 10). The VMCS 10 may receive information regarding the rate of wheel rotation, and speed may be calculated therefrom. The VMCS 10 may also be capable of determining speed information from GPS information and/or RFID tag scanning rate.

[0072]; *see also* Carlson, [0099]-[0100] (explaining how RFID tags can be scanned to determine the time it takes for a train to pass from one tag to another and/or the absolute or relative position of the train).

78. Based on the positional and speed information it obtains from its various systems, VMCS 10 determines whether an unsafe condition exists, *e.g.*, the distance between it and another vehicle or a reporting station is below a threshold. For example, the VMCS will “generate an alert if the distance between [it] and [a]

control signal interface is less than a first threshold,” and/or will generate an alert “if the distance between [it] and [a second VMCS 10] is less than a second threshold.” Carlson, [0016]. Similarly, if the VMCS determines the train on which it is mounted “is not observing [a] control signal, speed limit, or approaching vehicle,” then the VMCS “automatically brakes the vehicle, for example, using an auto-braking system.” Carlson, [0118].

79. Figure 8 of Carlson (which I have reproduced below) depicts an exemplary process for “enforcing rail vehicle adherence to control signals” using Carlson’s technique. Carlson, [0026]; *see also id.*, [0108]-[0119] (describing the method of Figure 8).



80. At step 820, the VMCS uses “time of flight techniques” to determine the distance between it and a signal control point.” Carlson, [0110]. At step 830, the VMCS determines what signal an approach signal control point is indicating (*e.g.*, stop), then at step 840, if the signal control point’s signal indicates that the train should stop or slow down, an “alert” can be generated. Carlson, [0112]. With respect to this alert at step 840, Carlson further explains:

[S]tep 840 can involve generating a warning signal via a warning system component of a collision avoidance system on the rail vehicle. In certain embodiments, the warning system can issue a series of beeps or alarms that will continue until the vehicle operator acknowledges the signal, for example, by pressing a button or communicating a signal acknowledgement, or until the vehicle reduces its speed or comes to a stop. In certain embodiments, the warning signal can be a progressive warning signal that increases in volume, duration, repetition rate, and/or frequency as the signal control point draws nearer. In this manner, the warning signal can be used as a failsafe to ensure that the vehicle operator recognizes the signal and thereby take steps to slow and/or stop the vehicle. Warning signal(s) may also be visual.

Carlson, [0112]; *see also* Carlson, [0047] (“if a vehicle is approaching a signal control point indicating a red (i.e., stop) signal, the present technology can notify the operator of the vehicle that the red signal is approaching via an audible tone, a visual indication, and/or continuously provide an updated distance to the red signal to help ensure that the operator is aware of the stop indication.”).

81. At step 850 the VMCS “determines whether the vehicle is observing the control signal,” and this determination is “be based on factors such as the vehicle speed, vehicle location relative to the rail signal, and rail track conditions whether it is possible for the vehicle to come to a stop in a safe manner. For example, given the speed of the vehicle, the track conditions, and the distance to the signal control point, an appropriate braking distance or speed reduction distance may be determined. This is a distance that allows for safe braking by the time the vehicle reaches the signal control point. If the vehicle does not begin slowing down at an appropriate

rate once the distance is reached, then it can be determined that the vehicle is not observing the control signal.” Carlson, [0113].

82. Finally, at step 860, if the operator does not take corrective action such that the VMCS determines the vehicle is still not observing the control signal properly, then the VMCS “automatically brakes the vehicle, for example, using an auto-braking system.” Carlson, [0118]. The auto-brakes “can be applied until the rail vehicle comes to a complete stop, or until the vehicle speed is below a determined threshold (e.g., below 2 miles per hour or below the speed limit for that portion of the track), depending on the conditions and the situation.” Carlson, [0118]; *see also* Carlson, [0047] (“[I]f the vehicle operator fails to stop the [sic: vehicle] in an appropriate time or distance relative to the red signal, the technology can apply vehicle brakes to slow or stop the vehicle.”); [0076] (“When the collision avoidance system 100 determines that the signals provided by the signal control point 40 are not being followed by the rail vehicle operator, the processor 150 can operate one or more other functions of the collision avoidance system 100. For example, the processor may use the auto-braking system 130 to initiate an auto-braking feature to automatically brake or otherwise reduce the speed of the rail vehicle.”); [0077] (“[T]he auto-braking system 130 can be adapted to automatically brake a rail vehicle based on the distance between the vehicle and a signal control point 40, depending on the signal indicated by the signal control point 40.”).

83. Although Figure 8 describes a method for ensuring compliance with a control signal (*e.g.*, a stop signal), Carlson explains that VMCS 10 can also issue alerts and apply its auto-braking system when the VMCS 10 determines that the distance between the train upon which it is mounted and another train-mounted VMCS or reporting/signal station is below a minimal separation distance threshold. For example, Carlson explains that its system “can monitor the separation distance between equipped rail vehicles, and apply safeguards to assure that the vehicle operators are warned of potential collision threats, and/or apply automatic stopping and braking of the vehicles where a collision may be imminent.” [0048]; *see also* Carlson, [0076] (“[W]hen the collision avoidance system 100 determines that the distance between the rail line vehicle and a proximate rail line vehicle operating on the same railroad track has come within a predetermined limit, the collision avoidance system 100 may initiate the auto-braking feature in order to prevent and/or reduce the likelihood of a collision.”), [0077] (“When the distance between the rail vehicle and the signal control point approaches or exceeds a limit where it is no longer possible to bring the vehicle to a complete stop before the safety point during existing conditions, the auto-braking system 130 can automatically brake the vehicle.”).

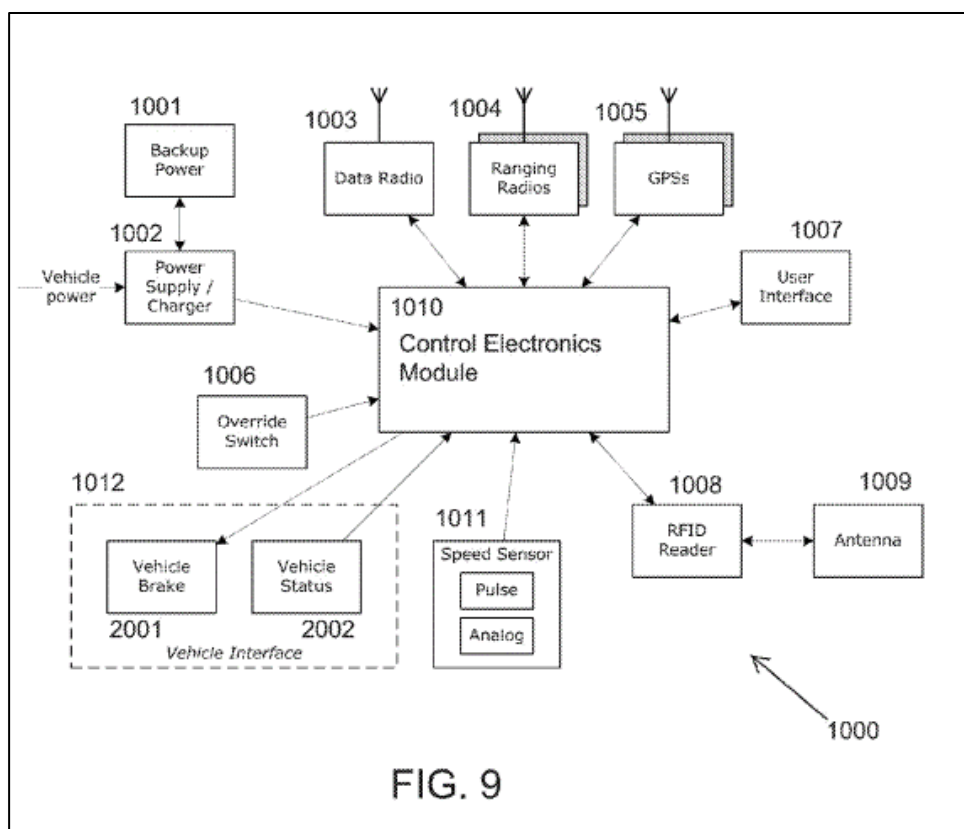
84. In addition to VMCS 10, Carlson also describes a VMCS 1000 that Carlson states is “similar to VMCS 10” and that either VMCS 10 or VMCS 1000

can “perform” Carlson’s “techniques.” Carlson, [0127]. POSAs would have understood Carlson’s VMCS 10 and VMCS 1000 to be very similar embodiments, with VMCS 1000 being used in Carlson primarily to provide a more detailed description of certain aspects of a VMCS (generally) such that those additional details would apply to VMCS 10 as well. In other words, POSAs would immediately envisage a VMCS 10 that includes features of VMCS 1000 that are consistent with VMCS 10’s features but which are described in more detail in the context of VMCS 1000. Moreover, to the extent it is found that VMCS 10 does not include the same components and functionality described in context of VMCS 1000, POSA had reason to use their ordinary skill to include those components and functionality in VMCS 10 for the benefits that Carlson describes for those components and functionality in context of VMCS 1000.

85. For example, Carlson describes VMCS 10 as including an “interface” through which a train operator can “acknowledge” a warning alert. Carlson, [0081]. Carlson, however, does not provide details regarding that interface when discussing VMCS 10, but it does provide details regarding a “user interface” with an acknowledgment button when discussing VMCS 1000. Carlson, [019] (“This acknowledgement can be accomplished by pressing a confirmation button on the user interface.”), [0135] (“The user interface 1007 may include one or more displays, input devices, or speakers. The user interface may receive inputs through the input

device(s) from an operator. System information may be displayed on the display(s). Alerts may also be displayed on the display(s). The speaker(s) may also produce alerting sounds.”). Reading Carlson in its entirety, POSAs would immediately envisage an embodiment of VMCS 10 that uses the “user interface” Carlson describes for VMCS 1000.

86. Figure 9 of Carlson (which I have reproduced below) illustrates various components for VMCS 1000 (Carlson, [0127]):



87. As seen above in Figure 9, VMCS 1000 includes “a backup power module 1001, a power supply/charger 1002, a data radio 1003, one or more ranging radios 1004, a GPS radio 1005, an override switch 1006, a user interface 1007, an

RFID reader 1008, an RFID antenna 1009, a control electronics module 1010, a speed sensor 1011, and/or a vehicle interface 1012.” Carlson, [0127]. With respect to the “ranging radios 1004,” Carlson states:

One particularly useful technology for the ranging radios 1004 is an UWB network. UWB may provide a wide bandwidth distance measurement signal that can be used to measure distance, for example, within inches. UWB may be resistant to multipath distortions. Narrow-band time-of-flight distance measurement systems may suffer from multipath distortion. UWB may be compatible with varying operating environments including ones with buildings and walls (which cause reflections), curved tunnels, and underground. In addition to determining range information, the UWB network may be used to communicate data, such as: the VMCS’s unique ID, a signal indication, a track number, a track direction, the vehicle speed, the vehicle direction of travel, or GPS information (position information and/or GPS clock value).

Carlson, [0132]; *see also* Carlson, [0051], [0091].

88. Again, although described in the context of VMCS 1000, POSAs would have understood that Carlson’s description of UWB-ranging and UWB-data communication (including the type of information that can be conveyed via UWB signaling, like non-ranging data and the “VMCS’s unique ID”) applied equally to the UWB ranging and data communication that VMCS 10 performs with its UWB radio(s).

### 3. Claim 1

#### a. [1PRE]: “A system for providing decentralized control operations in a railway network”

89. I understand that whether a claim’s preamble is treated as a limitation on the scope of claim is a legal question. For purposes of my analysis, I have been told to assume that the preamble to claim 1 is limiting.

90. As I explained in Section V.B, the ’363 patent describes “*decentralized control operations*” as control operations that trains may execute on their own without reliance on a separate centralized entity. EX1001, 4:12-19.

91. Carlson discloses a “system for providing decentralized control operations in a railway network,” as claimed.

92. Specifically, Carlson discloses a “control system” for “a rail network.” Carlson, [0010] (“Certain embodiments of the present technology provide a railroad control system operable to manage rail vehicle separation on a railroad track. The railroad control system can include a rail network that maintains information relating to the location and speed of rail vehicles on the railroad track.”). In Carlson’s system, “[t]he vehicle-side portion of the system *can operate autonomously* and make internal operational decisions *without requiring a central server*.” Carlson, [0122] (emphasis added). Such “autonomous” operations that do not require a “central server” are “*decentralized control operations*,” as recited in claim 1’s

preamble, and Carlson identifies these operations as including such control operations as the “auto-braking system.” Carlson, [0077]-[0078].

93. Indeed, Carlson explicitly describes its system as “decentralized.” Specifically, Carlson says: “Such a **decentralized approach** may allow each vehicle to determine its safe operating envelope using only the necessary local inputs from signals and other vehicles.” Carlson, [0126] (emphasis added); *see also* [0077]-[0078] (describing autonomous “auto-braking”).

94. While Carlson’s system can include a centralized “rail network” as part of the overall system (*see, e.g.*, Carlson, [0010], FIG. 1), Carlson nonetheless still meets the preamble of claim 1. Read in view of the specification of the ’363 patent, claim 1’s preamble is plainly not limited to a system that excludes the existence of a centralized server or entity so long as **some** aspects of the system “*provid[e] decentralized control operations.*”

95. First, as I noted above when providing an overview of the ’363 patent, the patent is explicit that the invention “support[s] **mostly** decentralized control of trains and operations thereof.” EX1001, 3:5-9 (emphasis added); *see also id.*, 3:37-40 (“In other words, in [the disclosed system] **most** of the functions may be implemented and/or deployed within the trains rather in the surrounding infrastructure.”) (emphasis added). The specification thus teaches that “most”—but **not all**—train functions are performed in a decentralized manner.

96. Indeed, the '363 patent explicitly teaches the existence of a central server or centralized entity—akin to the rail network in Carlson—that is part of the patent's overall rail network system. For example, the '363 patent discloses at 14:63-15:10 that “trains may report such information as position, speed, direction of travel, and health status **to a central server**,” so that “PTCS-2 based carborne units (particularly the lead units) of each train” can “**quer[y] the server** to determine the nearest PTCS-2 equipped train ahead.” Emphasis added. Likewise, the '363 patent teaches that the train can also communicate with a central “automatic train supervision (ATS”) system.” EX1001, 4:48-60. The centralized ATS system, the patent explains, can send a “movement request” or a “speed restriction message” to the train. EX1001, 19:24-30, 24:21-28; FIG. 10; *see also id.*, 9:63-10:2 (explaining a train's route may be “chosen remotely by the central dispatcher using Automatic Train Supervision (ATS)”), 11:7-22 (explaining that work zones can be “centrally designated,” including by “a dispatcher in a remote location using the ATS console, where the data is communicated via the data communication network”); 26:41-59 (explaining ATS system “generates a message” regarding the location and start/end time of a work zone that is relayed to trains). The role of the “central server” or ATS in the '363 patent is similar to the role of the “rail network” in Carlson. *Compare* Carlson, [0150] (disclosing the train's VMCS 1000 communicating “[d]ata logs

including vehicle incidents (*e.g.*, alarm-generating incidents) and speed-limit compliance” to the rail network).

97. Moreover, as I discuss further below, claim 12 of the ’363 patent explicitly recites that the train-mounted unit is configured to communicate with “one or more other components or devices in the railway network ***not being part of*** decentralized train control system.” Emphasis added. Thus, POSAs would understand that claim 1, from which claim 12 depends, must be read broadly enough to encompass systems where the train-mounted units performing “*decentralized control operations*” in the railway network can communicate with non-decentralized components or devices (*e.g.*, centralized components or devices in the system like Carlson’s rail network).

98. Indeed, Patent Owner’s infringement contentions in the related litigations expressly identifies “the MTA’s ***centralized train control system***” as allegedly meeting claim 12. EX1016, 33; *see also e.g., id.*, 31 (“The Defendants’ system also communicates with legacy ‘zone controllers’ that ***pass information to a central control point*** and to other trains.”). In other words, Patent Owner does not read claim 1 as limited to a system that is ***entirely*** decentralized and instead reads it on a system that purportedly provides some “*decentralized control operations*” but which also interfaces with a centralized component.

99. Finally, as I discussed above, Carlson expressly discloses that system “can operate autonomously and make internal operational decisions without requiring a central server.” Carlson, [0122]. Thus, while Carlson’s system *can* communicate with a centralized network, POSAs understood that Carlson’s disclosed system includes implementations that operate without any centralized server at all. Regardless, even in embodiments where the centralized network is present, ***train control operations*** occur autonomously (*i.e.*, without control signals from the centralized network), as I explained above in this section.

100. For at least these reasons, Carlson discloses a system for “*decentralized control operations in a railway network*,” as claimed.

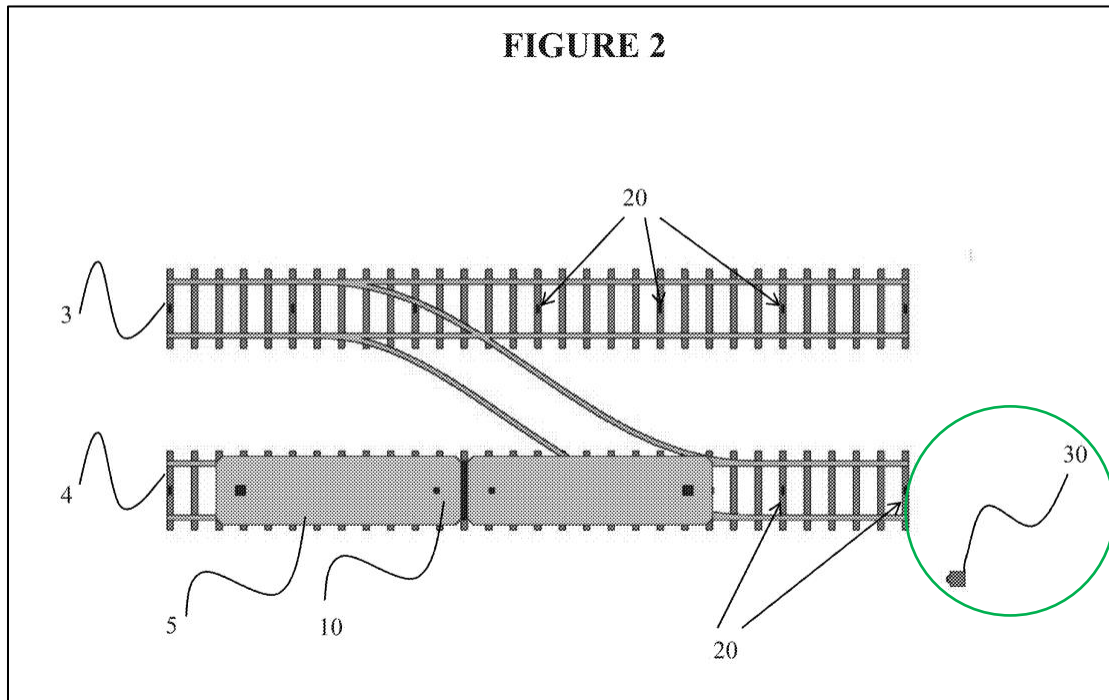
**b. [1A]: “a plurality of wayside units, each configured for placement on or near tracks in the railway network”**

101. Carlson discloses a system for “decentralized control operations in a railway network,” that includes “a plurality of wayside units, each configured for placement on or near tracks in the railway network,” as claimed.

102. Carlson’s system includes “one or more reporting stations 30 located along a railroad.” Carlson, [0051]. “The reporting stations 30 can be located at or integrated with, for example, signal control points or other objects positioned at fixed positions along a railroad track.” Carlson, [0051].

103. Carlson’s Figure 2 “also shows a reporting station 30 located along the railroad track 4. As shown, the reporting station 30 is located to the side of the

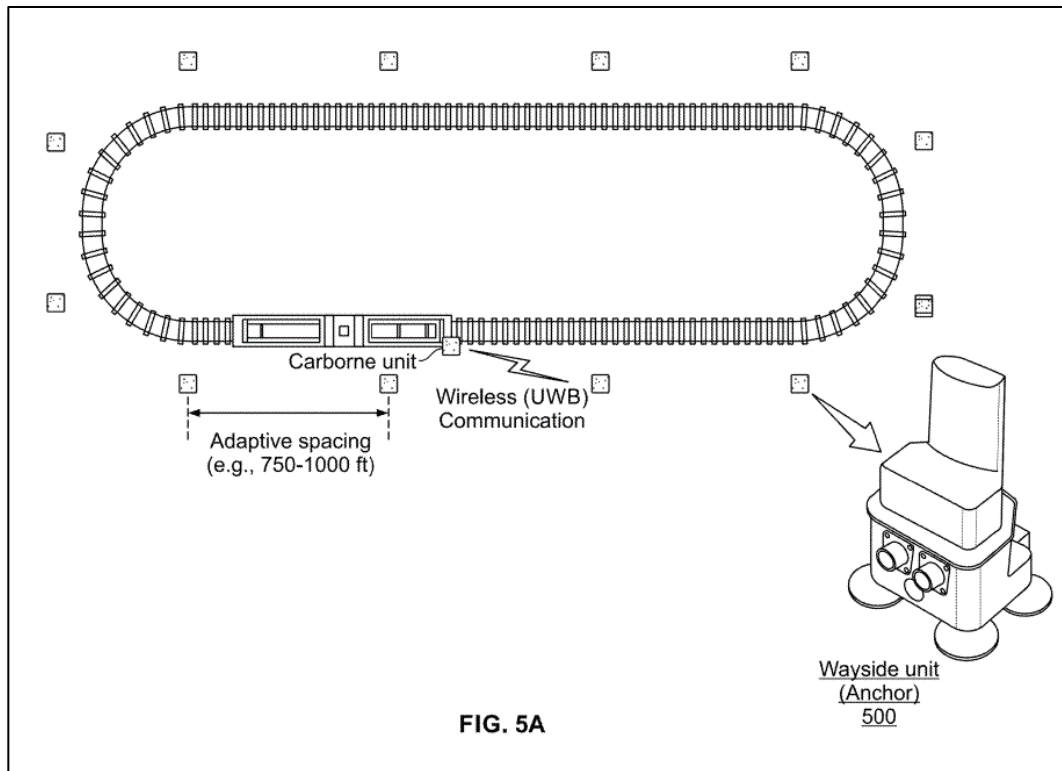
railroad tracks in close proximity to the tracks. In this manner, the reporting station can be visible to a vehicle operator on a passing rail vehicle.” Carlson, [0057]. I have reproduced Figure 2 below and circled in green the exemplary reporting station 30 for the portion of the railroad track shown in that figure:



104. Carlson further explains that a “reporting station 30 can also be, for example, a signal control point that generates signals viewable by an operator of the rail vehicle 5.” Carlson, [0058]; *see also* Carlson, [0040], [0051]. Carlson explains that, like its reporting stations, a “signal control point” can be “located about a railroad track (e.g., alongside a railroad track).” Carlson, [0032]; *see also id.*, [0010] (“The railroad control system can also include at least one signal control point located along the railroad track.”).

105. Because Carlson describes each report station and signal control point as being “located along the railroad track,” POSAs would have understood that Carlson’s reporting stations and signal control points are “*wayside devices*,” as claimed. Indeed, Carlson says this explicitly: “The techniques can operate through the use of multiple sensing and communication technologies which are mounted on the vehicle and at strategic ***wayside locations***.” Carlson, [0122] (emphasis added).

106. Moreover, the plain meaning of “wayside” is on the edge of a road or (in the railway context) a track. This is consistent with the ’363 patent which explains that its “wayside units” are positioned “near the tracks, such as tunnel walls, signal posts, etc.” EX1001, 4:48-51; *see also* EX1001, 14:39-42 (“In this regard, as noted above, PTCS-2 based train control systems may incorporate anchors as wayside devices, with these anchors being installed along the track.”). Figure 5A of the ’363 patent likewise depicts its “wayside units” as positioned located along the railroad track:



107. Therefore, because Carlson’s reporting stations and signal control points are each “located along the railroad track,” POSAs would have understood that each was a “*wayside device*,” as claimed.

108. For at least these reasons, Carlson discloses a system for “decentralized control operations in a railway network,” that includes “a plurality of wayside units, each configured for placement on or near tracks in the railway network,” as claimed.

- c. **[1B]: “one or more train-mounted units, each configured for deployment on a train operating in the railway network”**

109. Carlson discloses a system for “decentralized control operations in a railway network,” that includes “one or more train-mounted units, each configured for deployment on a train operating in the railway network,” as claimed.

110. Carlson’s system includes one or more “vehicle mounted control system (‘VMCS’) 10” that are “mounted or installed on a rail vehicle such as a train or subway car.” Carlson, [0050]; *see also id.*, [0062]-[0066] (describing more details regarding VMCS 10).

111. Figure 2 (annotated below) depicts a VMCS 10 module (circled in blue) on top of a rail vehicle 5:

**FIGURE 2**

FIGURE 2 is a schematic diagram of a system for monitoring a structure. A horizontal structure 3 is shown with vertical members 20. A sensor assembly 4 is positioned below it, containing a sensor 10. A cable 5 connects the sensor 10 to a processing unit 30. The sensor 10 is highlighted with a blue circle. Arrows indicate the sensor's field of view or measurement area.

112. For at least these reasons, Carlson discloses a system for “decentralized control operations in a railway network,” that includes “one or more train-mounted units, each configured for deployment on a train operating in the railway network,” as claimed.

- d. **[1C]: “wherein each train-mounted unit is configured to:**
  - i. **[1C1]: “communicate with any wayside unit or other train-mounted unit that comes within communication range of the train-mounted unit, wherein the communicating comprises use of ultra-wideband (UWB) based signals”**

113. Carlson discloses a system in which “each train-mounted unit,” *i.e.*, each VMCS 10, “is configured to communicate with any wayside unit or other train-mounted unit that comes within communication range of the train-mounted unit, wherein the communicating comprises use of ultra-wideband (UWB) based signals,” as claimed. Alternatively, such a system would have been obvious over Carlson alone in view of a POSA’s general knowledge.

114. Each VMCS 10 is configured to communicate with any reporting/signaling station (*i.e.*, “wayside unit,” *supra* limitation Ground 1, 1A) or other train-mounted VMCS (*i.e.*, “train-mounted unit,” *supra* limitation Ground 1, 1B) that comes within communication range. Carlson, [0067] (“transponder sensor module [in the VMCS]...communicate[s] with other transponder sensor modules installed on proximate rail vehicles”), [0091] (“when the rail vehicle passes a reporting station...VMCS 10 can communicate information to the report station”); *see also id.*, [0009] (“The rail vehicle control system can include a collision avoidance system including a transponder sensor module. In some embodiments, the transponder sensor module is operable to communicate with one or more

transponder sensor modules installed on one or more proximate rail vehicles, and/or one or more signal control points to detect a distance between the rail vehicle and the proximate vehicle and/or the signal control point.”), [0015] (similar disclosure), [0050]-[0051] (“The VMCS's 10 mounted on various rail vehicles can be configured to communicate with one another in order to determine the speed of the vehicles, and the relative distance between the vehicles, for example.... The reporting stations 30 can include a communication mechanism that allows the rail vehicles and/or the VMCS 10 installed on the rail vehicles to exchange data and information, and otherwise communicate with the reporting stations 30.”), [0062]-[0064] (“[T]he VMCS 10 is adapted to communicate with one or more VMCS's 10 installed on another rail vehicle operating on the same railroad track.”), FIGS. 1-2.

115. The train-mounted VMCS 10s and wayside-located reporting/signaling stations “communicate with each other through [] UWB components,” which send and receive UWB-based signals. Carlson, Abstract; *see also id.*, [0013] (discussing “ultra-wideband (UWB) communications” between system components), [0038] (“[T]he present technology combines ranging technology such as ultra-wideband (‘UWB’) ranging, RFID tags and detectors, an ad hoc wireless network between vehicles and control signal control portions, and a wireless or wired data collection system.”), [0040] (discussing UWB ranging between system components), [0051] (explaining reporting stations communicate with VMCS using “UWB” wireless

communication), [0067] (“the transponder sensor module 110 [of VMCS 10] can be or include a UWB ranging unit configured to send UWB radio waves”), [0074] (“[T]he collision avoidance system 100 [of VMCS 10] and/or the transponder sensor module 110 [of VMCS 10] can communicate with reporting stations and/or signal control points, such as the signal control point 40 depicted in FIG. 3 (for example, via UWB communications).”), [0132] (describing UWB ranging).

116. In fact, claim 7 of Carlson explicitly recites a system that includes two vehicle-mounted subsystems, *e.g.*, two VMCS 10s, and a control signal interface subsystem, *e.g.*, a reporting station, and further recites that the various subsystems “communicate” using “UWB communications.”

117. If Carlson is found not to disclose that VMCS 10 communicates with “*any*” reporting/signal station or train-mounted VMCS 10 within range, then POSAs had reason to implement VMCS 10 in that manner. As I discuss below with respect to limitation 1C2 (and as I discussed above when providing an overview of Carlson), VMCS 10 communicates with other system devices to make vehicle-control decisions based on, for example, the vehicle’s distance to reporting/signal stations and/or other train-mounted VMCS 10 modules. *See, e.g.*, Carlson, [0076]-[0082]. Having a VMCS 10 module communicate with *any* reporting/signal station(s) or VMCS 10 module within range would have better ensured that VMCS 10 received all potentially relevant data, *e.g.*, to detect more potential collisions. For example,

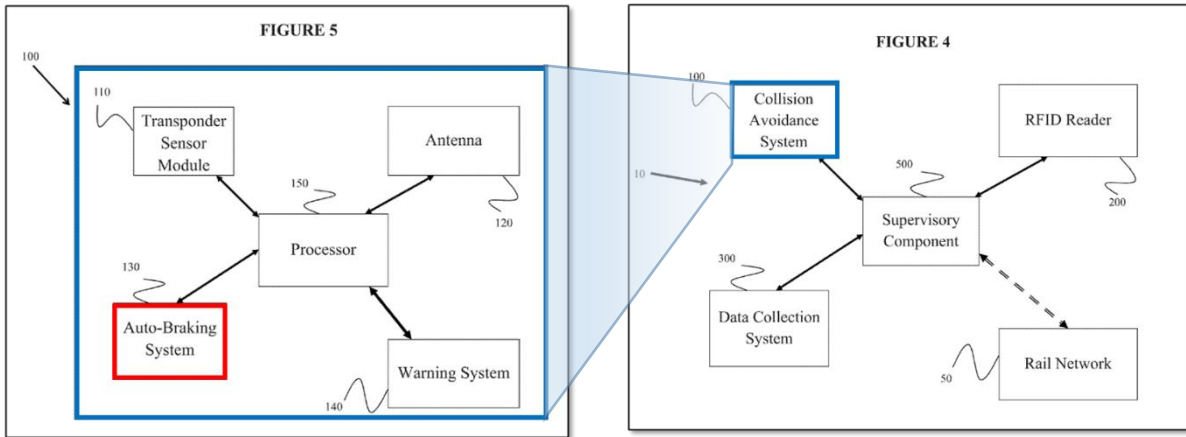
POSAs would have understood that communications received from a particular wayside station could be corrupted (*e.g.*, because the wayside unit is malfunctioning). By communicating with any reporting/signal station(s) or VMCS 10 module within range (rather than, say, just the closest external unit), it would have increased the likelihood of signals/data being received properly, thereby improving safety in the system. EX1024, 5:58-6:18 (explaining that “[a] **key advantage**” to a “collaborative positional determination approach” that fuses positional information from multiple technologies “it offers **redundancy** in the sense that each capability complements the others”); *see also* Carlson, [0071]-[0074] (disclosing the benefits of redundant ranging technologies, which POSAs understood had benefits that also applied to redundant **sources** of ranging and communication signals, whether using the same or different communication technologies as each other).

118. For at least these reasons, Carlson either discloses a system in which “each train-mounted unit,” *i.e.*, each VMCS 10, “is configured to communicate with any wayside unit or other train-mounted unit that comes within communication range of the train-mounted unit, wherein the communicating comprises use of ultra-wideband (UWB) based signals,” as claimed; alternatively, such a system would have been obvious over Carlson alone in view of a POSAs general knowledge.

- ii. **[1C2]: “generate based on the communication, control information configured for use in controlling one or more functions of the train in conjunction with operation in the railway network,”**

119. Carlson discloses a system in which “each train-mounted unit,” i.e., each VMCS 10, “is configured to generate based on the communication, control information configured for use in controlling one or more functions of the train in conjunction with operation in the railway network,” as claimed.

120. VMCS 10 includes a collision-avoidance system that has “an auto-braking system.” Carlson, [0063] (“VMCS 10 comprises a collision avoidance system 100”), [0065] (explaining collision-avoidance system has, among other components, “an auto-braking system 130”). As seen below, Carlson’s Figure 4 (on the right) depicts VMCS 10 as including collision-avoidance system 100 (which I have annotated with a blue box), and its Figure 5 (on the left) depicts collision-avoidance system 100 as including auto-braking system 130 (which I have annotated with a red box within the blue box):



121. As I explain below, VMCS 10 uses its auto-braking system to “control[] one or more functions of the train in conjunction with operation in the railway network,” as claimed.

122. For example, if VMCS 10 determines that the distance to another train-mounted VMCS “violate[s] a pre-set separation distance,” then VMCS 10 will “initiate an auto-brake function to slow the offending vehicle or vehicles in order to maintain a safe distance.” Carlson, [0040]; *see also id.* [0076] (“When the collision avoidance system 100 determines that the signals provided by the signal control point 40 are not being followed by the rail vehicle operator, the processor 150 can operate one or more other functions of the collision avoidance system 100. For example, the processor may use the auto-braking system 130 to initiate an auto-braking feature to automatically brake or otherwise reduce the speed of the rail vehicle.”), [0093] (“The present technology can include systems that have an auto-braking system 130 that automatically reduces the speed of the rail vehicle when the

distance between the rail vehicle and the proximate rail vehicle on the rail track is within a predetermined limit.”), [0118] (describing Figure 8: “If it is determined at step 850 that the rail vehicle is not observing the control signal, speed limit, or approaching vehicle, then the flow diagram 800, at step 860, automatically brakes the vehicle, for example, using an auto-braking system.”), claim 9 (“train-mounted subsystem” configured to “cause the braking system of the vehicle to activate if the distance between the first vehicle-mounted subsystem and the second vehicle-mounted subsystem is less than a second threshold”).

123. VMCS 10’s auto-braking system can also “automatically brake a rail vehicle based on the distance between the vehicle and a signal control point.” Carlson, [0077]; *see also id.*, [0082] (“If the vehicle doesn’t begin braking within a predetermined distance or time (e.g., 50 feet or two seconds of passing the signal control point 40), the collision avoidance system 100 use the auto-braking system 130 to slow or bring the vehicle to a halt.”), claim 9 (“train-mounted subsystem” configured to “cause the braking system of the vehicle to activate if the distance between the first vehicle-mounted subsystem and the control signal interface subsystem is less than a first threshold”).

124. VMCS 10 determines whether to initiate auto-braking using distance determinations it generates based on its UWB-transponder’s wireless communications with UWB-transponders on either (1) other train-mounted VMCS

modules and/or (2) wayside-located reporting/signal stations. Carlson, [0012] (“the step of determining a distance can be based at least in part on the time it takes a signal to travel between the transponder sensor modules on the rail vehicle and signal control point”), [0015] (“determine[s] a distance” based on “communication between the UWB communications component[s]”); [0040] (“UWB system” used to “determine a distance” to “another rail vehicle or signal control point”); [0067]-[0068] (“[T]he transponder sensor module 110 [of VMCS 10] can be or include a UWB ranging unit configured to send UWB radio waves... In this manner, a distance between the various transponder sensor modules 110 (and thus, the distance between the rail vehicles upon which the transponder sensor modules are installed) can be determined. By measuring how long it takes a wave/pulse or a signal to travel (for example by reflecting and/or bouncing, or a precisely timed response) between two transceivers, the distance between the transponder sensor modules can be accurately determined. That is, the present technology can detect the distance between two rail vehicles and/or the distance between a rail vehicle and signal/reporting station based on the time it takes a signal to travel between the transponder sensor modules.”); claim 1 (“determine a distance between the vehicle-mounted subsystem and the control signal interface subsystem based on a time-of-flight of at least one communication between the UWB communications component of the control signal interface subsystem and the UWB communications component

of the vehicle-mounted subsystem”), claim 7 (“determine a distance between the first vehicle-mounted subsystem and the second vehicle-mounted subsystem based on a time-of-flight of at least one communication between the UWB communications component of the second vehicle-mounted subsystem and the UWB communications component of the first vehicle-mounted subsystem”).

125. The UWB-derived distance determinations that VMCS 10 generates and/or the information it generates based on those determinations to initiate/control its auto-braking system are “*control information*” that are “*generated based on the [UWB] communication*” between VMCS 10 and other train-mounted VMCS modules and/or wayside-located reporting/signal stations, as claimed.

126. For at least these reasons, Carlson discloses a system in which “each train-mounted unit,” *i.e.*, each VMCS 10, “is configured to generate based on the communication, control information configured for use in controlling one or more functions of the train in conjunction with operation in the railway network,” as claimed.

**e. [1D] “wherein generating the control information comprises or is based on obtaining ranging measurements”**

127. Carlson discloses a system in which “each train-mounted unit,” *i.e.*, each VMCS 10, generates control information “wherein generating the control information comprises or is based on obtaining ranging measurements,” as claimed.

128. As I explained above with respect to limitation 1C2, the distance determinations that VMCS 10 generates and/or the information it generates based on those determinations to initiate/control its auto-braking system are “*control information*,” as claimed. In Carlson’s system, this “*control information*” “*comprises or is based on obtaining ranging measurements*,” as claimed in limitation 1D.

129. For example, the distance between the UWB transponder on one VMCS 10 and the UWB transponder on either another train-mounted VMCS or a reporting/signal station is measured “based on the time it takes a [UWB] signal to travel between the transponder sensor modules,” so-called “time-of-flight,” which POSAs understood is a ranging measurement. Carlson, [0068]. Indeed, Carlson consistently teaches that its UWB transponders perform ranging measurements. See, e.g., Carlson at Abstract (explaining that the system’s components use UWB to measure distances based on “time-of-flight”), [0013] (similar), [0015] (similar), [0038] (describing UWB as a “ranging technology”), [0041] (similar), [0067] (“UWB ranging unit”), [0131] (explaining that a “ranging radio” is called “ranging” because it may “determine a distance” using “time-of-flight” techniques), [0132] (“One particularly useful technology for the ranging radios 1004 is an UWB network...”), claim 7 (reciting “determine a distance...based on time-of-flight of at

least communication between the UWB communications component” on each system device).

130. For at least these reasons, Carlson discloses a system in which “*each train-mounted unit,*” i.e., each VMCS 10, generates control information “*wherein generating the control information comprises or is based on obtaining ranging measurements,*” as claimed.

f. [1E]: “**wherein obtaining the ranging measurements comprises:**

i. [1E1]: “**broadcasting ultra-wideband (UWB) based signals within a wireless range of the train-mounted unit...**”

131. Carlson discloses a system in which “*each train-mounted unit,*” i.e., VMCS 10, generates control information based on ranging measurements, and the VMCS obtains those ranging measurements by “*broadcasting ultra-wide (UWB) based signals within a wireless range of the train-mounted unit,*” as claimed. Alternatively, such a system would have been obvious over Carlson alone in view of a POSA’s general knowledge.

132. “Broadcasting” is a well-known term in the field of wireless communication and it is understood to mean the communication or transmission of a message (e.g., a data packet) from one transmitting-station to multiple receiving-stations simultaneously. This meaning is reflected in numerous technical dictionaries. EX1017 (defining “broadcast” as “to communicate or transmit...to

numerous recipients simultaneously”); EX1027 (similar); EX1028 (similar). It is also how POSAs described “broadcasting” in prior art publications. See, e.g., EX1023 at [0003]-[0004] (“Broadcast/multicast service is used to communicate the same information to a number of end devices.... As is generally know[n], ‘broadcast’ tends to refer to point-to-multipoint communication where all people within a broadcast area receive the broadcast signals ....”).

133. In the more specific context of UWB signaling, “broadcasting” was well known. For example, the IEEE Standard for Local and Metropolitan Area Networks (EX1019) taught using an identifier (“0xffff”) in the Destination PAN (Personal Area Network) Identifier field or Destination Address field of the standardized communications to “represent the **broadcast**” “address, which shall be accepted” “by **all devices currently listening** to the channel.” EX1019, 59-60 (emphasis added).

134. The ’363 patent uses “broadcast” in its ordinary sense to mean the transmission of a message to multiple receiving devices simultaneously. EX1001, 15:31-35 (“Thus, train control initialization may be performed, where the PTCS-2 based carborne unit may send a broadcast UWB message for all UWB devices (e.g., PTCS-2 anchors) within its wireless range, to announce its presence and identification information.”). In other words, the carborne unit broadcasts a single UWB message by sending it out for all companion devices within range

simultaneously (i.e., it is broadcast because any communication device within range can receive it).

135. As I explained above with respect to limitations 1C and 1D, each VMCS 10 in Carlson “include[s] a UWB ranging unit configured to send UWB radio waves” to other UWB-enabled transponders within wireless range of the VMCS, *e.g.*, transponders on another train-mounted VMCS modules or on wayside-located reporting/signal stations. Carlson, [0067]; *see also* Carlson, [0013] (“The system also includes a vehicle-mounted subsystem including a UWB communications component.”), [0040]-[0041] (explaining system is based on UWB communications between components), [0065]-[0068] (explaining how system uses UWB to perform collision avoidance), FIG.1 (depicting communication between system components), FIGS. 4-5, 8 (similar).

136. Based on Carlson’s disclosure and plain meaning of “broadcast,” POSAs would have understood that VMCS 10 transmits UWB signals using a broadcast technique, *i.e.*, one to many, because the signals are communicated to multiple UWB-enabled transponders simultaneously. Carlson, [0009] (“[T]he transponder sensor module is operable to **communicate with one or more transponder sensor modules** installed on one or more proximate rail vehicles, and/or **one or more signal control points** to detect a distance between the rail vehicle and the proximate vehicle and/or the signal control point.”) (emphasis added), [0064]

(explaining VMCS 10 “determine[s] a distance between the rail vehicle and the proximate rails **vehicles** [plural] on the same track”) (emphasis added), [0067] (“The transponder sensor module 110 can be used to communicate with other **transponder sensor modules installed on proximate rail vehicles**, for example, by sending radio waves/pulses outward via the antenna 120 or other transceivers associated with the transponder sensor module 110.”) (emphasis added), [0103] (“For example, in some embodiments, a VMCS can be used to **send signals, and receive signals from other VMCS devices mounted on proximate rail vehicles**. In this manner, a time of flight technology can be used to determine a separation distance between the rail vehicles. In some embodiments, a GPS unit can be used to determine **the separation distance between two or more rail vehicles**.”) (emphasis added).

137. If Carlson is found not to disclose that VMCS 10 broadcasts UWB signals, POSAs would have had reason to implement VMCS 10 to broadcast UWB signals. For example, POSAs would have understood that the VMCS 10 would not always be aware of all reporting/signal stations and/or other VMCSs within its wireless range. This “blind” scenario would occur, for example, when the VMCS 10 is first powered on and thus has not been in recent wireless communication with any companion devices. Similarly, this would occur when a reporting/signal station or another train first comes into wireless range, *e.g.*, as the train on which the VMCS 10 is mounted moves through the system, it moves into wireless range of new

companion devices that were previously out-of-range (*e.g.*, because it was around a curve with an interfering object in between).

138. By broadcasting UWB ranging signals, rather than addressing them to individual transponders, Carlson's system would have better ensured that VMCS 10 identified and received responses from ***all*** wayside-located reporting/signal stations and train-mounted VMCSs within communication range, not just those already known to the VMCS. This technique would have advanced Carlson's goal of reducing vehicle collisions by better ensuring detection of all reporting/signal stations and VMCS-equipped vehicles within wireless range. This technique would have also advanced Carlson's goal of redundancy in the system. *See, e.g.*, Carlson, [0055], [0071], [0075], [0087], [0090], [0101], [0145]. To put it simply, it makes little sense in Carlson's collision avoidance context to limit (and there would be benefits in not limiting) the VMCS 10's ability to detect potential collisions to only those collisions that might occur with known companion devices rather than with all companion devices whether known to the VMCS 10 or not.

139. Broadcasting UWB-based signals for ranging purposes was also conventional by the mid-2010s, and thus POSAs would have had a reasonable expectation of success in modifying VMCS 10 to broadcast such signals. For example, U.S. Patent Application Publication No. 2004/0240565 (EX1021) published in 2004 and it describes a ranging technique using UWB signals.

Specifically, it teaches the use of a broadcasted “distance request message” that is sent to all other UWB devices within range so that those other devices can determine their distance from the transmitting UWB radio, and the receiving radios also send back a “distance response message” to the transmitting radio so that it too can determine its distance from the other UWB radios. EX1021, [0076]-[0077]. Moreover, as I explained above, broadcasting UWB signals was part of the IEEE standard nearly a decade before the application that became the ’363 patent was filed. See, e.g., EX1019, 146-147. Modifying Carlson to use this UWB broadcasting technique would have therefore been routine to POSAs by the time of the alleged invention.

140. For at least these reasons, Carlson discloses a system in which “*each train-mounted unit,*” i.e., VMCS 10, generates control information based on ranging measurements, and the VMCS obtains those ranging measurements by “*broadcasting ultra-wide (UWB) based signals within a wireless range of the train-mounted unit,*” as claimed; alternatively, such a system would have been obvious over Carlson alone in view of a POSAs general knowledge.

**ii. [1E2]: “the UWB based signals comprising information identifying the train-mounted unit”**

141. Carlson discloses a system in which “*each train-mounted unit,*” i.e., VMCS 10, generates control information obtained by broadcasting UWB based signals and wherein “*the UWB based signals compris[e] information identifying the*

*train-mounted unit,”* as claimed. Alternatively, such a system would have been obvious over Carlson alone in view of a POSA’s general knowledge.

142. When describing VMCS 1000, Carlson explains that the UWB signals it transmits include information beyond “range information” such as the VMCS’s “unique ID.” Carlson, [0132]. As I explained earlier in my overview of the reference, Carlson describes VMCS 1000 as being “similar to VMCS 10” and explicitly teaches that either VMCS “may be adapted to perform the techniques disclosed herein.” Carlson, [0127]. Given their similarities and Carlson’s explicit teaching that each VMCS is adapted to perform the various techniques disclosed within Carlson, POSAs would have understood that VMCS 10—just like VMCS 1000—included its “unique ID” in its broadcasted UWB signals.

143. For example, Carlson’s train-mounted VMCSs “exchange data and information” with reporting stations (Carlson, [0051]), which then relay that information to the rail network that “manages and maintains information relating to the speed and location of” trains in the system (Carlson, [0052]). For the reporting stations to properly associate the exchanged “data and information” with the right VMCS 10 in the system that sent the data and thus allow the rail network to track individual trains, POSAs understood that each VMCS 10’s broadcasted UWB signals—like VMCS 1000’s UWB signals—include a unique ID identifying the VMCS.

144. If Carlson is found not to disclose that the UWB signals VMCS 10 broadcasts include information identifying VMCS 10, POSAs had reason to implement Carlson such that the UWB signals VMCS 10 broadcasts include information identifying it as the source of the signal.

145. First, as discussed above, Carlson teaches that VMCSs and reporting stations “exchange data and information” (Carlson, [0051]), which is used by the rail network to track trains (Carlson, [0052]). Carlson also teaches that one piece of data that can be exchanged via UWB signaling is the “unique ID” of the device transmitting the UWB signal. [0127], [0132]. Including the VMCS 10’s unique ID in UWB-based signals broadcast by the VMCS would have therefore facilitated Carlson’s goal of tracking vehicles in the network and been consistent with the type of data that Carlson explicitly taught was exchanged via UWB signaling.

146. Second, Carlson’s ranging requires that the VMCS 10 receive a “responsive signal from a corresponding transponder sensor module.” Carlson, [0067]. Carlson further discloses using a “***precisely timed*** response” to “distance between the various transponder sensor modules.” Carlson, [0068] (“distance between the various transponder sensor modules...can be determined [b]y measuring...a ***precisely timed response***”) (emphasis added). However, a corresponding transponder sensor module used for ranging (which is located in another VMCS or in a wayside reporting or signaling station) would sometimes



reason to include each VMCS 10's unique ID in the broadcast signal to enable the responding transponder to include that unique ID in its response.

148. The prior art confirms that including the transmitting radio's unique ID would have been conventional and beneficial. For example, EX1020, which teaches at [0028] a time-of-flight technique (similar to Carlson's) wherein a first signal from an initiating device (a device that wants to determine its location or distance to another device) "include[s] identification data that identifies the initiating device" so that the "response signal may also include th[at] identification data" so that "when the initiating device receives the response signal it can determine that the response signal was a response to the first signal sent by that initiating device, as opposed to some other possible initiating devices in the worksite." EX1020 teaches (as POSAs understood), by including and responding with identification information, in systems "having multiple responding devices in the worksite [], the initiating device can determine which responding device responded to its initiating signal." *See also* EX1021, [0074]-[0075] (describing a conventional example of UWB-based ranging broadcasts and responses), FIG. 4 (corroborating that these conventional signals include a "Destination Address" (i.e., identifying information for a recipient unit); "Source Address" (i.e., identifying information for the sending unit)).

149. As another corroborating example, EX1022 at [0069] teaches, as was well-known to POSAs, that wireless communication devices conventionally include

a so-called “MAC address[, which] is an address that uniquely identifies each device” and that these address can be “broadcast” to “mak[e] the presence of the relevant device known to others.” EX1022 at [0069] further teaches that “[i]n case of UWB interface, the beacon information contains, in addition to the MAC address of the source of transmission, the MAC address of each processing device with which the processing device that transmitted the beacon information can be coupled.” Thus, “the MAC address of the processing device that transmitted the beacon information as well as the MAC address of each nearby processing device.” EX1022, [0069]. EX1022, therefore, teaches another known benefit of including a unique identifier in UWB communications—it can be used to inform UWB-based devices of all other USB-based devices in the system, even if not yet in communication range of each other.

150. Third, including a source address—*i.e.*, a unique identifier for the transponder sending a UWB signal—was a standardized technique for UWB signaling. The IEEE 802.15.4-2011 standard sets forth a standardized MAC frame for UWB signals, which includes a “Source Address” uniquely identifying the transponder that sends the MAC frame. EX1019, 40-41 (“Source Address field...shall contain the address of the device sending the frame”), 57-59 (“Source PAN identifier...specifies the **unique** PAN identifier of the originator”); *see also id.* 8-9 (“Unique 64-bit extended address or allocated 16-bit short address”; “All devices

operating on a network...have unique addresses, referred to as extended addresses. A device will use either the extended address for direct communication within the PAN or the short address that was allocated by the PAN coordinator when the device associated.”), 59 (noting that “[a] value of 0xffff in th[e Destination PAN Identifier field/Destination Address] field shall represent the broadcast PAN identifier[/short address, which shall be accepted as a valid PAN identifier[/valid address] by all devices currently listening to the channel”).

151. Including information identifying the transmitting VMCS 10 would therefore have been a routine implementation of the then-standardized UWB MAC frame. The IEEE standard thus reinforces that including information identifying the transponder that sends a UWB signal was conventional by the mid-2010s, and thus POSAs would have had a reasonable expectation of success in modifying VMCS 10 to broadcast such signals, even if VMCS 10 were not already transmitting its identification information, for the reasons I discussed above in this section.

152. For at least these reasons, Carlson discloses a system in which “*each train-mounted unit,*” i.e., VMCS 10, generates control information obtained by broadcasting UWB based signals and wherein “*the UWB based signals compris[e] information identifying the train-mounted unit,*” as claimed; alternatively, such a system would have been obvious over Carlson alone in view of a POSA’s general knowledge.

**iii. [1E3]: “selecting based on received responses to the broadcast UWB based signals, one or more of the plurality of wayside units; and**

153. Carlson discloses a system in which “*each train-mounted unit,*” *i.e.*, VMCS 10, generates control information obtained by broadcasting UWB based signals and “*selecting based on received responses to the broadcast UWB bases signals, one or more of the plurality of wayside units,*” as claimed.

154. Although it never uses the specific term “selecting,” the ’363 patent describes one embodiment in which a train-mounted unit broadcasts UWB-based signals to a plurality of wayside units (*i.e.*, anchors) and receives responses from the wayside units. This embodiment is discussed in column 15 of the ’363 patent. In that embodiment, a train-mounted unit “send[s] a broadcast UWB message for all UWB devices (*e.g.*, PTCS-anchors) within its wireless range, to announce its presence and identification information.” EX1001, 15:31-35. “Once the UWB responses from the UWB devices (*e.g.*, anchors) are received, the [] carborne unit commences an individual range measurement with each responding UWB device.” EX1001, 15:35-39. The patent is explicit that the initial UWB responses that the carborne unit receives “include a range measurement,” which permits the carborne unit to determine its distance from the responding device(s) based, at least in part, on the initial response(s). EX1001, 15:42-50.

155. Read in light of the specification and the embodiment disclosed in column 15, POSAs would understand limitation 1E3 covers a train-mounted unit that is configured for “*selecting*” one or more wayside units simply by receiving and using responses from those wayside units that responded to its original broadcast signal. In other words, there is nothing in the specification to suggest to a POSA that the “*selecting*” clause in limitation 1E3 requires that when the train-mounted unit received multiple responses from wayside units that it picks only a subset of the responses it receives from the wayside units.

156. Carlson’s VMCS 10 selects wayside units in a similar manner to the carborne unit in the above-described embodiment. As discussed above with respect to limitation [1E4], to perform a ranging measurement, VMCS 10 receives a responsive signal from the wayside reporting/signal stations that received the broadcast signal(s) that the VMCS 10 transmitted. Carlson, [0067]-[0068] (discussing how UWB transponders exchange signals for distance determinations); *see also e.g.*, Carlson, [0013] (explaining UWB used to determine distance between a train and signaling station), claim 1 (same). When VMCS 10 obtains a ranging measurement based on the responsive signal(s), VMCS 10 has selected the reporting/signal station(s) in the same way the ’363 patent selects wayside units.

157. For at least these reasons, Carlson discloses a system in which “*each train-mounted unit,*” *i.e.*, VMCS 10, generates control information obtained by

broadcasting UWB based signals and “*selecting based on received responses to the broadcast UWB bases signals, one or more of the plurality of wayside units,*” as claimed.

- iv. **[1E4]: “determining ranging information corresponding to each of the one or more wayside units, based on ultra-wideband (UWB) based signals communicated respectively with each of the one or more of the plurality of wayside units.”**

158. Carlson discloses a system in which “*each train-mounted unit,*” i.e., VMCS 10, generates control information obtained by broadcasting UWB based signals and “*determining ranging information corresponding to each of the one or more wayside units, based on ultra-wideband (UWB) based signals communicated respectively with each of the one or more of the plurality of wayside units,*” as claimed.

159. As I explained with response to limitation 1C, Carlson’s VMCS 10 includes “a UWB ranging unit configured to send UWB radio waves.” Carlson, [0067]. The ranging unit “detect[s] the distance...between a rail vehicle and signal/reporting station based on the time it takes a [UWB-based] signal to travel between the transponder sensor modules.” Carlson, [0068]; *see also* claim 1 (“determine a distance...based on a time-of-flight” of UWB-signals), claim 7 (same). Thus, Carlson’s VMCS 10 determines ranging information (e.g., distance)

to wayside signal/reporting stations based on the UWB-based signals it communicates with wayside signal/reporting stations, as claimed.

160. For at least these reasons, Carlson discloses a system in which “*each train-mounted unit,*” i.e., VMCS 10, generates control information obtained by broadcasting UWB based signals and “*determining ranging information corresponding to each of the one or more wayside units, based on ultra-wideband (UWB) based signals communicated respectively with each of the one or more of the plurality of wayside units,*” as claimed.

**4. Claim 2: “The system of claim 1, wherein the train-mounted unit is configured to generate at least part of the control information based on sources other than processing of the ultra-wideband (UWB) based signals.”**

161. Carlson discloses that for the system that I discussed above (or in the obvious variants of that system that I discussed above), “*the train-mounted unit is configured to generate at least part of the control information based on sources other than processing of the ultra-wideband (UWB) based signals,*” as claimed.

162. As I discussed *supra* for limitation [1C2], VMCS 10’s collision-avoidance system (1) generates distance determinations (e.g., the distance between the VMCS and another VMCS 10 or a wayside signal / reporting station) based on processing of UWB-based signals exchanged with those other unit(s) and (2) uses those distance determinations to control the train’s movement (e.g., generating

control information to stop/slow the train if the distance to another train is below a threshold).

163. In addition to being based on processing UWB-based signals, Carlson’s distance determinations—which, as I discussed above for limitation 1C2, are “*control information*” or information used to determine control information—are also determined by processing ***non-UWB-based signals***. For example, Carlson discloses that VMCS 10 also determines distances based on GPS-position information, which is “used in combination with” the “time of flight” technology (*e.g.*, UWB-based ranging) “to determine a separation distance.” Carlson, [0071]; *see also* Carlson, [0013] (“determine a distance” “based on a time-of-flight” based on “one communication between the UWB communications component[s]”), [0041] (“The present technology can use ***time of flight techniques***... to detect a distance between rail vehicles and/or between rail vehicles and other objects, such as signal control points and/or reporting stations. ***For example***, in some embodiments of the present technology, signal and/or reporting stations located along a railroad track can be equipped with collision avoidance systems, transponder sensor modules, ***UWB systems***, and/or other ranging technology or radio network signaling devices.”) (emphasis added); Claim 1 (“***determine a distance*** between the vehicle-mounted subsystem and the control signal interface subsystem ***based on a time-of-flight*** of at least one ***communication between the UWB communications***

**component** of the control signal interface subsystem **and the UWB communications component** of the vehicle-mounted subsystem”) (emphasis added).

164. VMCS 10 is therefore configured to generate at least part of the distance determinations (i.e., the “*control information*” or information used to determine the control information, as claimed) based on sources other than processing UWB-based signals, e.g., GPS signals, as claimed.

## 5. Claim 3

- a. [3A]: “The system of claim 2, wherein the train-mounted unit is configured to assess based on the processing of the ultra-wideband (UWB) based signals, one or more conditions relating to operation of the train within the railway network”

165. Carlson discloses that for the system that I discussed above for claim 2 (or in the obvious variants of that system that I discussed above), “*the train-mounted unit is configured to assess based on the processing of the ultra-wideband (UWB) based signals, one or more conditions relating to operation of the train within the railway network,*” as claimed.

166. As I discussed *supra* for limitation [1C2] and claim 2, VMCS 10 (using its collision-avoidance system) processes UWB-based signals to determine the distance between itself and either another VMCS and/or wayside reporting station(s). This distance determination is a “*condition relating to operation of the*

*train within the railway network,”* as claimed. The “condition” in this example being the VMCS’s distance to other units in the railway network.

167. In addition to determining distance separations, VMCS 10 also processes UWB signals to determine other “*conditions relating to operation of the train within the railway network,”* as claimed. For example, VMCS 10 processes UWB signals to determine the ***absolute position*** and/or ***speed*** of the vehicle on which the VMCS is mounted. Carlson, [0071] (UWB signals used, in part, to calculate absolute position of the vehicle), [0072] (“measure speed using the UWB time-of-flight data”), [0090] (“The VMCS 10 may actually have several ***ways of determining speed***. Such ways include determining speed by: wheel rotation rate; GPS information; RFID tag 20 scanning; and/or ***distance ranging over time (for example, using the UWB time-of-flight data over time)***.” (emphasis added)).

168. The absolute position and speed of the vehicle on which the VMCS is mounted as well as its distance from other vehicles or reporting/signal stations within the railway network are all “*conditions relating to operation of the train within the railway network*” that are assessed by the processing of UWB-based signals, as claimed.

- b. [3B]-[3C]: “when at least one condition meets one or more particular criteria, determine one or more responsive actions and perform or cause performing each of the one or more responsive actions.”

169. Carlson discloses that for the system that I discussed above for claim 2 (or in the obvious variants of that system that I discussed above), “*when at least one condition meets one or more particular criteria, determine one or more responsive actions and perform or cause performing each of the one or more responsive actions,*” as claimed. VMCS 10 initiates its auto-braking system and/or warning system (FIG. 5), when it determines that one of the conditions the VMCS assesses based on the processing of UWB-based signals (*i.e.*, the train’s absolute position, speed, or separation distance to other units) meets a particular criterion.

170. For example, when the VMCS determines that the separation distance between it and either (1) another VMCS or (2) a reporting station “has come within a predetermined limit,” the VMCS “initiate[s] the auto-braking feature.” Carlson, [0076], [0082] (describing auto-braking function: “If the vehicle doesn’t begin braking ***within a predetermined distance or time*** (e.g., 50 feet or two seconds of passing the signal control point 40) [*i.e.*, criteria], the collision avoidance system 100 ***use[s] the auto-braking system 130 to slow or bring the vehicle to a halt***” [*i.e.*, one or more responsive actions].) (emphasis added). Similarly, when the separation distance comes within a predetermined limit, the train-mounted VMCS can warn the train operator (*e.g.*, via audio or visual indicators). Carlson, [0035] (“warn the

operator...when the distance between vehicles has breached an acceptably safe value”), [0080]-[0081] (“warning system...can generate an audible and/or visual warning”). The warning is a responsive action to a condition meeting a criterion (i.e., violating the “acceptably safe value” distance between vehicles).

171. Likewise, when the VMCS determines that the vehicle’s speed exceeds a pre-determined limit (i.e., a condition meeting a criterion), the VMCS can automatically brake the train and/or issue a warning to the operator (i.e., responsive actions). Carlson, [0036] (when the train is speeding, the system “can effectively warn the operator, automatically brake the rail vehicle, or otherwise control the rail vehicle”), [0117]-[0118] (“If a warning is being generated, ***the failure of the vehicle to observe control points, speed limits, or recognize an approaching vehicle may escalate the level of the warning***—e.g., causing a louder warning or a brighter, different colored warning (for example, go from yellow to red).... ***If it is determined at step 850 that the rail vehicle is not observing the control signal, speed limit, or approaching vehicle, then the flow diagram 800, at step 860, automatically brakes the vehicle***, for example, using an auto-braking system. In some embodiments, the auto-braking feature can be applied until the rail vehicle comes to a complete stop, or until the vehicle speed is below a determined threshold (e.g., below 2 miles per hour or below the speed limit for that portion of the track), depending on the conditions and the situation.”) (emphasis added).

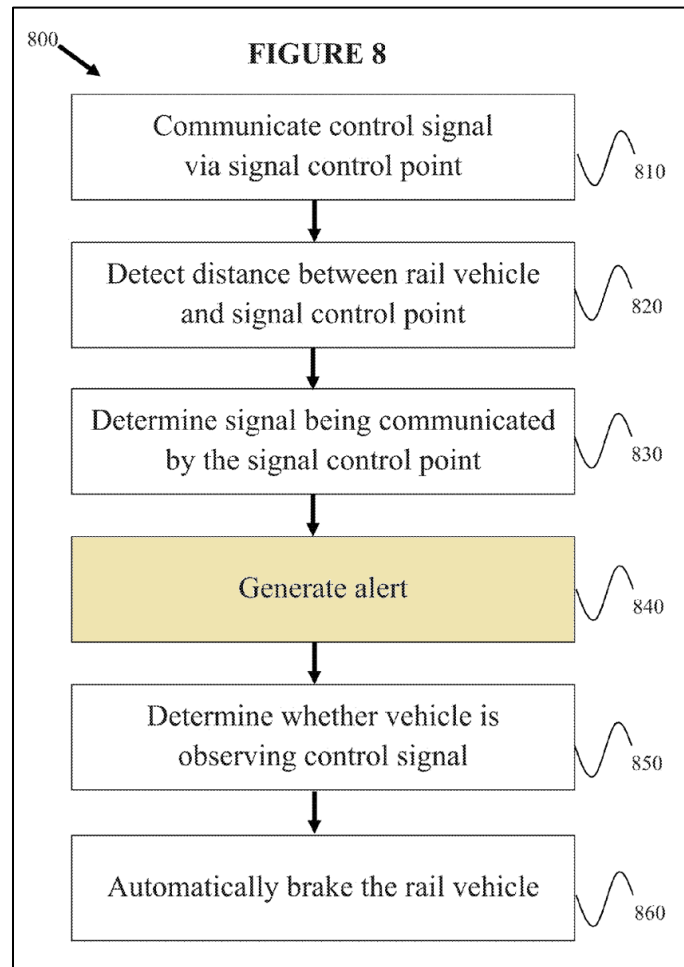
172. Initiating the auto-braking or warning system that I described above is each a “*responsive action*” that the VMCS 10 determines should be performed “*when at least one condition*” discussed with respect to limitation 3A, i.e., a distance and/or speed, “*meets one or more particular criteria*,” e.g., the vehicle is too close to another vehicle (i.e., the separation distance is below a distance threshold criterion) or traveling too fast (i.e., the train is traveling at a speed above a speed threshold criterion).

## **6. Claim 4**

- a. [4A]: “The system of claim 3, wherein, when the one or more responsive actions comprise providing indication or feedback, relating to the at least one condition, to a train operator”**

173. Carlson discloses that for the system that I discussed above for claim 3 (or in the obvious variants of that system that I discussed above), “when at least one condition meets one or more particular criteria, determine one or more responsive actions and perform or cause performing each of the one or more responsive actions,” as claimed. As I discussed above for limitation 3B, one responsive action the train-mounted VMCS performs is “generat[ing] a warning signal,” for example, “beeps or alarms that will continue until the vehicle operator acknowledges the signal.” Carlson, [0112], FIG. 8 (step 840: “Generate alert” annotated below), claim 2 (“generate an alert”). The warning signal for the train operator relates to at least one of the conditions discussed above, e.g., (1) the distance to another VMCS or a

reporting/signal station being below a threshold or (2) the train's velocity exceeding a speed limit. Carlson, [0080]-[0081], [0117]. The warning signal is an “*indication or feedback, relating to the at least one condition, to a train operator,*” as claimed.



**b. [4B]: “the train-mounted unit is configured to: monitor actions of the train operator”**

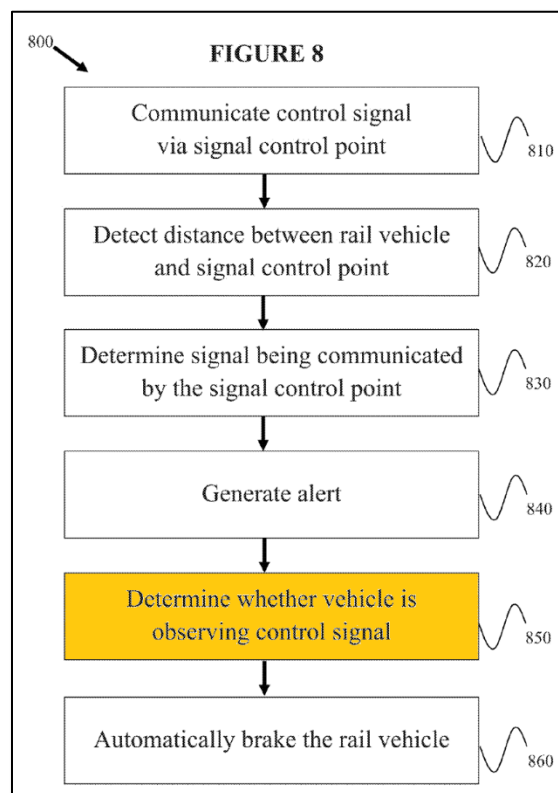
174. VMCS 10’s collision-avoidance system “*monitors actions of the train operator,*” as claimed. For example, VMCS 10 monitors whether the operator has “decreased the [train’s] speed” or caused it to stop, which is an action of the train operator, as claimed. Carlson, [0081], [0112], FIG. 8 (step 850: “Determine whether

vehicle is observing control signal” annotated below). Thus, Carlson discloses that the “*the train-mounted unit [VMCS] is configured to: monitor actions of the train operator,*” as claimed.

c. [4C]: “**assess based on the monitoring, the train operator’s compliance with at least one expected subsequent responsive action**”

175. VMCS 10’s collision-avoidance system assesses whether “the condition that originally caused the alarm has been cleared” by the train operator’s compliance with at least one expected responsive action. Carlson, [0081] (“In some embodiments, the warning signal can sound continuously until the operator presses an acknowledge button an interface, until the vehicle has come to a stop, or until the condition that caused the alarm has been cleared.”), [0082] (“For example, when the vehicle passes a red signal ***without stopping***, the collision avoidance system 100 can alert the vehicle operator using the warning system 140, log the event description, timestamp, signal state, measured distance to the signal, and the vehicle operating conditions when the alarm was sounded. The collision avoidance system 100 can be configured such that the warning signal can be quieted if the vehicle operator presses a confirmation button, but to ***sound a periodic alert until vehicle is stopped or the signal is no longer red***. If the vehicle ***doesn’t begin braking within a predetermined distance or time*** (e.g., 50 feet or two seconds of passing the signal control point 40), the collision avoidance system 100 use the auto-braking system 130 to slow or bring

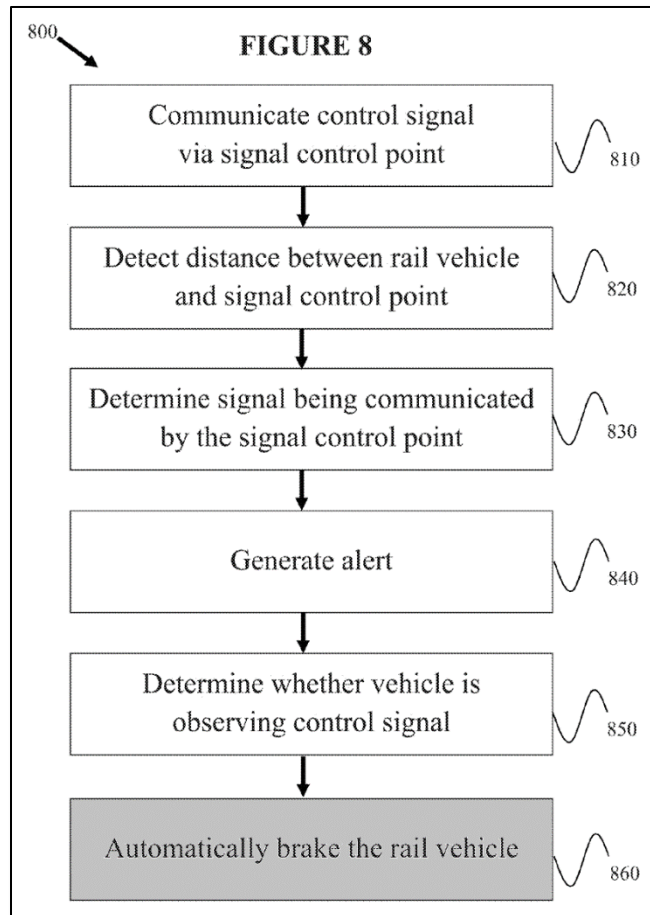
the vehicle to a halt.”) (emphasis added), FIG. 8 (step 850: “**Determine** whether vehicle is observing control signal” annotated below), [0112] (assess whether operator has “take[n] steps to slow and/or stop the vehicle”) (emphasis added). For example, VMCS 10 will assess whether the operator has taken responsive action and started “braking within a predetermined distance or time.” Carlson, [0082]; *see also* [0076] (“When the collision avoidance system 100 **determines that the signals** provided by the signal control point 40 **are not being followed by the rail vehicle operator**, the processor 150 can operate one or more other functions of the collision avoidance system 100.”) (emphasis added).



176. Determining whether the condition that cause an alarm has been cleared (*e.g.*, by the vehicle stopping or begun braking within a predetermined distance or time), as I described above, is the system “*assess[ing] based on the monitoring, the train operator’s compliance with at least one expected subsequent responsive action,*” as claimed.

- d. **[4D]: “when the train operator fails to do so, directly perform the at least one expected subsequent responsive action or perform an alternative action.”**

177. When VMCS 10’s collision-avoidance system determines that the operator has failed to take sufficiently corrective/responsive action as I described *supra* for limitation [4C], VMCS 10 will directly perform the expected corrective/responsive action, *e.g.*, the VMCS will automatically “slow or bring the vehicle to a halt.” Carlson,[0082], [0076] (“initiate the auto-braking feature”). For example, the VMCS determines that “the vehicle does not begin slowing down at an appropriate rate once the distance is reached, then it can be determined that the vehicle is not observing the control signal.” Carlson, [0113]-[0114]. In response to that determination, the VMCS will “automatically brake[] the vehicle, for example, using an auto-braking system.” Carlson, [0118]; *see also* FIG. 8 (step 860: “Automatically brake the rail vehicle” annotated below).



178. Automatically braking the vehicle is “directly perform[ing] the at least one expected subsequent responsive action or perform an alternative action” “when the train operator fails to do so,” as claimed.

7. **Claim 5: “The system of claim 1, wherein the train-mounted unit is configured for utilizing non-UWB based signals for communicating at least some data with the wayside unit and/or another train-mounted unit.”**

179. Carlson discloses that for the system that I discussed above for claim 1 (or in the obvious variants of that system that I discussed above), “*the train-mounted unit is configured for utilizing non-UWB based signals for communicating at least some data with the wayside unit and/or another train-mounted unit,*” as claimed.

This is because, in addition to the UWB-based communication components that I discussed above (*e.g.*, for limitation [1C1]), Carlson discloses that VMCS 10 also includes communication components for “a **second** or **redundant** wireless network,” that is “a different type than the first network,” *i.e.*, different in type than the UWB network, such as “a spread-spectrum network,” which a POSA understood is a non-UWB based network. Carlson, [0075]. The ’363 patent expressly recognizes “spread-spectrum links” as an alternative, “redundant data channels” to UWB-based ranging radios. See EX1001, 6:50-54, 8:5-11 (identifying UWB and “spread spectrum” as different “wireless systems”); EX1030, 3 (“contrast[ing UWB] with spread spectrum radio technologies”). Other non-UWB based networks that Carlson’s VMCS 10 uses for communication include “Bluetooth” and/or “WiFi.” Carlson, [0091].

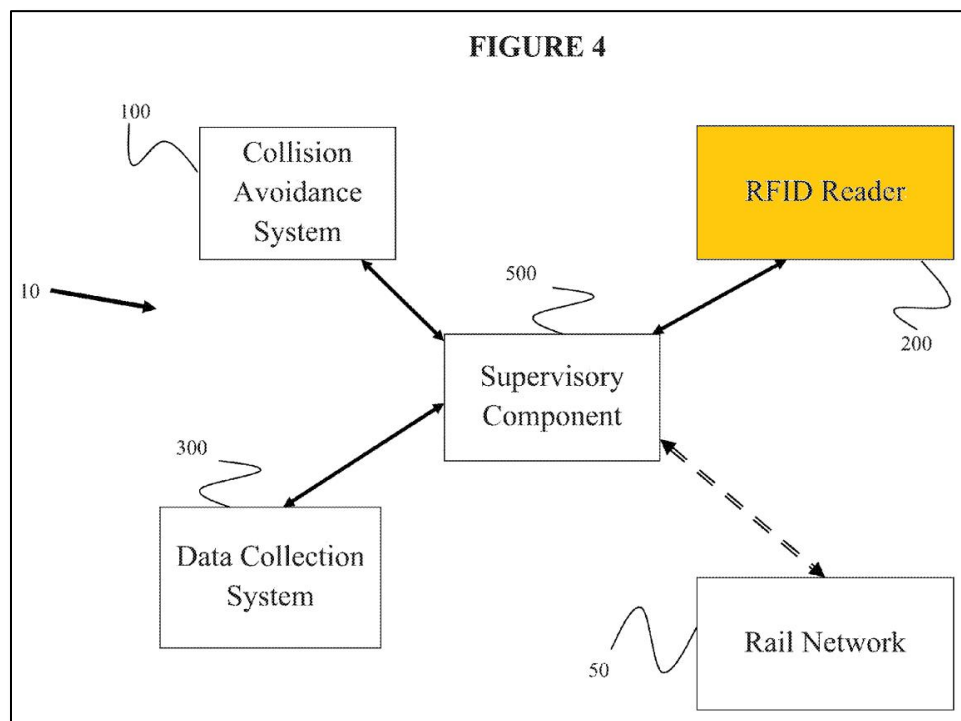
180. The VMCS 10’s non-UWB network is used to “transmit information [*i.e.*, data] similar to what is transmitted by the first network.” Carlson, [0075]. For example, the non-UWB networks, like WiFi or Bluetooth, are used to “communicate information about the rail vehicle location, speed,” etc., to wayside reporting/signal stations, which is communicated as the VMCS 10 passes those stations. Carlson, [0091]; *see also* [0046] (data is indirectly communicated to the rail network from a VMCS 10 via reporting stations); [0051] (“the reporting stations 30 can include transceivers that allow the reporting stations to send and receive information via

Bluetooth, WiFi, radio signals, cellular signals, UWB, peer-to-peer networks, microwaves, infrared signals, lasers, ultrasonic signals, electromagnetic induction signals, or other modes of wireless communication”), [0052] (“The reporting station 30 can also communicate and exchange information with a rail network 50. For example, the reporting station can be in wireless or wired communication with a rail network 50 that manages and maintains information relating to the speed and location of the rail vehicles connected to the network 50, as well as other information about the rail tracks and present weather conditions, for example.”), [0053] (“Information from the VMCS 10 mounted on the rail vehicles can communicate with the network 50 via the reporting stations 30 such that each vehicle can be aware of the location of other vehicles traveling along the railroad, their speeds, weather conditions, railroad conditions or situations (e.g., steep grades, approaching sharp curves, rail crossings, or stations), and other information that can be useful to ensure safe and efficient rail transportation.”).

**8. Claim 6: “The system of claim 1, wherein the train-mounted unit is configured for handling radio-frequency identification (RFID) based signals with RFID devices used within the railway network.”**

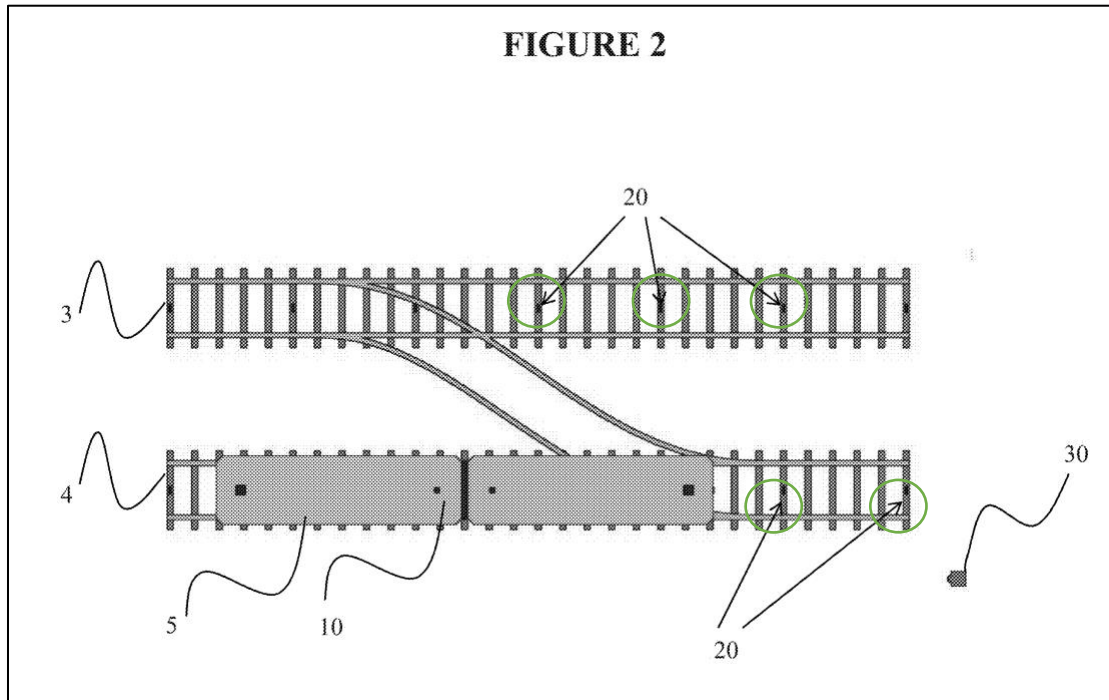
181. Carlson discloses that for the system that I discussed above for claim 1 (or in the obvious variants of that system that I discussed above), *“the train-mounted unit is configured for handling radio-frequency identification (RFID) based signals with RFID devices used within the railway network,”* as claimed. As illustrated by

Carlson's Figure 4 (which I have annotated below), Carlson discloses that VMCS 10 includes an RFID reader "mounted on the train," which is configured for handling RFID-based signals transmitted by RFID devices within the system. Carlson, [0042]; see also [0009] ("The control system can also include a radio frequency identification ("RFID") reader adapted to detect serialized **RFID tags mounted at locations along a railroad.**") (emphasis added), [0084]-[0089], FIGS. 4, 9.



182. As Carlson's Figure 2 (which I have annotated below) illustrates, the RFID reader "read[s]," i.e., communicates with, "RFID tags 20" (circled green below) mounted "at locations along the railroad track." Carlson, [0054], [0061] (*"The VMCS 10 also senses RFID tags 20 that are located along a railroad track.*

One embodiment of the VMCS 10 is depicted in greater detail in FIG. 4.”) (emphasis added).



183. Using its RFID reader, Carlson discloses that VMCS 10 retrieves information stored in the RFID signal and processes that information to perform various functions like determining the train’s speed and/or location. [0011] (“Some embodiments of the method can also include **determining vehicle speed information based at least in part on the location of the first RFID tag** and the first time, and the location of the second RFID tag and the second time.”) (emphasis added), [0014] (“According to another technique, the vehicle-mounted subsystem further includes: a radio-frequency identification (RFID) subsystem configured to **scan at least one RFID tag external to the vehicle to retrieve information stored on the at least one**

**RFID tag.** In this technique, the vehicle-mounted subsystem is further configured to **determine a distance** between the vehicle-mounted subsystem and the control signal interface subsystem **based on the information stored on the at least one RFID tag....** The vehicle-mounted subsystem **determines a changing distance** between the vehicle-mounted subsystem and the control signal interface subsystem **based on the information stored on the at least one RFID tag** and the information relating to speed of the vehicle.”) (emphasis added), [0042] (“In this manner, each RFID tag can be associated with a location, so that **when the serialized RFID tag is read by the RFID reader, the system can have knowledge of the location of the rail vehicle upon which the RFID reader is mounted.** Moreover, providing multiple **RFID tags mounted on the railroad tracks allows the system to calculate the rail speed using the distance and time between successively read RFID tags.**”) (emphasis added), [0044]-[0045], [0056], [0072], [0084]-[0090], claim 4.

184. VMCS 10 is therefore “configured for handling radio-frequency identification (RFID) based signals with RFID devices used within the railway network,” as claimed.

**9. Claim 7: “The system of claim 1, wherein the train-mounted unit is configured for handling satellite based signals.”**

185. Carlson discloses that for the system that I discussed above for claim 1 (or in the obvious variants of that system that I discussed above), “*the train-mounted unit is configured for handling radio-frequency identification (RFID) based signals*

with *RFID devices used within the railway network*,” as claimed. As I discussed *supra* for claim 2, VMCS 10 is configured for handling satellite-based GPS-signals. Carlson, [0071] (“the ***collision avoidance system 100 also includes a GPS unit*** that can be used in combination with (or as a component of) the transponder sensor module to determine a position (e.g., an absolute position) of the rail vehicle”) (emphasis added), [0072] (“The VMCS 10 may also be capable of ***determining speed information from GPS information*** ....”) (emphasis added), [0090] (“The VMCS 10 may actually have several ways of determining speed. Such ways include determining speed by: wheel rotation rate; ***GPS information***;....”) (emphasis added), [0094], FIG. 9 (“GPSs” 1005)

**10. Claim 8: “The system of claim 7, wherein the train-mounted unit is configured for obtaining from received satellite based signals information, and generating or adjusting the control information based on the obtained information.”**

186. Carlson discloses that for the system that I discussed above for claim 7 (or in the obvious variants of that system that I discussed above), “*the train-mounted unit is configured for obtaining from received satellite based signals information, and generating or adjusting the control information based on the obtained information*,” as claimed.

187. Carlson discloses that VMCS 10 is configured for obtaining GPS-based positional from the received GPS satellite-based signals and to use that data with the UWB-based signals to determine the distance between the VMCS and either another

VMCS or a reporting station. For example, Carlson at [0071] discloses the “collision avoidance system 100 [within VMCS 10] also includes a GPS unit that can be used in combination with (or as a component of) the transponder sensor module **to determine a position** (e.g., an absolute position) of the rail vehicle.” Emphasis added. Carlson then discloses in [0071] that VMCS 10 uses GPS to “ensure that the time of flight technology is not providing incorrect separation distance information.” See also Carlson, [0103] (VMCS “may use a combination of time of flight and GPS technology to more accurately detect and determine a distance between rail vehicles”). Because GPS information is used to detect and determine a distance between the VMCS and another vehicle, the GPS information is used to “*generat[e] or adjust[]*” the VMCS’s distance determination, which is “*control information*” or is information that is used to determine the control information, as I discussed above for limitation [1C2]. Thus, Carlson’s “*train-mounted unit [VMCS] is configured for obtaining from received satellite based signals information [e.g., GPS-related information], and generating or adjusting the control information based on the obtained information [e.g., generating control information to brake the vehicle if a separation violation is determined based, at least in part, on GPS-based information],*” as claimed.

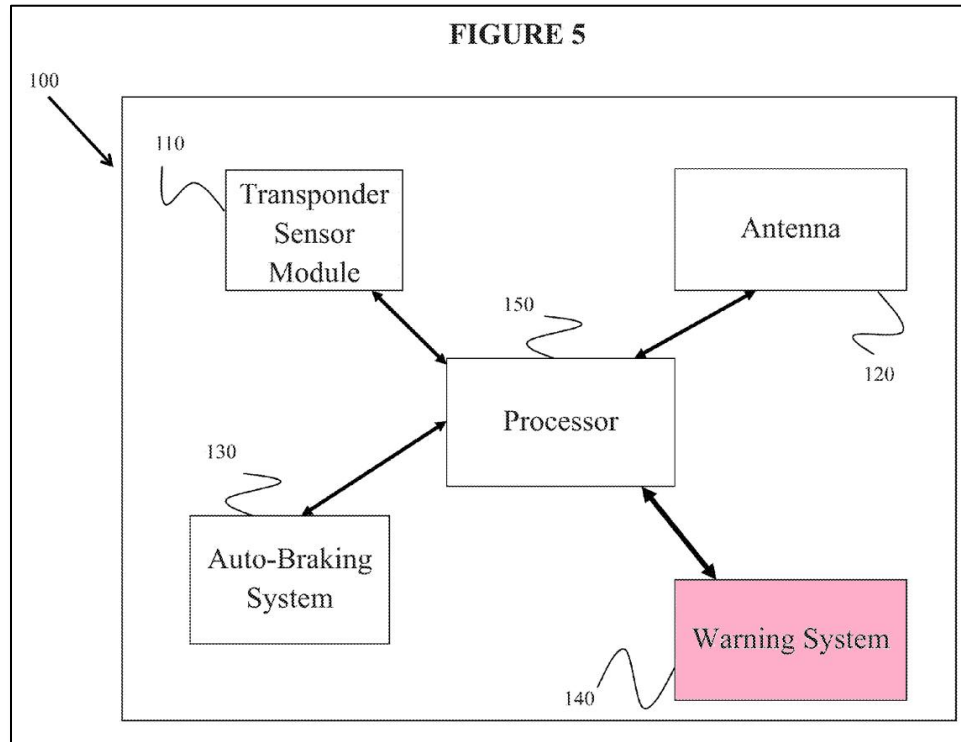
**11. Claim 9: “The system of claim 1, wherein the train-mounted unit is configured for connecting to and/or interfacing with other systems of the train.”**

188. Carlson discloses that VMCS 10 is “configured to[] **interface** with a braking system.” Carlson, [0013]; *see also* Abstract. In particular, VMCS 10’s auto-braking system “work[s] with” the train’s “brakes and associated vehicle componentry,” which are “*other systems of the train*,” as claimed. Carlson, [0079]; *see also* [0127], [0138] (“interfaces with existing vehicle controls and data”), [00139] (“VMCS 1000 may include a vehicle interface 1012 that interfaces with existing vehicle controls and data,” like “interface[ing] with the vehicle’s **existing brake system**.”) (emphasis added), FIG. 9 (illustrating that VMCS 1000 communicates and interfaces with other systems of the train, such as the “Vehicle interface” comprising the “Vehicle Brake” system 1002). Thus, Carlson’s “*train-mounted unit is configured for connecting to and/or interfacing with other systems of the train [e.g., existing brake system]*,” as claimed.

**12. Claim 10: “The system of claim 1, comprising 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.”**

189. As Carlson’s Figure 5 (which I have annotated below) illustrates, VMCS 10’s collision-avoidance system includes a warning system 140 (Carlson, [0065]) that provides output to the train operator by “generat[ing] an audible and/or

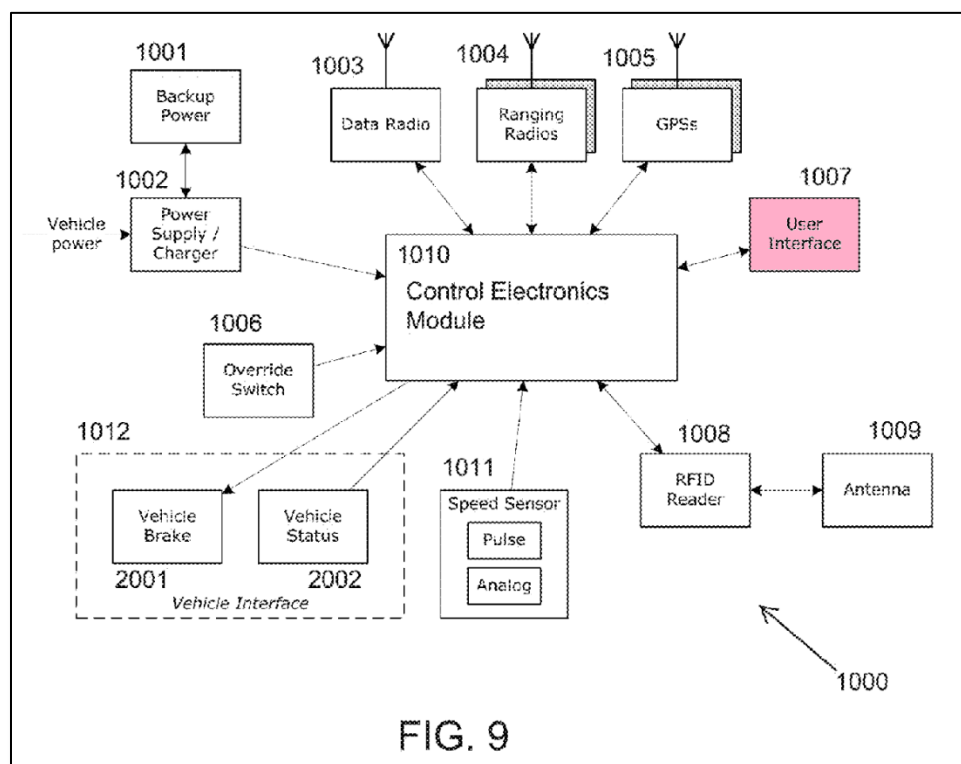
visual warning” signal. Carlson, [0080]-[0081]. The warning system is thus an “*output component*,” as claimed.



190. Carlson discloses that the warning signal will sound “until the operator presses an acknowledge button [on] an interface.” Carlson, [0081]; *see also* [0082] (“confirmation button” to “quiet[]” the warning signal). The acknowledgement/confirmation button is thus an “*input component*,” as claimed. VMCS 10 therefore comprises “*one or more input/output (I/O) components*,” as claimed.

191. Alternatively, as Carlson’s Figure 9 (which I have annotated below) illustrates, VMCS 1000 includes a user interface 1007. Carlson, [0127]. The user interface includes I/O components like “displays, input devices, or speakers” for

“receive[ing] inputs...from an operator” and “display[ing]” outputs to the operator, as claimed. Carlson, [0134], [0141] (“The control electronics module 1010 may **cause an alert to be generated by the user interface 1007** (visual and/or auditory) ....”) (emphasis added), [0142] (“after a suitable period of time, the control electronics module 1010 **may receive an input from the user interface 1007** indicating that the braking event should end. This may occur through an **operator** acknowledging and ending the braking event by **interacting with the user interface 1007**”) (emphasis added).



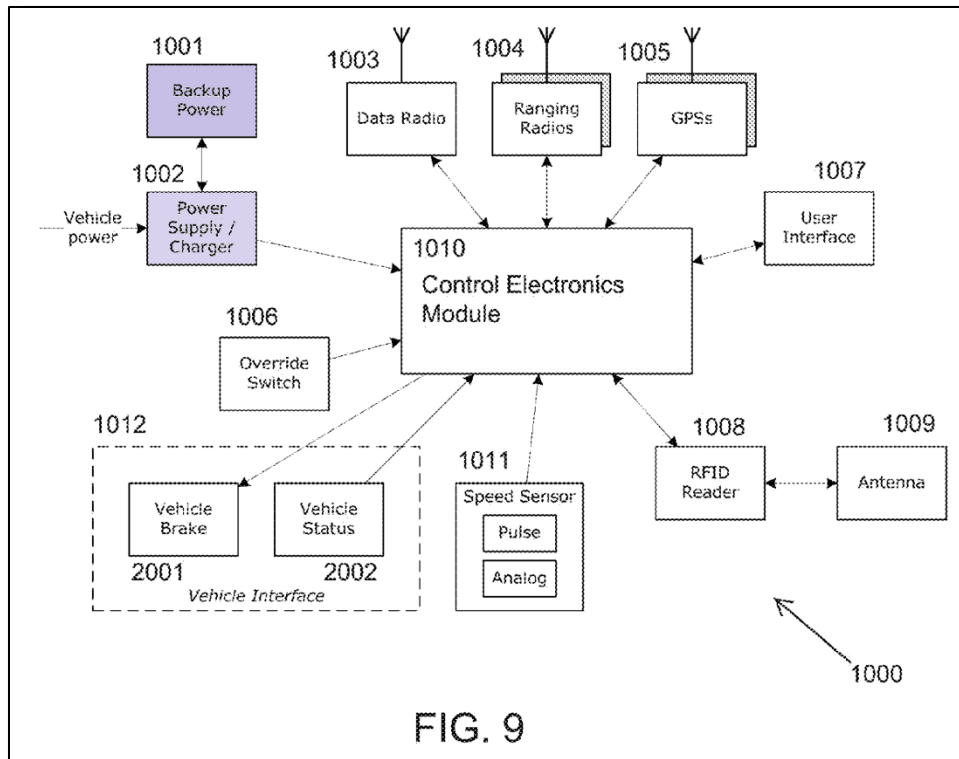
192. For the reasons I discussed above (§VII.A.2), POSAs would have understood VMCS 10 includes the same or similar user interface to receive the

inputs/outputs. Indeed, Carlson discloses that VMCS 1000 is “similar to VMCS 10” and either can “perform the techniques disclosed therein.” Carlson, [0127]. Alternatively, POSAs had reason to include VMCS 1000’s user interface to implement VMCS 10’s I/O components because both embodiments produce similar outputs to, and receive similar inputs from, vehicle operators. For example, Carlson at [0080]-[0081] discloses initiating warning signals to “the rail vehicle operators” until, for example, “the operator presses an acknowledgement button,” which is similar to the Carlson’s discloses at [0141]-[0142] of “caus[ing] an alert to be generated by the user interface” and causing an automatic break even until the “control electronics module 1010” “receive[s] an input from the user interface 1007 indicating that the braking event should end,” for example, by “an operator...interacting with the user interface.”

193. Thus, Carlson’s system “compris[es] 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,” as claimed

**13. Claim 11: “The system of claim 1, comprising a power component for supplying and/or obtaining power for components of the train-mounted unit.”**

194. As Carlson’s Figure 9 (which I have annotated below) illustrates, VMCS 1000 includes a “power supply,” which “provide[s] suitable electrical power to” the VMCS. Carlson, [0128].



195. For the reasons I discussed above (§VII.A.2), POSAs would have understood that VMCS 10 includes the same or similar power components to supply or obtain power for its electronics components because an electronic device like a VMCS 10 requires a power source for supplying and/or obtaining power for the components of VMCS 10. Carlson, [0127]. Alternatively, POSAs had reason to include VMCS 1000’s power source in VMCS 10 because electronic devices like VMCS 10 require a power component and VMCS 1000 is “similar to VMCS 10” and both “perform the techniques disclosed” in Carlson ([0127]), as I I discussed above (§VII.A.2).

196. Thus, Carlson’s system “compris[es] a power component for supplying and/or obtaining power for components of the train-mounted unit,” as claimed.

14. **Claim 12: “The system of claim 1, wherein the train-mounted unit is configured for communicating, directly or via at least one of the wayside unit and another train-mounted unit, with one or more other components or devices in the railway network, the one or more other components or devices in the railway network not being part of decentralized train control system.”**

197. Carlson discloses that for the system that I discussed above for claim 1 (or in the obvious variants of that system that I discussed above), “*the train-mounted unit is configured for communicating, directly or via at least one of the wayside unit and another train-mounted unit, with one or more other components or devices in the railway network, the one or more other components or devices in the railway network not being part of decentralized train control system,*” as claimed.

198. Carlson discloses that VMCS 10 “communicates, either directly or indirectly, with a rail network 50.” Carlson, [0061]; *see also* [0037] (“The present technology also ***provides systems and methods that allow a rail vehicle*** (or a rail vehicle operator) to determine the location, operating track, and speed of a rail vehicle, and ***to communicate that information to a rail network.***”) (emphasis added), [0063]; FIG. 1 (illustrating VMCS 10 communication with “Rail Network” 50). Indirect communication with the railway network occurs “via the reporting stations 30,” *i.e.*, the “*wayside units*” that I discussed above in connection with

limitation 1A . The wayside reporting station relay information from the VMCS to the network. Carlson, [0052] (“The reporting station 30 can also communicate and exchange information with a rail network 50.”), [0053] (“Information from the VMCS 10 mounted on the rail vehicles can communicate with the network 50 via the reporting stations 30....”). Direct communication between the VMCS and railway network occurs “via a wireless communication mode without the use of a reporting station.” [0053] (“[T]he VMCS 10 *can communicate directly with the rail network 50* via a wireless communication mode without the use of a reporting station.”) (emphasis added).

199. Using information that VMCS 10 communicates to the railway network (directly or indirectly, as discussed above), the rail network “manage[s] and maintain[s]” the system “to ensure that all rail vehicles...are operating at safe distances from one another and/or are properly distributed for timely transit operations.” Carlson, [0091]. The device/component in rail network 50 that communicates with the VMCS (directly or indirectly) is “*not being part of the decentralized train control system,*” as claimed, because that device/component in the railway network is part of the *centralized* aspect of the overall railway system and, thus, is not needed for VMCS 10 to perform its autonomous operations, like automatically braking based on distance and/or speed determinations that are made without communication with the centralized railway network. Carlson, [0052]

(describing rail network 50's role in the system); [0091] (similar); [0010] ("The railroad control system can include a rail network that maintains information relating to the location and speed of rail vehicles on the railroad track."); [0122] (explaining VMCS "***can operate autonomously*** and make internal operational decisions ***without requiring a central server***") (emphasis added).

200. Thus, in Carlson's system "the train-mounted unit is configured for communicating, directly or via at least one of the wayside unit and another train-mounted unit, with one or more other components or devices in the railway network, the one or more other components or devices in the railway network not being part of decentralized train control system," as claimed.

15. **Claim 13: "The system of claim 1, wherein the train-mounted unit is configured to substantially continually determine absolute position of the train, based on the ranging information obtained from ranging with wayside units."**

201. Carlson discloses that for the system that I discussed above for claim 1 (or in the obvious variants of that system that I discussed above), "*the train-mounted unit is configured to substantially continually determine absolute position of the train, based on the ranging information obtained from ranging with wayside units,*" as claimed. As discussed *supra* for limitation 3A, Carlson discloses that VMCS 10 uses its UWB-based ranging information "in combination with" GPS "to determine a position (*e.g., an absolute position*)" of the vehicle. Carlson, [0071] (emphasis added). Carlson further discloses that the ranging information that VMCS 10

generates (and uses to determine its absolute position) “provides ***substantially continuous location information*** over time.” Carlson, [0072] (emphasis added). The UWB-based ranging information used with GPS positional-information to substantially continually determine VMCS 10’s absolute position includes ranging information that VMCS 10 received from reporting stations, *i.e.*, the “*wayside units*,” as I discussed *supra* for limitations [1C]-[1E]. VMCS 10 is thus configured “to *substantially continually determine absolute position of the train, based on the ranging information obtained from ranging with wayside units*,” as claimed.

202. If Carlson were not found to disclose that VMCS 10 is configured to substantially continually determine the absolute position of the train, in my opinion POSAs had reason to do so. For example, POSAs understood that substantially continually determining the absolute position of the train would have been useful information to provide rail network 50 because the network “maintains information relating to the speed and ***location*** of the rail vehicles connected to the network.” Carlson, [0052] (emphasis added). POSAs would have understood that this information would be more beneficial to the network than periodic updates of vehicle position and speed because substantially continually providing information provides more accurate real-time train location, which improves the ability to execute safety and rail network management purposes. For example, substantially continuous position information could be used to confirm that the train was on

schedule and following the correct route, rather than off-schedule or on an incorrect route.

203. POSAs would have reasonably expected success in substantially continually determining the train's absolute position by ranging with wayside reporting/signal stations because the wayside reporting/signal stations were located at "fixed positions along a railroad track," and thus provided (or could have provided) known (absolute positions) from which the train and/or network could use to calculate (in combination with GPS) the absolute position of the train based on distance from a wayside reporting/signal station(s). Carlson, [0051] ("The reporting stations 30 can be located at or integrated with, for example, signal control points or other objects positioned at fixed positions along a railroad track."), [0086] ("***Location may also be determined by interaction between a signal control point 30 and a map*** (for example, one stored in the VMCS 10 or remotely) (emphasis added). If the ***signal control point 30 is known*** and the distance of the VMCS 10 from the signal control point is known, ***then location can be determined.***") (emphasis added).

204. Thus, in Carlson's system "the train-mounted unit is configured to substantially continually determine absolute position of the train, based on the ranging information obtained from ranging with wayside units," as claimed.

**16. Claim 14: “The system of claim 13, wherein the train-mounted unit is configured to determine the absolute position of the train based on the ranging information and positioning information obtained without ranging to wayside units.”**

205. As I discussed *supra* for limitation 1E and claim 13, VMCS 10 determines “an absolute position” for the train on which it is mounted based on the “*ranging information*” it obtains from UWB-based ranging with wayside-located reporting/signal stations.

206. VMCS 10 also determines the train’s “*absolute position*” using “*positioning information obtained without ranging to wayside units,*” as claimed. For example, VMCS 10 uses its UWB-derived ranging information “in combination with” GPS-derived information to calculate a train’s absolute position. Carlson, [0071] (“[T]he collision avoidance system 100 also includes a GPS unit that can be used in combination with (or as a component of) the transponder sensor module **to determine a position (e.g., an absolute position) of the rail vehicle.**”) (emphasis added). GPS-derived information is from satellites and is “*positioning information obtained without ranging to wayside units,*” as claimed (it is positioning information obtained from processing GPS-satellite signals).

207. Additionally, Carlson discloses that VMCS 10 “senses RFID tags 20...located along a railroad track.” Carlson, [0061]. Each RFID tag has a known location stored in a database, which “VMCS 10 can consult...to determine the

location of the RFID tag 20, and thus, the location of the rail vehicle.” Carlson, [0086]; *see also* [0100] (RFIDs have known “latitude and longitude coordinates” that can be used to determine “precise” vehicle location); [0045] (“[T]he RFID system can also monitor a specific train position when the train is located in areas ***where conventional GPS positioning navigational aids are inoperative***, such as tunnels and subways, for example. By reading each RFID tag’s serialization code, or alternatively, a programmed mile-marker value, ***a specific location of the train can be determined.***”) (emphasis added). Location information based on RFID-derived coordinates is “*positioning information obtained without ranging to wayside units,*” as claimed (it is positioning information obtained from communications with RFID tags). *See also* EX1001, 10:3-11 (explaining “absolute position” determined by referencing known location of wayside devices, similar to Carlson’s disclosure of using known location of RFID tags to determine a train’s specific location).

208. Finally, as I discuss below for claim 15, Carlson discloses that VMCS 10 also communicates with each reporting/signal station it passes and each reporting/signal station provides its identification to the VMCS 10 so that the VMCS 10 can determine (via a map) its location relative to the reporting/signal station’s known location. Carlson, [0086] (“[T]he VMCS 10 can consult the database via the data collection system 300 to determine the location of the RFID tag 20, and thus, the location of the rail vehicle. Location may also be determined by interaction

between a signal control point 30 and a map (for example, one stored in the VMCS 10 or remotely). If the signal control point 30 is known and the distance of the VMCS 10 from the signal control point is known, then location can be determined.”)

209. Thus, in Carlson’s system “the train-mounted unit is configured to determine the absolute position of the train based on the ranging information and positioning information obtained without ranging to wayside units,” as claimed.

**17. Claim 15: “The system of claim 14, wherein the train-mounted unit is configured to obtain at least portion of the positioning information from each wayside unit as the train passes the wayside unit.”**

210. Claim 15 requires that at least part of “*the positioning information*” of claim 14, *i.e.*, the information that is obtained “*without ranging to wayside units,*” be obtained from “*each wayside unit as the train passes the wayside unit.*” POSAs would understand that claim 15 aligns with an embodiment of the ’363 patent wherein each wayside anchor has an “ID number” that it transmits to a passing train so that the train can “referenc[e] the distance to that anchor with [an] on-board track map.” EX1001, 10:3-11.

211. Carlson discloses that in addition to obtaining ranging information from reporting/signal stations, VMCS 10 also obtains non-ranging information/data from reporting/signal stations, *i.e.*, “*wayside units,*” as claimed. For example, Carlson at [0046] discloses that trains and reporting stations “communicate wirelessly...to transmit and receive relevant vehicle information *as the rail vehicle passes the*

**reporting station** on the track.” Emphasis added. Carlson at [0051] discloses that reporting station “include[s] a communication mechanism that allows the rail vehicles and/or the VMCS 10 installed on the rail vehicles to **exchange data and information**...” See also Carlson, [0057] (“[T]he reporting station 30 can include a transponder sensor module adapted to communicate with the transponder sensor module installed on the rail vehicle 5.”), [0058] (similar); [0060] (reporting stations “communicate...with a VMCS 10 mounted on a **passing** rail vehicle”) (emphasis added).

212. Carlson further explains that VMCS 10 can determine its location based on its distance from a reporting/signal station with a known location. For example, Carlson at [0086] discloses that “[i]f the [location of the] signal control point 30 is known and the distance of the VMCS 10 from the signal control point is known, then location can be determined.” POSAs thus understood that at least part of the information that a reporting station transmits to a passing VMCS 10 would be the identification of the reporting/signal station so that the VMCS could determine its location relative to the reporting station’s location.

213. If Carlson is found not to disclose that VMCS 10 obtains positioning information from reporting stations, POSAs would have had reason to implement Carlson such that its reporting stations transmitted positional information to VMCS units. For example, Carlson teaches that wayside-located RFID-devices

advantageously transmit “location information” to VMCS 10 so the VMCS can determine its position more accurately, *e.g.*, when GPS is unavailable or unpredictable. Carlson, [0008], [0037], [0045], [0049]. Having reporting stations provide similar position information to VMCS 10 would have improved Carlson’s system by providing a redundant source of positioning information, *e.g.*, in case the RFID-devices malfunctioned. Carlson repeatedly teaches the benefits of redundant systems, which would have suggested and motivated “*obtain[ing] at least portion of the positioning information from each wayside unit as the train passes the wayside unit,*” as claimed, to improve safety of the system. *See, e.g.*, Carlson, [0055], [0071], [0075], [0087], [0145]. Thus, POSAs had reason to implement Carlson’s reporting stations such that they transmitted their location to VMCS 10 when the train on which the VMCS was mounted passes the reporting station.

214. Thus, in Carlson’s system (or, alternatively, in the obvious variant that I discussed above), “the train-mounted unit is configured to obtain at least portion of the positioning information from each wayside unit as the train passes the wayside unit,” as claimed.

- 18. Claim 16: “The system of claim 15, wherein the train-mounted unit is configured to obtain at least portion of the positioning information from at least one wayside unit as the train passes that wayside unit using non-UWB communications.”**

215. As I discussed *supra* for claim 15, VMCS 10 receives non-ranging-based position information from reporting stations, *i.e.*, “wayside units,” as claimed, when the train on which the VMCS 10 is mounted passes the station. This transmission of information occurs over “communication link 35.” Carlson, [0060]. As I also discussed *supra* for claim 15, POSAs separately had reason to implement Carlson’s VMCS 10 such that it receives non-ranging-based position information from reporting stations. For the reasons discussed below, POSAs had reason to implement VMCS 10 such that it used non-UWB communications for transmission of the non-ranging-based position information.

216. As I discussed *supra* claim 5, VMCS 10 includes a “second or redundant wireless network” that is a “different type than the first [UWB-based] network” (*e.g.*, spread spectrum, WiFi, and/or Bluetooth) to “transmit information.” Carlson, [0075]. Carlson further teaches that VMCS 10 and reporting stations “exchange data and information” with one another using non-UWB wireless technologies like Bluetooth or cellular. Carlson, [0051]. Carlson thus suggested, and POSAs had reason (*e.g.*, for the well-known benefits of redundancy) to have the reporting stations transmit non-ranging positional information to VMCS 10 using

VMCS 10’s “second or redundant wireless network” that is different from its first, UWB-based network. POSAs would have selected from any of the suitable wireless technologies that Carlson identifies ([0051]) such as Bluetooth or cellular because those technologies were well-known and proven information-communication technologies.

217. Implemented as set forth above, VMCS 10 would have been “configured to obtain at least portion of the positioning information from at least one wayside unit as the train passes that wayside unit using non-UWB communications,” as claimed.

**B. Ground 2: Claims 1-14 Would Have Been Obvious Over Ghaly in View of Heddebaut**

**1. Overview of Ground 2**

218. For the reasons I discuss below, it is my opinion that claims 1-14 would have been obvious over Ghaly (EX1008) in view of Heddebaut (EX1009).

**2. Ghaly (EX1008): European Patent No. 2,571,742 B1<sup>1</sup>**

219. According to the face of the document, Ghaly is a European patent that issued on February 24, 2016 (code (45)), titled “Onboard Train Control Device” (code (54)). Because Ghaly issued in 2016, I understand that Ghaly qualifies as prior art even if the challenged claims were entitled to the August 4, 2017 filing date of Provisional Application No. 62/541,454 (see ’363 patent, code (60)). I understand

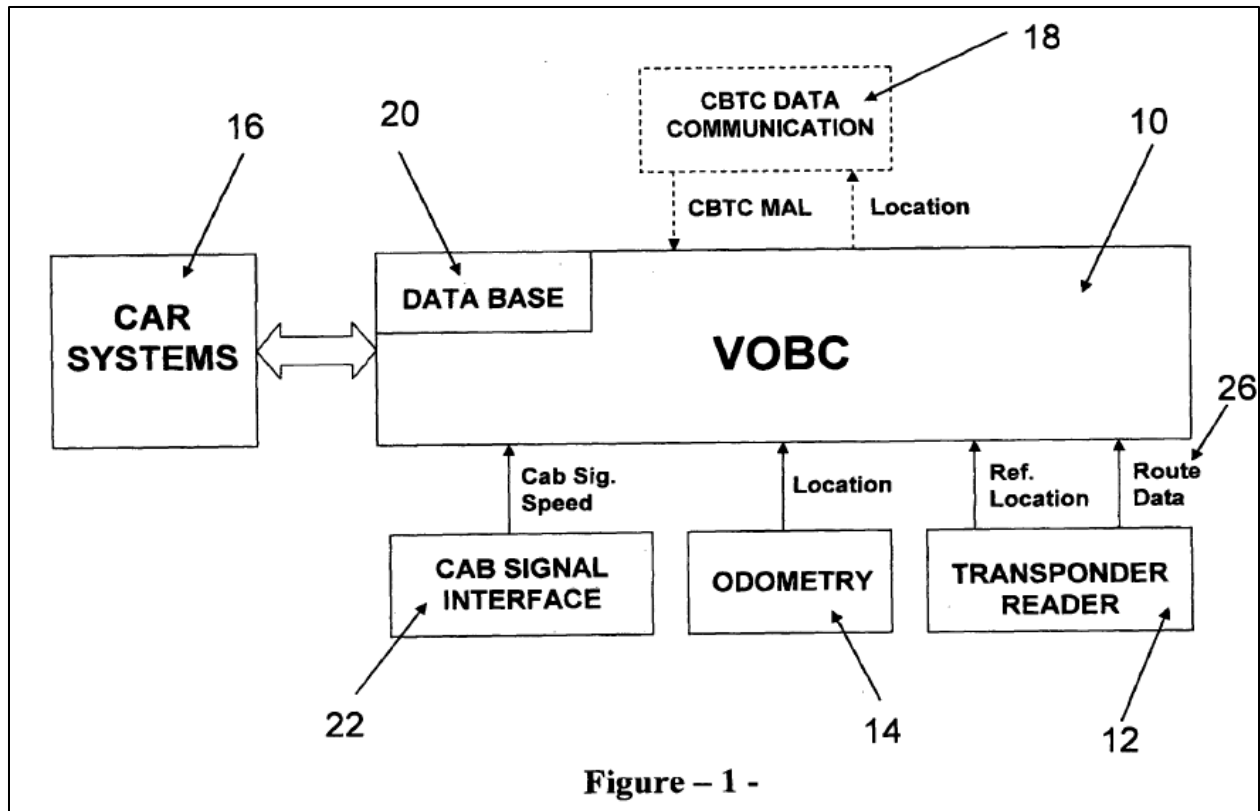
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<sup>1</sup> All citations in this section are to Ghaly unless I specify otherwise.

that Ghaly was not cited during prosecution of the '363 patent but that related applications to the same inventor were cited. See '363 patent, code (56) (references cited).

220. Like the '363 patent, Ghaly discloses a “train control system[.]” Ghaly, [0001]. In Ghaly, the train is an “intelligent train” because it uses “intelligent [] carborne equipment” to, *inter alia*, “determine[] [the train’s] own location” and to “generate[] and enforce[] a safe speed profile.” The intelligent carborne equipment includes an “intelligent CBTC carborne device.” As Ghaly explains and as a person of skill would have understood, CBTC refers to “communication based train control (CBTC) technology,” and “the benefits and advantages of CBTC are well known[.]” Ghaly, [0001], [0003], [0006].

221. Ghaly’s CBTC system includes an “onboard CBTC device.” [0010]. This device includes a “vital onboard controller (VOBC),” such as the VOBC depicted in Figure 1 (below):

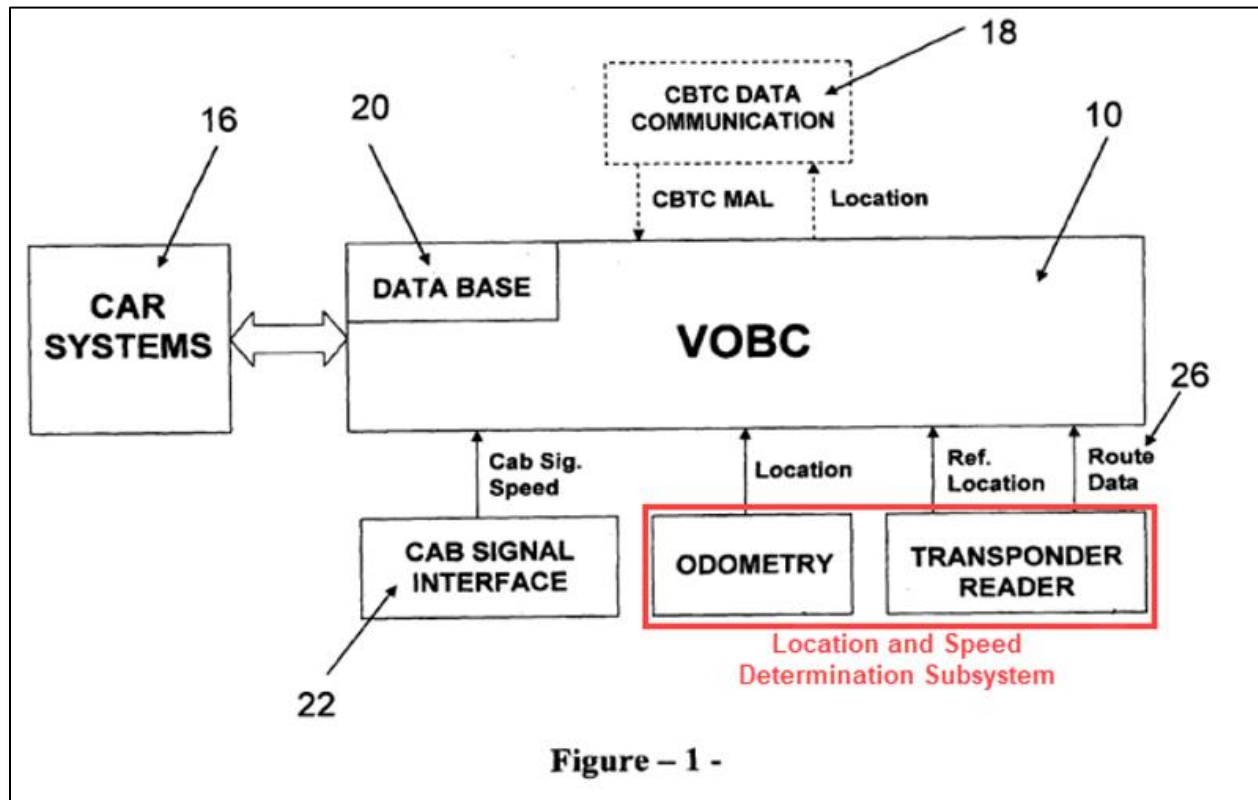


222. As discussed in the following sections, the VOBC performs at least three functions related to train control: (i) determining the location and speed of the train, (ii) receiving and/or generating a movement authority limit for the train and generating a stopping profile for the train to comply with the movement authority limit, and (iii) enforcing the generated stopping profile by slowing and/or stopping the train.

**a. Location and Speed Determination**

223. The VOBC includes and/or interfaces with an “independent location and speed determination subsystem.” [0010]. In the example embodiment depicted in Figure 1, the odometry and transponder reader components together form the

location and speed determination subsystem with which the VOBC interfaces, as I have shown in the annotated Figure 1 below:



224. In the example embodiment depicted in Figure 1, the transponder reader “receives location information from passive transponders installed on the tracks” and “provides reference location information” to the VOBC. [0026]. More specifically, “transponders located on the track” at known locations provide “reference locations” to the VOBC. “Between transponders, an odometry device” is used to “continuously calculate[] train location and speed.” [0010]. For instance, the odometry device of Figure 1 “provides location and/or speed measurement functions

to the VOBC 10 so that the VOBC 10 can continuously determine[] the location and speed of the train as the train moves on the track.” [0026]. As the train moves along the track and continues to detect transponders, the “reference location received from the transponder reader” at each transponder is “used to reset any uncertainty in the calculated train location.” [0026].

225. Although Ghaly depicts and describes an example embodiment that uses a transponder reader and odometer to determine the train’s location and speed, Ghaly explains that its system can use “any location and speed determination system that is independent of the wayside track circuits.” [0011].

#### **b. Movement Authority Limit and Stopping Profile**

226. As the VOBC continuously determines the train’s location and speed, Ghaly’s train-control system enables “conventional CBTC operation” in areas that are “equipped with wayside zone controllers.” [0022]. Indeed, conventional CBTC systems are “based on continuous two-way communications between intelligent trains and Zone controllers on the wayside.” [0003].

227. In CBTC operation, the VOBC uses the “data communication unit 18” (orange below) to “continuously transmit[] its location [i.e., the location determined by the location-determination subsystem] to [a] wayside zone controller.” [0022]. In turn, the zone controller “issues a movement authority to a train based on the [train’s] location.” [0022].

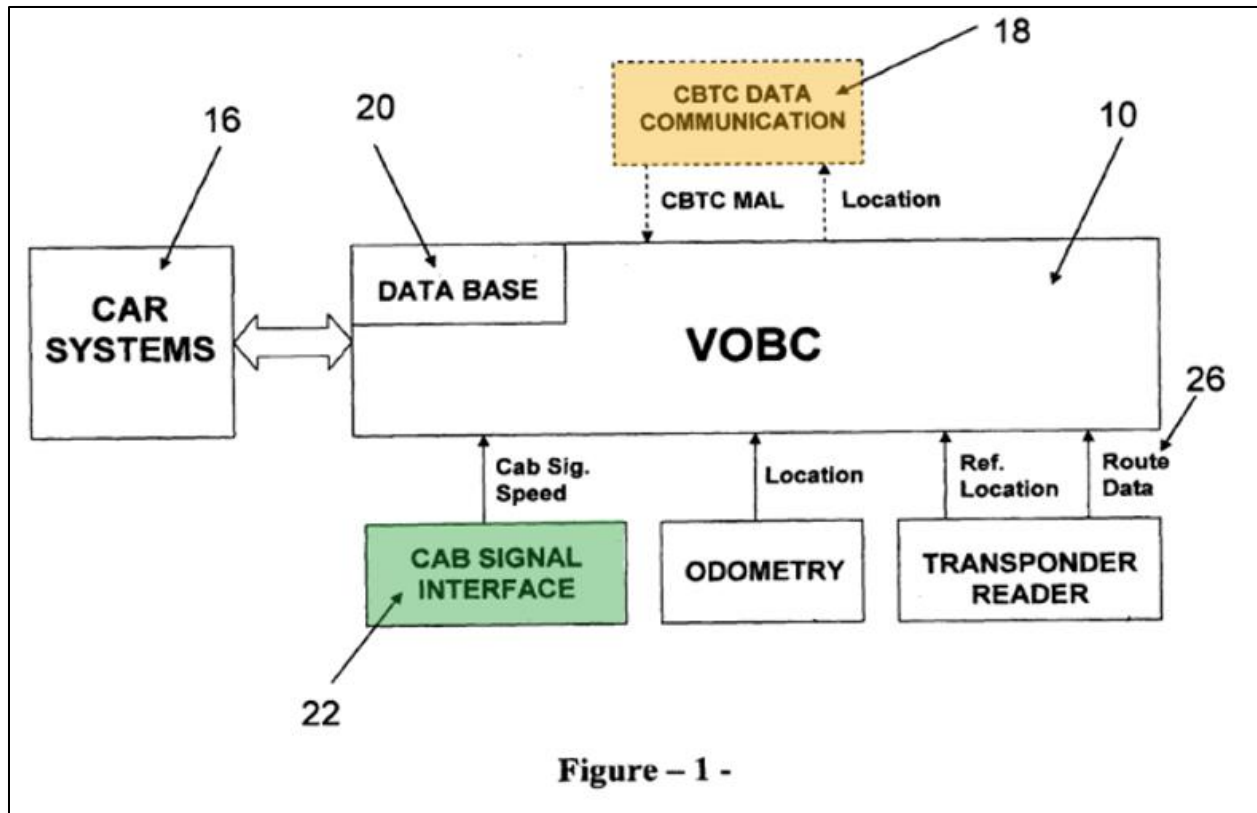


Figure – 1 -

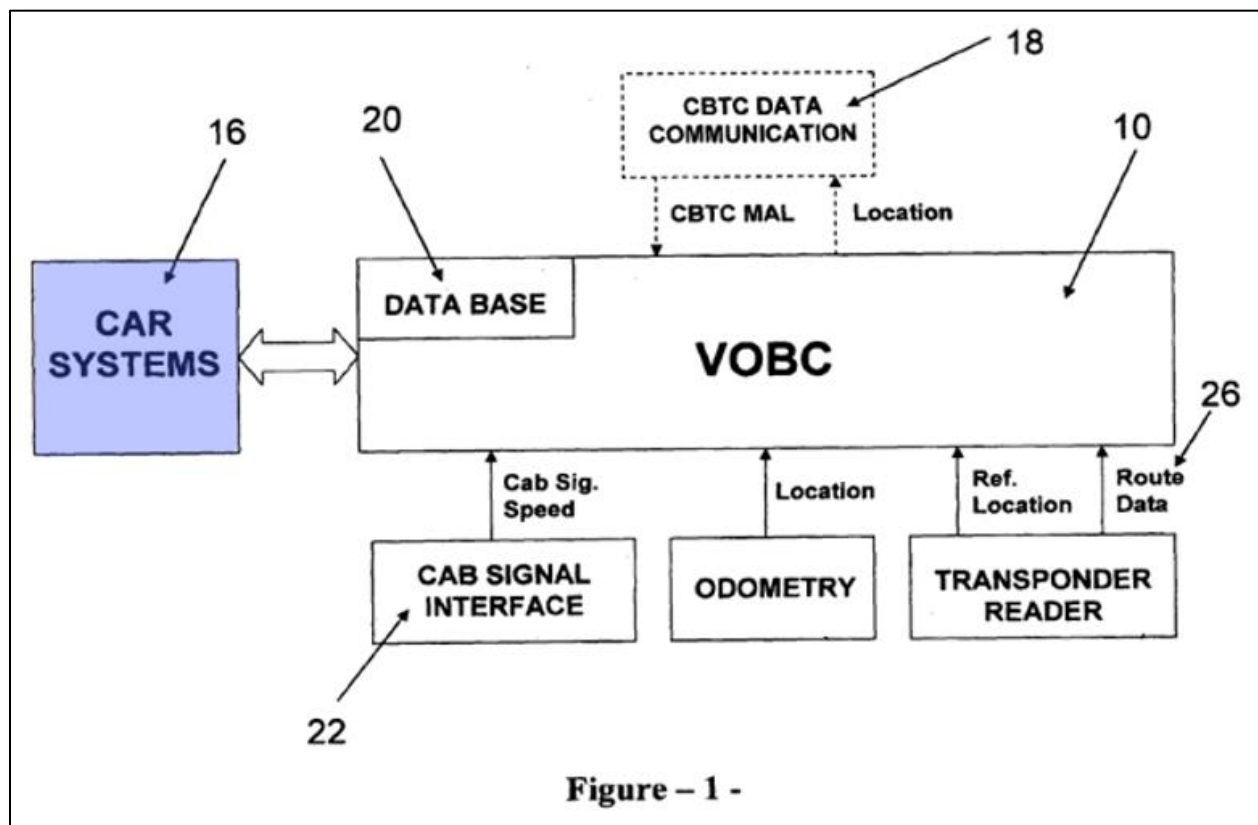
228. Additionally or alternatively, the VOBC receives “speed limits” via the “cab-signal interface unit” (green above) and, based on these speed limits, generates a “movement authority limit.” [0027]; [0039]. To generate a movement authority limit onboard the train, the VOBC uses the “CBTC train location” that is “generated by the on-board location determination subsystem.” [0028].

229. Based on the received/generated movement authority limit, the VOBC “generates ... a stopping profile that corresponds to the received movement authority limit.” [0022]. The “stopping profile” is a “speed/distance curve” that is used “to control the speed of the train” and to “enforce the stopping of the train at the end of the movement authority limit.” [0038]. The stopping profile (or “speed profile”)

“takes into account the limit of the movement authority, the civil speed limits, the topography of the track, and the braking characteristics of the train.” [0004], [0038].

### c. MAL and Stopping Profile Enforcement

230. After generating a “stopping profile that corresponds to the received movement authority limit,” the VOBC “enforces [the] stopping profile.” [0022]. In particular, the VOBC “ensures that the actual speed of the train does not exceed the safe speed limit” set by the stopping/speed profile. [0004]. To enable the enforcement of the stopping profile, the VOBC is configured to “interface[] with” certain “subsystems” of the train, including the “car propulsion and braking systems 16” (blue below) Ghaly, [0026].



231. Using this car systems-interface, the VOBC “provides over-speed protection by ensuring that the actual speed of the train as measured by the [location/speed-determination subsystem] does not exceed the allowable speed limit determined by the generated stopping profile.” [0038]. “In the event of an over-speed condition, the VOBC will activate the train brake subsystem.” [0038].

### **3. Heddebaut (EX1009): U.S. Patent 7,725,252 B2<sup>2</sup>**

232. According to the face of the document, Heddebaut is a United States patent that issued on May 25, 2010 (code (45)), titled “Device and Method for Positioning and Controlling Railway Vehicles with Ultra-Large Bandwidth” (code (54)). Because Heddebaut issued in 2010, I understand that Heddebaut qualifies as prior art even if the challenged claims were entitled to the August 4, 2017 filing date of Provisional Application No. 62/541,454 (see ’363 patent, code (60)). I understand that Heddebaut was cited during prosecution of the ’363 patent but not relied upon as the basis for any prior art rejections. See ’363 patent, code (56) (references cited).

233. Like Ghaly and the ’363 patent, Heddebaut discloses a system for “positioning and controlling rail vehicles.” 1:64-2:8. The specific characteristics of Heddebaut’s train-control system are described in greater in the following sections.

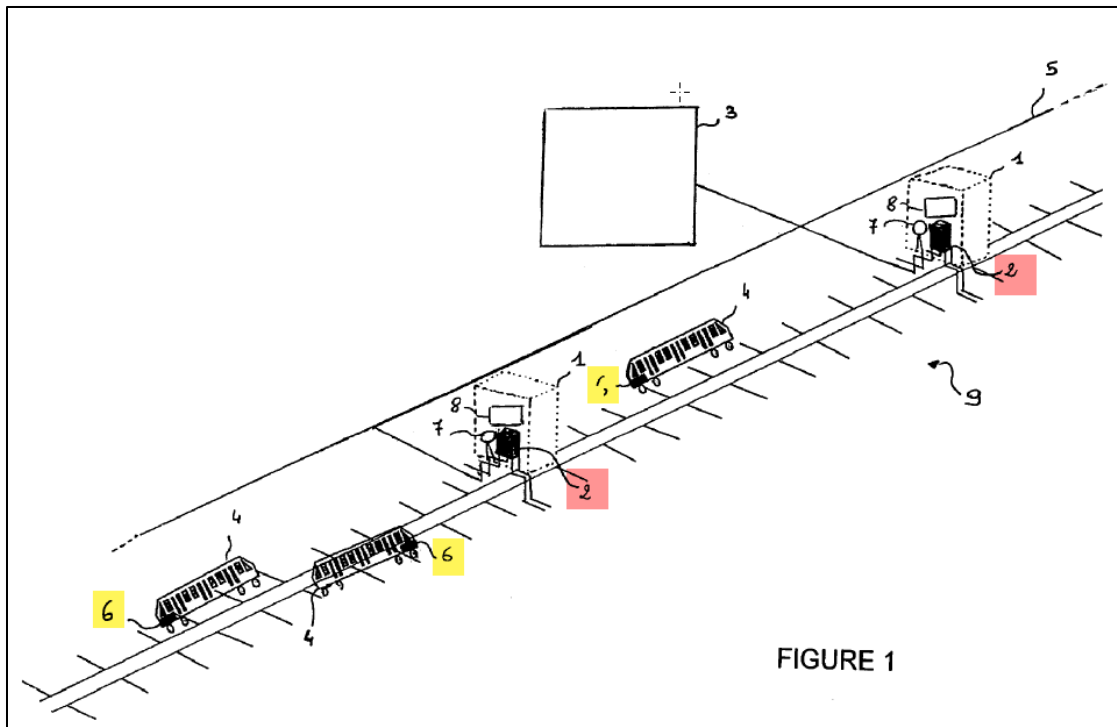
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<sup>2</sup> All citations in this section are to Heddebaut unless I specify otherwise.

**a. Heddebaut's Transmitting/Receiving Elements**

234. Heddebaut's system includes multiple sets of "transmission-reception means" (also referred to as "elements for transmitting/receiving"). Abstract, 2:14-18. In Heddebaut, the first set of transmitting/receiving elements are associated with "fixed stations," while the second set of transmitting/receiving elements are associated with "each rail vehicle" in the system. Abstract, 3:58-61, 4:14-15. As used in Heddebaut, "rail vehicle" encompasses "any guided transport system, regardless [of] whether the guiding system is operated by railways, longitudinal sleepers or any other means." 2:35-37.

235. These transmitting elements are depicted in annotated Figure 1, below, in which the transmitting/receiving elements of the fixed stations are highlighted in red and the transmitting/receiving elements of the rail vehicles are highlighted in yellow:



236. In operation, each transmitting/receiving element in Heddebaut's system is configured to send and/or receive a "signal" that "contain[s] a specific identifier of the transmitter and at least one message." *Id.*, 4:15-18. Each identifier is a "specific identity...ascribed to [the] transmitter." 4:27-38. "These identifiers are known by the whole transport network but not divulged to the outside since such elements are kept confidential to improve the stealthiness of the communications and thereby increase global safety of the transport system[.]" 4:28-32.

#### **b. Transmitting/Receiving of Ultra-Wideband Signals**

237. To send and receive wireless signals, Heddebaut's transmitting/receiving elements each use "an ultra wide band technique." *Id.*, 4:27-38. More specifically, the signals sent and received are "radio signals with a very

large passband whereof the frequency spectrum ranges between 1 and 10 GHz.”

4:52-55. The devices send and receive signals using a “wide band aerial,” which may be “a circular disk type monopole or a dipole formed of two circular disks.”

5:6-10. This aerial “enables to provide the requested passband 1 to 10 GHz for disk diameters smaller than some ten centimeters.” 5:10-13.

238. Heddebaut describes many benefits of using ultra-wideband technology in its train-control system, including the following passage identifying the characteristics of ultra-wideband technology that make it “optimal” for an “automated driving system of rail vehicles such as an automated underground train”:

The signals of the first and second transmission-reception means 2, 6 are radio signals with a very large passband whereof the frequency spectrum ranges between 1 and 10 GHz. Indeed, for such high frequencies, the tunnel behaves like an oversized wave guide. From then on, for tunnel sections of tunnel of several hundred meters, the signals of frequencies 1 to 10 GHz are attenuated much less. There results that the transmission balances of these signals are compatible with a range of the order of one kilometer. These signals are hence perfected surrounded in the frequency range propagating efficiently in an underground tunnel. Besides, the wide spectrum spread of the signals processed as well as the very small elementary duration (of the order of a nanosecond) of an ultra wide band signal enable to dispense with difficult propagation conditions in tunnel characterised by numerous multiple paths linked with the reflections against the walls as well as to signal spreads which may be as high, in tunnel, as several ten nanoseconds. The ultra wide band technology enables therefore optimal radioelectric coverage necessary to an automated driving system of rail vehicles such as an automated underground train.

4:52-5:5.

239. Additionally, Heddebaut notes that ultra-wide band signals—and/or the devices used to send/receive such signals—are “simple in their design,” have “very high transfer rate,” are “economical,” “limit[] the risks of interference[],” and provide “highly available” coverage. Abstract, 1:64-2:8.

**c. Processing of Ultra-Wideband Signals**

240. Each rail vehicle includes “means for determining the position and the direction of said vehicle,” as well as “means for determining an actual speed measurement of said vehicle.” 2:42-47. Thus, the “speeds and positions of [the] rail vehicles” are determined “on-board the rail vehicle.” 5:51-56.

241. More specifically, the speed and position of the train can be determined based on “analysis of the ultra wide band signals exchanged between the ground and the vehicles.” *Id.*, 5:51-56. These location and speed determinations can be made based on the principle, well known to those of skill in the art well before 2016, that the “flight time” of a signal between a transmitting device and a receiving device “corresponds to [the] distance travelled through the air” by the signal and, thus, the distance between those two devices. 6:2-18.

242. Accordingly, based on this principle, Heddebaut’s on-train devices can “measur[e] the distance relative to a fixed reference upstream and/or downstream as based on the flight time of signals derived from pieces of geolocalised equipment and situated in upstream/downstream stations” and can “determine[], with high

degree of certainty and accuracy, the absolute position of the guided mobile.” 6:3-9. As a result, “[a]ll the rail vehicles 4 may calculate their distances to the downstream and upstream fixed stations where they are situated locally,” enabling “precise localisation of the rail vehicles.” 5:57-65.

243. Additionally, the processing of the ultra-wideband signal enables the on-train equipment to determine an “actual speed measurement of the rail vehicle.” 6:18-24. Specifically, because the train is able to determine the “distance relative to a fixed reference upstream and/or downstream,” and can make multiple such determinations at multiple points in time, the equipment can, using basic principles of calculus, “deriv[e] from” these distance measurements the “speed measurement” of the train. 6:3-24.

#### **4. Ghaly-Heddebaut Combination**

244. In my opinion, POSAs would have had reasons to combine Heddebaut’s ultra-wideband-based techniques for determining train speed and location with Ghaly’s CBTC-based train-control system. Specifically, POSAs would have had reasons to use Heddebaut’s ultra-wideband-based on-train and trackside transmitting/receiving elements as the location and speed determination subsystem described in Ghaly. In the resulting Ghaly-Heddebaut system, all other aspects of Ghaly’s CBTC train-control operations (e.g., generation and enforcement of movement authority limits and stopping profiles) would remain unchanged.

245. First, Ghaly notes that its system can utilize “any location and speed determination system that is independent of the wayside track circuits” to determine the train’s speed and location for purposes of generating and enforcing train-control operations. POSAs would have understood Heddebaut’s ultra-wideband-based techniques to be independent of the wayside track circuits and, therefore, would have understood that Ghaly’s train-control system would be compatible with Heddebaut’s ultra-wideband-based location/speed-determination techniques.

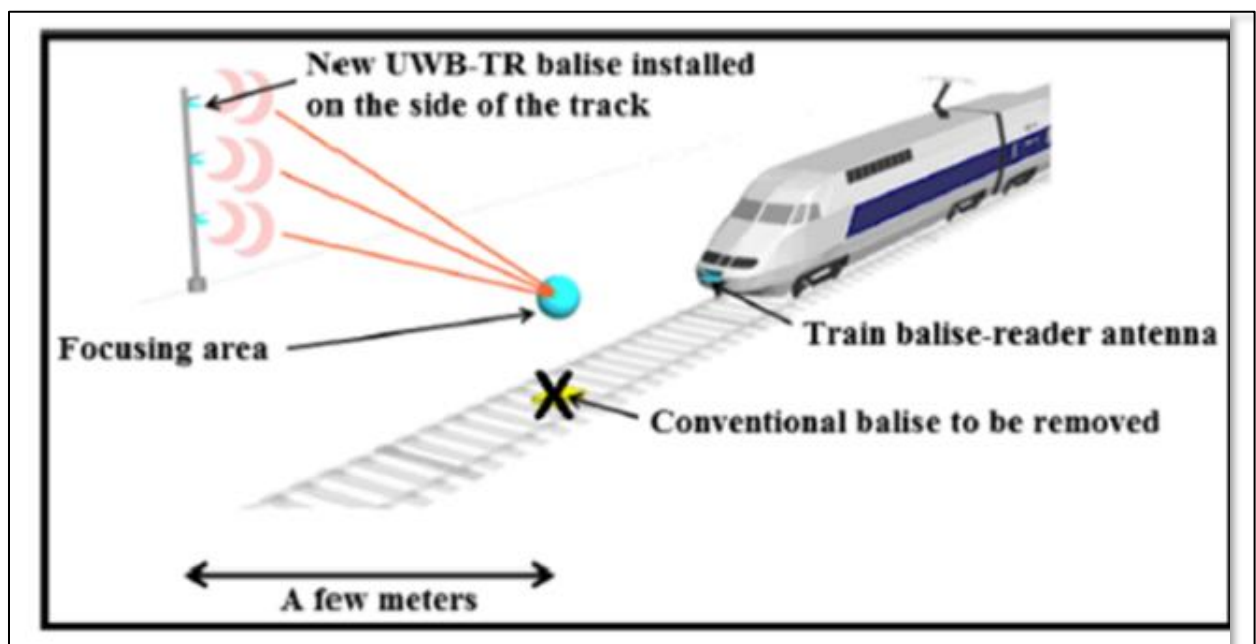
246. Moreover, Ghaly describes a particular example speed and location determinations subsystem that uses a “transponder reader” to receive “reference location information” from track-based transponders. Ghaly, [0003], [0026]. As described above, this reference location information can be used in combination with an additional source of information (e.g., an odometer) to determine the train’s location relative to the known reference location. Ghaly, [0010], [0026]. Heddebaut’s ultra-wideband transmitting/receiving elements function in a similar manner to the transponder system described in Ghaly. Specifically, like Ghaly’s transponders, the transmitting/receiving elements placed at Heddebaut’s fixed stations are located along a track. Also like Ghaly’s transponders, these transmitting/receiving elements are placed at known locations and thus provide a reference location to the on-train unit. Finally, like Ghaly’s transponder-based system, Heddebaut’s ultra-wideband-based system determines the train’s location

and speed by determining the distance between the train and the fixed reference location. However, while Ghaly's transponder-based system uses an odometry unit to determine the distance from the reference location, Heddebaut's system instead uses the time of flight of ultra-wideband signals to determine the same distance measurement. Accordingly, a person of ordinary skill would have had reason to make a simple substitute of Ghaly's transponders and transponder reader with Heddebaut's UWB transmitting/receiving elements to perform the same function with predictable results.

247. Second, POSAs would have had reason to substitute Heddebaut's UWB-based location and speed determination elements for Ghaly's transponder and transponder reader because of the many technical advantages of UWB technology. Indeed, Heddebaut highlights many of these technical advantages and, like the '363 patent, specifically describes using ultra-wideband signals in a train-control application. And, as discussed above, Heddebaut describes the use of ultra-wideband signals for location and speed determinations as being "optimal" for an "automated driving system of rail vehicles such as an automated underground train" because of the efficient propagation of such signals through tunnels, etc. Heddebaut, 4:52-5:5. POSAs would have been further motivated to make this combination by Heddebaut's express teachings that its ultra-wideband transmitting/receiving components are "simple in their design," have "very high transfer rates," are

“economical,” “limit[] the risks of interference[],” and provide “highly available” coverage. Heddebaut, Abstract, 1:64-2:8.

248. Third, POSAs would have had reason to utilize Heddebaut’s ultra-wideband-based location and speed determination techniques in Ghaly’s train-control system because, in addition to Heddebaut itself, several other prior-art publications proposed utilizing ultra-wideband ranging technology in train-control systems of the type described in Ghaly. For example, a 2014 publication taught that a UWB-transmitter could be “installed ... on the side of the track,” allowing for removal of an on-track transponder:



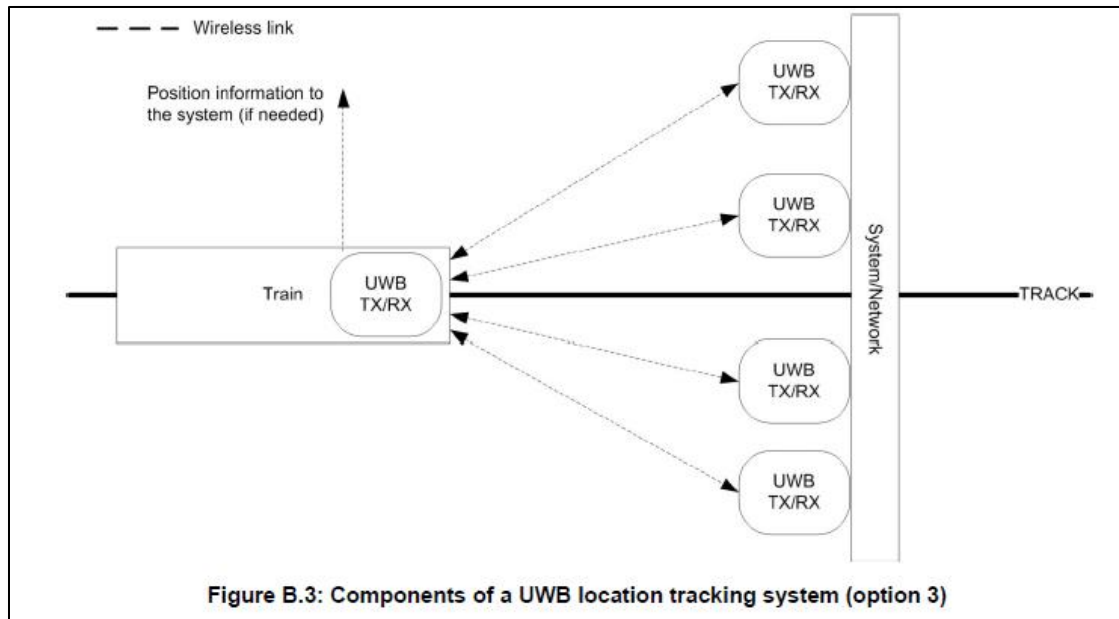
EX1012, 2-3. Page 140, Fig.1.

249. Similarly, a 2004 article described “utilizing ultra wideband radio technology” and providing “nodes along a railway right-of-way” to provide “precise information on the location and velocity of trains.” EX1026, Abstract.

250. Additionally, POSAs would have discovered that the European Telecommunications Standards Institute had published a Technical Report (EX1018, “ETSI-Report”) suggesting the use of UWB radios for “location tracking applications in [a] railway environment.” ETSI-Report, 4.

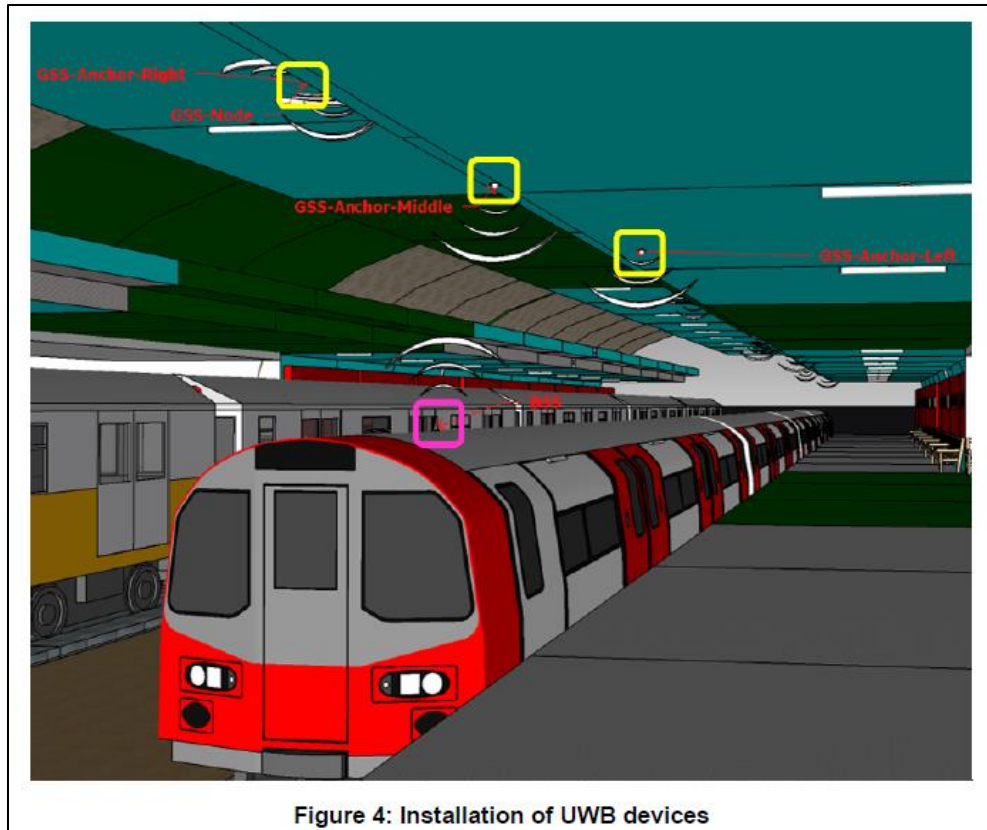
251. POSAs would have appreciated that the ETSI was, and continues to be, a leading standards-setting organization with many notable publications in the fields of train control and wireless signaling. POSAs would have thus viewed the ETSI’s publication of the ETSI-Report as further validation of the idea of using ultrawide-band-based ranging technologies in a train-control system, especially given the similarities between the system proposed by ETSI and the Ghaly-Heddebaut combination contemplated herein.

252. For example, the ETSI Report provided several exemplary “options for implementation,” each featuring a “UWB transmitter (TX) [] installed in a moving train” and “a network of fixed UWB receivers (RX)” “placed at known, fixed points” along the track. ETSI-Report at 21, Fig. B.3.



253. The ETSI-Report explained that “the 3D position of a rail vehicle can be found” in a train-control environment “by analysing, e.g. time-of-arrival and/or angle-of-arrival of [a UWB] radio signal relative to [] known reference stations.” ETSI-Report at 4.

254. The ETSI-Report explains that “[t]he subway represents a classic indoor use scenario for railway applications of UWB” and provides the example illustration below, in which a “UWB transmitter (BSS, Board SubSystem) is installed in a train and UWB receivers (GSS, Ground SubSystem) are mounted in the ceiling.” ETSI-Report at 11.



255. Furthermore, like Heddebaut, the ETSI-Report highlights many of the benefits of using ultra-wideband-based ranging technology in a train-control system. The ETSI Report emphasized that “[u]sing UWB in railway could increase the train positioning accuracy,” which would “increase the transport capacity in subways and light rail transit systems.” ETSI-Report, 20. To that end, the ETSI Report explained that the “heart of [its] proposed system is the ultra-wideband radio that will introduce high-level performances and benefits,” namely, achieving “high accuracy positioning combined with high velocity of the train.” ETSI-Report, 10. Moreover, like Heddebaut, the ETSI Report noted the benefits of using ultra-wideband

techniques in difficult propagation environments, such as underground tunnels where a subway system operates. ETSI-Report, 9-10, 21, 23.

256. POSAs would have understood, based on these references and the widespread recognition in the industry of the capabilities and benefits of ultra-wideband technology, that ultra-wideband ranging techniques would be a viable and beneficial technology to determine train location and speed in a system like Ghaly's.

## **5. Claim 1**

### **a. [1PRE]: “A system for providing decentralized control operations in a railway network”**

257. I understand that whether a claim's preamble is treated as a limitation on the scope of claim is a legal question. For purposes of my analysis, I have been told to assume that the preamble to claim 1 is limiting.

258. Ghaly discloses a system for providing decentralized control operations in a railway network.

259. Ghaly's “intelligent train” “determines its own location, and generates and enforces a safe speed profile.” Ghaly, [0003]. The train's “onboard CBTC device” includes “an independent location and speed determination subsystem.” Ghaly, [0009]-[0010]. The onboard CBTC device “receives wayside speed limit information coded in electrical signals” and generates a “movement authority limit.” [0010], [0027]; [0039]. The onboard CBTC device can “also communicate with an Automatic Train Supervision System (ATS), which . . . provides information related

to temporary speed restrictions, work zone limits, and status of interlocking devices.” Ghaly, [0009]. The ATS can also provide “route data” to the VOBC via its “data communication unit.” Ghaly, [0032]; *see also* [0048] (ATS transmits information related to wayside switches and route information to the train).

260. Based on the location and speed of the train as determined by the location and speed determination subsystem, the onboard CBTC device “generates . . . a stopping profile that corresponds to the [] movement authority limit.” [0022]. The “stopping profile” is a “speed/distance curve” that is used “to control the speed of the train” and to “enforce the stopping of the train at the end of the movement authority limit.” [0038]. The onboard CBTC device therefore “provides over-speed protection by ensuring that the actual speed of the train as measured by the [location/speed-determination subsystem] does not exceed the allowable speed limit determined by the generated stopping profile.” [0038]. “In the event of an over-speed condition, the VOBC will activate the train brake subsystem.” [0038].

261. As I explained above in Section VII.A.3.a, the ’363 patent explicitly teaches the existence of a central server or centralized entity that is part of the patent’s overall rail network system. The ’363 patent teaches that the train can communicate with a central “automatic train supervision (ATS) system.” EX1001, 4:48-60. The centralized ATS system, the patent explains, can send a “movement

request” or a “speed restriction message” to the train. EX1001, 19:24-30, 24:21-28; FIG. 10; *see also id.*, 9:63-10:2 (explaining a train’s route may be “chosen remotely by the central dispatcher using Automatic Train Supervision (ATS)”), 11:7-22 (explaining that work zones can be “centrally designated,” including by “[a] dispatcher in a remote location using the ATS console, where the data is communicated via the data communication network”); 26:41-59 (explaining how ATS system “generates a message” regarding the location and start/end time of a work zone that is relayed to trains). The ’363 patent also teaches that the carborne unit of its “decentralized” train “may request and obtain vital information” from a “wayside message interface (WMI).” EX1001, 19:31-38. The carborne “may then use any information [received via the WMI] pertinent to functions performed thereby.” EX1001, 19:34-38. For example, the train’s carborne unit may receive “[t]emporary speed restrictions,” “work zone boundaries,” and/or the location of other nearby trains via the WMI, which the train can then use to “support[] speed enforcement related functions” and “ensure safe separation” between trains. EX1001, 23:66-24:32 (speed enforcement based on information received via WMI); 25:49-26:3 (separation enforcement based on information received via WMI); 25:11-17, 26:48-53 (other control-related information received via WMI).

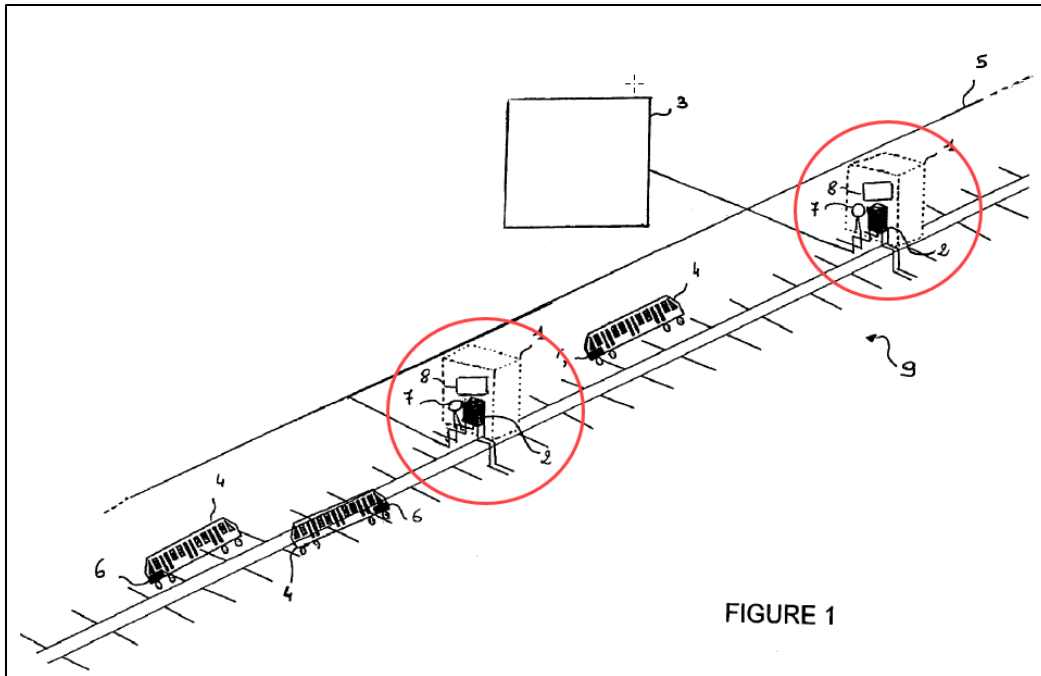
262. The role of the ATS in the ’363 patent is similar to the role of the “ATS” and/or the “Zone Controller” in Ghaly. Ghaly’s ATS and Zone Controller send

information to the train, such as track topography information, civil speed limits, route data, work zone limits, temporary speed restrictions, etc., which the VOBC then uses to generate and enforce movement authority limits and/or stopping profiles. Ghaly, [0004], [0009], [0017], [0031]-[0032].

263. Thus, Ghaly-Heddebaut discloses a system for decentralized control operations in a railway network, as claimed.

**b. [1A]: “a plurality of wayside units, each configured for placement on or near tracks in the railway network”**

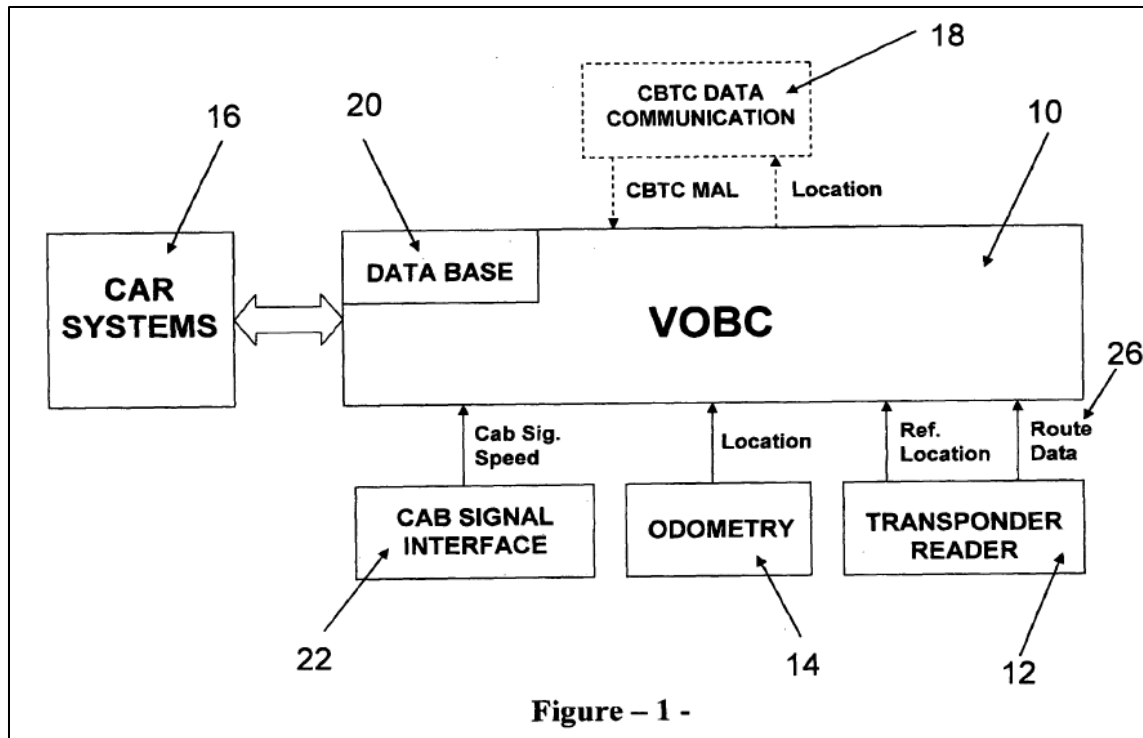
264. In Ghaly-Heddebaut, Heddebaut’s ultra-wideband-based transmitting/receiving elements are substituted for Ghaly’s “transponders” and are, therefore, like the transponders, “located on the track.” Ghaly, [0003]. This substitution of Heddebaut’s ultra-wideband-based transmitting/receiving elements for Ghaly’s transponders along the track is consistent with Heddebaut. Just as Ghaly’s system locates its transponder on the track, Heddebaut’s system positions the receivers/transmitters at “fixed stations” along the track and teaches that the “fixed stations” can thus be located both “upstream” and “downstream” of a moving train. See Heddebaut, 5:57-61, 6:3-9.



265. Thus, Ghaly-Heddebaut discloses a plurality of wayside units configured for placement on or near the tracks, as claimed.

**c. [1B]: “one or more train-mounted units, each configured for deployment on a train operating in the railway network”**

266. Ghaly-Heddebaut’s train is an “intelligent train” that uses “intelligent [] carborne equipment” to, *inter alia*, “determine[] [the train’s] own location” and to “generate[] and enforce[] a safe speed profile.” Ghaly, [0003]. The intelligent carborne equipment includes an “onboard CBTC controller,” (Ghaly, [0024]) such as the “vital onboard controller” VOB (Ghaly, [0026]) depicted in Figure 1 (below):



267. The onboard unit further includes and/or interfaces with several subcomponents, such as the data communication component, a cab signal interface, and a location and speed determination subsystem (which, in Figure 1, includes the transponder reader and odometry unit). Ghaly, [0024]-[0026].

268. Thus, Ghaly-Heddebaut discloses a train-mounted unit configured for deployment on a train, as claimed.

- d. **[1C]: “wherein each train-mounted unit is configured to:**
  - i. **[1C1]: “communicate with any wayside unit or other train-mounted unit that comes within communication range of the train-mounted unit, wherein the communicating comprises use of ultra-wideband (UWB) based signals”**

269. In Ghaly, the VOBC “interfaces with a transponder reader,” which, as discussed above, is a part of the location and speed determination subsystem in the example preferred embodiment in Ghaly. Ghaly, [0026]. In Ghaly-Heddebaut, the VOBC’s location and speed determination subsystem comprises Ghaly’s ultra-wideband-based transmitting/receiving elements. Thus, rather than interfacing with the transponder reader as in Ghaly, the Ghaly-Heddebaut VOBC interfaces with ultrawide-band transmitting/receiving elements as described in Heddebaut. Heddebaut, 4:14-18.

270. In operation, Ghaly-Heddebaut’s train-mounted transmitting/receiving elements “exchange[]” signals (specifically, “ultrawide band signals”) with UWB-transmitters/receivers positioned along the track, which in Ghaly-Heddebaut have been substituted for Ghaly’s on-track “transponders.” Heddebaut, 5:49-56. Heddebaut’s ultra-wideband transmitting/receiving elements also “enable[] direct communication between vehicles, which proved necessary in certain operating modes.” Heddebaut, 2:8-10.

271. Thus, Ghaly-Heddebaut discloses a train-mounted unit configured to communicate with any wayside unit or other train-mounted unit that comes within communication range, as claimed.

272. Ghaly-Heddebaut's on-train and on-track UWB-transmitter/receivers communicate "radio signals with a very large passband" with a "frequency spectrum [that] ranges between 1 and 10 GHz." Heddebaut, 4:52-55. POSAs would have understood that radio signals with a large passband and frequency spectrum ranging between 1 and 10 GHz would have been referred to as an ultra-wideband based signal, as claimed. *See, e.g.*, EX1019, 146-147 ("UWB PHY: combined burst position modulation (BPM) and BPSK modulation, operating in the **sub-gigahertz and 3–10 GHz bands**, as defined in Clause 14."); FCC (GPO) Title 47, Section 15 of the Code of Federal Regulations (§15.503) (10-1-05 Edition), 849 ("Ultra-wideband (UWB) transmitter. An intentional radiator that, at any point in time, has a fractional bandwidth equal to or greater than 0.20 or has a UWB bandwidth equal to or greater than 500 MHz, regardless of the fractional bandwidth.").<sup>3</sup>

273. Indeed, Heddebaut expressly refers to the signals as "ultra wide band," further corroborating my opinion that POSAs would have understood Heddebaut's

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<sup>3</sup> Captured by the Wayback Machine on January 14, 2012, as reflected in the Internet Archive's extended URL:  
[https://web.archive.org/web/20120114220448/http://edocket.access.gpo.gov/cfr\\_2005/octqtr/pdf/47cfr15.503.pdf](https://web.archive.org/web/20120114220448/http://edocket.access.gpo.gov/cfr_2005/octqtr/pdf/47cfr15.503.pdf)

signals to be ultra-wideband based signals. For instance, Heddebaut explains that its system is optimal for underground subway applications because the “[characteristics] of an ***ultra wide band signal*** enable to dispense with difficult propagation conditions in [a] tunnel.” Heddebaut, 4:52-66; *see also* 5:2-17. POSAs would have understood that the ultra-wideband signal referred to in Heddebaut and the “radio signal with a very large passband” and “frequency spectrum ranges between 1 and 10 GHz” to be referring to the same type of radio signal, which is an ultra-wideband based signal.

274. Thus, Ghaly-Heddebaut discloses a train-mounted unit configured to communicate ultra-wideband based signals, as claimed.

- ii. **[1C2]: “generate based on the communication, control information configured for use in controlling one or more functions of the train in conjunction with operation in the railway network,”**

275. Ghaly-Heddebaut’s VOBC generates a movement-authority limit (Ghaly, [0028]) and/or a “stopping profile (speed/distance curve) to control the speed of the train” (Ghaly, [0038]). The movement authority limit and stopping profile control functions of the train such as braking. For example, the VOBC “provides over-speed protection by ensuring that the actual speed of the train . . . does not exceed the allowable speed limit determined by the generated stopping profile. In the event of an over-speed condition, the VOBC will activate the train

brake subsystem.” Ghaly, [0038], [0026] (VOBC interfaces with propulsion and braking systems), [0004] (VOBC generates speed profile based on, *inter alia*, braking characteristics of the train), [0022] (VOBC generates stopping profile that corresponds with movement authority limit). Thus, Ghaly-Heddebaut discloses generating control information for use in controlling one or more functions of the train in conjunction with operation in the railway network, as claimed.

276. Ghaly-Heddebaut generates the movement authority limit and/or stopping profile based on the communication between the VOBC and wayside units because it is based on the location and speed of the train, which is determined based on the VOBC-wayside communication.

277. First, the control information is based on the train’s determined speed and/or location. Ghaly discloses that the “CBTC train location” is “required” to generate the operations. Ghaly, [0028]. Additionally, to generate and enforce the train’s stopping profile, the VOBC must use the train’s location and/or speed because enforcing the stopping profile requires determining whether “the actual speed of the train” has “exceed[ed] the allowable speed limit determined by the generated stopping profile.” Ghaly, [0038].

278. Second, the train’s determined speed and/or location is based on ultra-wideband communications between the VOBC and one or more wayside units. In Ghaly-Heddebaut, the VOBC determines the train location by using Heddebaut’s

ultra-wideband-based transmitting/receiving elements to “calculate [its] distance[] to” each transmitting/receiving elements located “upstream” or “downstream” of the train as it moves along the track. Heddebaut, 5:57-61. This distance calculation is based on “analysis of the ultra wide band signals exchanged between the [track-located transmitting/receiving elements] and the [train-located transmitting/receiving elements].” Heddebaut, 5:49-56. In Ghaly-Heddebaut, the VOBC also determines the train’s speed using Heddebaut’s ultra-wideband-based techniques. Specifically, the VOBC uses two “distance” measurements by the transmitting/receiving elements at two distinct points in time to determine how far the train moved over that discrete period of time, enabling the derivation of an “actual speed measurement.” Heddebaut, 6:18-21.

279. Thus, Ghaly-Heddebaut discloses a train-mounted unit that generates control information for use in controlling one or more functions of the train based on the ultra-wideband based communication between the train-mounted unit and one or more wayside units, as claimed.

**e. [1D] “wherein generating the control information comprises or is based on obtaining ranging measurements”**

280. As discussed above in Limitation 1C2, Ghaly-Heddebaut’s VOBC generates a movement authority limit and/or a stopping profile (i.e., control information) based on the location and speed of the train, as determined by the

VOBC's location and speed determination subsystem. In Ghaly-Heddebaut, determining the location and speed of the train comprises or is based on obtaining ranging measurements, as claimed.

281. In Ghaly-Heddebaut, the VOBC can "calculate [its] distance[] to" each wayside unit based on "analysis of the ultra wide band signals exchanged between the [track-located transmitting/receiving elements] and the [train-located transmitting/receiving elements]." Heddebaut, 5:49-61. Using two such "distance" measurements, the VOBC can derive an "actual speed measurement." Heddebaut, 6:18-21.

282. POSAs would have understood the VOBC's calculation of the distance to one or more upstream or downstream transmitting/receiving elements to comprise or be based on obtaining ranging measurements. The '363 patent does not provide a specialized definition of ranging measurement, and POSAs would have understood a ranging measurement to refer to a measurement of distance between two points, such as the distance between the train-mounted unit and one or more wayside units. Accordingly, POSAs would have understood Ghaly-Heddebaut's disclosure that the VOBC determines its location by calculating the distance to known reference points ahead of and/or behind the train to be a disclosure of ranging measurements.

283. Thus, Ghaly-Heddebaut discloses that generating the control information comprises or is based on obtaining ranging measurements, as claimed.

- f. **[1E]: “wherein obtaining the ranging measurements comprises:**
  - i. **[1E1]: “broadcasting ultra-wideband (UWB) based signals within a wireless range of the train-mounted unit...”**

284. As discussed in connection with limitation [1D], performs “ranging measurements” when the VOBC ultra-wideband-based transmitting/receiving elements exchange ultra-wideband signals with one or more track-based transmitting/receiving elements and determine the train’s location by calculating the distance to one or more of the track-based units. These operations comprise broadcasting ultra-wideband signals within a wireless range of the train-mounted unit, as claimed.

285. In particular, to perform the above-described distance determinations, the VOBC’s ultra-wideband based transmitting/receiving elements send an ultra-wideband signal to track-based transmitting/receiving elements nearby. The VOBC transmits these signals using a broadcast technique, as claimed, because the signals are being sent from a single device (the VOBC’s transmitting/receiving elements) to potentially many receiving devices in range. As Heddebaut teaches, the train-mounted unit determines its location by calculating the “distances” (plural) “to the downstream and upstream fixed stations” (plural). Heddebaut, 5:57-61. POSAs would have understood this disclosure to indicate that Ghaly-Heddebaut’s VOBC transmits a signal from one device to many, and POSAs would have recognized that

the conventional way of achieving this one-to-many transmission would have been to broadcast the ranging-request signal from the VOBC.

286. Additionally, even if Ghaly-Heddebaut does not disclose broadcasting ultra-wideband signals, POSAs had reason to implement VOBC such that it broadcasted UWB signals for at least the same reasons as discussed above with respect to Carlson. For example, POSAs would have understood that the VOBC would not always be aware of all track-based transmitting/receiving elements and/or other VOBCs within its wireless range. This “blind” scenario would occur, for example, when the VOBC is first powered on and thus has not been in recent wireless communication with any companion devices. Similarly, this would occur when a transmitting/receiving element or another VOBC first comes into wireless range, *e.g.*, as the train on which the VOBC is mounted moves through the system, it moves into wireless range of new companion devices that were previously out-of-range (*e.g.*, because it was around a curve with an interfering object in between).

287. By broadcasting UWB ranging signals, rather than addressing them to individual transponders, Ghaly-Heddebaut's system would have better ensured that VOBC identified and received responses from ***all*** wayside-located transmitting/receiving elements and VOBCs within communication range, not just those already known to the VOBC. This technique would have reduced vehicle collisions by better ensuring detection of all wayside stations and VOBC-equipped

vehicles within wireless range. This technique would have also provided redundancy in the system. To put it simply, it makes little sense in Ghaly-Heddebaut's collision avoidance context to limit (and there would be benefits in not limiting) the VOB's ability to detect potential collisions to only those collisions that might occur with known companion devices rather than with all companion devices whether known to the VOB or not.

288. Broadcasting UWB-based signals for ranging purposes was also conventional by the mid-2010s, and thus POSAs would have had a reasonable expectation of success in modifying the VOB to broadcast such signals. For example, U.S. Patent Application Publication No. 2004/0240565 (EX1021) published in 2004 and describes a ranging technique using UWB signals. Specifically, it teaches the use of a broadcasted "distance request message" that is sent to all other UWB devices within range so that those other devices can determine their distance from the transmitting UWB radio, and the receiving radios also send back a "distance response message" to the transmitting radio so that it too can determine its distance from the other UWB radios. EX1021, [0076]-[0077]. Moreover, as I explained above, broadcasting UWB signals was part of the IEEE standard nearly a decade before the application that became the '363 patent was filed. *See, e.g.*, EX1019, 146-147. Modifying Ghaly-Heddebaut to use this UWB

broadcasting technique would have therefore been routine to POSAs by the time of the alleged invention.

289. Thus, Ghaly-Heddebaut discloses broadcasting ultra-wideband based signals within a wireless range of the train-mounted unit, as claimed.

**ii. [1E2]: “the UWB based signals comprising information identifying the train-mounted unit”**

290. Ghaly-Heddebaut’s VOBC determines its location and speed using the ultra-wideband-based techniques disclosed in Heddebaut. In Heddebaut, all transmitting/receiving elements in the system—including the train-mounted element(s)—send and receive ultra-wideband signals that “contain[s] a specific identifier of the transmitter and at least one message.” Heddebaut, 4:15-18. Each identifier is a “specific code and a specific identity...ascribed to [the] transmitter” and can be transmitted using “an [UWB] technique.” Heddebaut, 4:27-38. There is a “single identifier[] per rail vehicle 4 and fixed station 1,” which is included in the ultra-wideband signals by “modulat[ing] a pulse string according to an ultra wide band technique.” Heddebaut, 4:27-35. Each element in the system (e.g., the train-mounted and wayside elements) also “include[s] processing means 8 for determining the identifier and at least said message of each signal received.” Heddebaut, 5:17-19. More specifically, each element includes a “Storage memory” containing “the identifiers of the different transmission-reception ultra wide band means of the

network,” such that each system component can determine the identity of the sender of a received ultra-wideband signal. Heddebaut, 5:20-30.

291. In Ghaly-Heddebaut, POSAs would have retained this attribute of Heddebaut’s disclosure, recognizing it as a critical component of the location- and speed-determination techniques disclosed therein. For example, POSAs would have recognized that including identifying information each signal transmitted by the train-mounted unit would provide any wayside unit receiving that signal with information needed to send a responsive signal. Because Heddebaut teaches that the location of the train is determined based on signals “exchanged between the ground and the vehicles,” POSAs would have recognized the benefits of including identifying information in the signal broadcast by the train to allow the wayside units to respond in turn.

292. Thus, Ghaly-Heddebaut discloses that the train-mounted unit broadcasts an ultra-wideband signal comprising information identifying the train-mounted unit, as claimed.

**iii. [1E3]: “selecting based on received responses to the broadcast UWB based signals, one or more of the plurality of wayside units; and**

293. As I explained *supra* §VII.A.3.f.iii (Ground 1, limitation 1E3), the “selecting” recited in [1E3] requires receiving responses from any wayside unit that responds to the train-mounted unit’s originally-broadcasted UWB signals.

294. Ghaly-Heddebaut's VOBC "calculate[s] [its] distance[] to the downstream and upstream" wayside units based on "the analysis of the [UWB] signals exchanged between" the train-mounted unit and the wayside units. Heddebaut, 5:49-61.

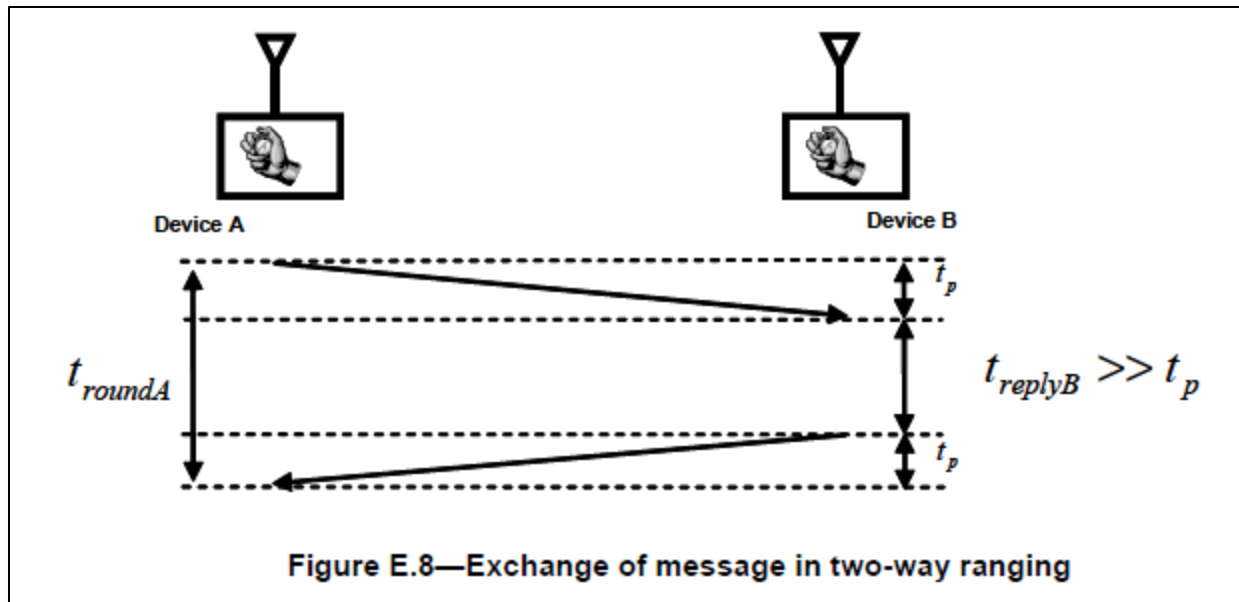
295. To calculate the distance, the VOBC "[m]easur[es] the distance...based on the flight time" of these exchanged signals. Heddebaut, 6:2-18. Based on Heddebaut's disclosure, POSAs would have understood Heddebaut's "calculations" and "measurements" to be a form of two-way distance ranging, which is a conventional technique for determining the distance between a transmitting device and receiving device based on the "flight time" of one or more signals "exchanged between" those devices.

296. In conventional two-way ranging, a first device broadcasts a ranging request message that is received by a second device. The second device sends a message in response to the message received from the first device. The first device can then use the round-trip time of flight to calculate the distance.

297. Here, POSAs would have understood that Ghaly-Heddebaut would have implemented conventional two-way ranging techniques by configuring the train-mounted transmitting/receiving element to broadcast a ranging request message to all nearby track-based transmitting/receiving elements. Any track-based transmitting/receiving elements receiving the train's ranging request would respond

by sending a message back to the train-mounted transmitting/receiving element. The VOBC would then use the round-trip time of flight (or “flight time”) to calculate the distance between the train-mounted transmitting/receiving element and the one or more responding track-based transmitting/receiving elements.

298. This type of two-way ranging was well known to POSAs, who would have also recognized that standards-setting bodies had developed and published detailed specifications setting forth how such ranging operations could (and should) be performed. One such specification of which POSAs would have been aware is IEEE 802.15.4a, which was published by 2011 and which discloses conventional two-way ranging. In this conventional two-way ranging (illustrated below), Device A sends a ranging request, Device B responds to the ranging request, and Device A calculates the distance between itself and Device B based on the round-trip time of flight ( $t_{\text{roundA}}$ ):



299. POSAs would have therefore recognized that Heddebaut discloses not only broadcasting of an ultra-wideband signal by the train-mounted transmitting/receiving element, but also that the track-based transmitting/receiving elements receiving the ranging request would send responsive messages to the train based VOBC so as to enable the VOBC to “[m]easur[es] the distance...based on the flight time” of these exchanged signals. Heddebaut, 6:2-18.

300. Thus, Ghaly-Heddebaut discloses that the train-mounted unit selects one or more wayside units based on received responses to the broadcast UWB based signal, as claimed.

- iv. **[1E4]: “determining ranging information corresponding to each of the one or more wayside units, based on ultra-wideband (UWB) based signals communicated respectively with each of the one or more of the plurality of wayside units.”**

301. As discussed in connection with Limitation 1E3, Ghaly-Heddebaut’s VOBC “calculate[s] [its] distance[] to the downstream and upstream” UWB-transmitters/receivers located along the track based on “the analysis of the [UWB] signals exchanged [there]between.” Heddebaut, 5:49-61. By “measuring the distance relative to a fixed reference upstream and/or downstream as based on the flight time” of the ultra-wideband signals, the VOBC is able to “determine[], with a high degree of certainty and accuracy, the absolute position of the [train].” Heddebaut, 6:3-9.

302. As discussed in connection with Limitation 1D, POSAs would have understood these ultra-wideband-based distance calculations of Heddebaut’s transmitting/receiving elements to be ranging measurements. For similar reasons, POSAs would have understood the results of these distance calculations to be ranging information corresponding to each of the one or more wayside units with which the VOBC has exchanged these signals and calculated its distance therefrom.

303. Thus, Ghaly-Heddebaut discloses determining ranging information corresponding to each wayside unit with which ultra-wideband based signals have been communicated, as claimed.

\* \* \*

304. Accordingly, for the reasons discussed above, in my opinion the Ghaly-Heddebaut combination meets every limitation of claim 1.

**6. Claim 2: “The system of claim 1, wherein the train-mounted unit is configured to generate at least part of the control information based on sources other than processing of the ultra-wideband (UWB) based signals.”**

305. Ghaly-Heddebaut’s VOBC generates/receives movement authority limits and generates stopping profiles, which, as discussed *supra* §VII.B.5.d, are control information. *See, e.g.*, Ghaly, [0022], [0028], [0038]. The movement authority limit and stopping profiles are partially based on the processing of ultra-wideband based signals insofar as the location and speed determination subsystem utilizes Heddebaut’s ultra-wideband-based ranging techniques to determine train location and speed. *See, e.g.* Heddebaut, 5:49-61.

306. However, in addition to using the ultra-wideband based position and speed of the train to generate this control information, the VOBC also uses other information not based on the processing of ultra-wideband based signals. For example, the VOBC generates a stopping/speed profile that “incorporates the civil speed limits” and “takes into account... the topography of the track, and the braking characteristics of the train.” Ghaly, [0004], [0038]. The VOBC also uses information not based on processing of ultra-wideband based signals to generate a movement authority limit, such as information stored in an on-board database or

received via the data communication unit. See Ghaly, [0001] (VOBC “generates a movement authority limit (MAL) based on the speed commands received from [non-UWB] devices”), [0009]-[0011] (VOBC receives “information related to temporary speed restrictions, work zone limits, and status of interlocking devices”), [00026]-[0028] (VOBC may generate MAL based on “route data”), [0032] (“route data 26 could be provided by wayside transponders, from a wayside zone controller, or from the ATS subsystem using the data communication unit 18” or “could also be implied from the received cab-signaling speed code 30 in conjunction with information stored in the on-board data base 20”).

307. Thus, Ghaly-Heddebaut discloses that the VOBC generates control information based on sources other than processing of ultra-wideband based signals, as claimed.

## **7. Claim 3**

- a. [3A]: “The system of claim 2, wherein the train-mounted unit is configured to assess based on the processing of the ultra-wideband (UWB) based signals, one or more conditions relating to operation of the train within the railway network”**

308. In Ghaly-Heddebaut, the VOBC uses Heddebaut’s “ultra wide band technology” for the CBTC system’s location and speed determination subsystem to determine the location and speed of the train. More specifically, the VOBC determines the train’s location by “measuring the distance” of the VOBC “relative

to a fixed reference upstream and/or downstream as based on the flight time of signals.” Heddebaut, 6:4-21. By determining the distance relative to a known location at multiple points in time, the VOBC can determine an “actual speed measurement of the rail vehicle.” Heddebaut, 6:4-21. POSAs would have understood the train’s location and speed to both be conditions relating to operation of the train that is assessed based on the processing of UWB signals, as claimed.

**b. [3B]-[3C]: “when at least one condition meets one or more particular criteria, determine one or more responsive actions and perform or cause performing each of the one or more responsive actions.”**

309. Ghaly-Heddebaut’s VOBC “generate[s] a stopping profile (speed/distance curve) to control the speed of the train” and “provides over-speed protection by ensuring that the actual speed of the train...does not exceed the allowable speed limit determined by the generated stopping profile.” Ghaly, [0038]. If the train speed “exceed[s] the allowable speed limit determined by the generated stopping profile”, the VOBC will determine that the train has entered an “over-speed condition” and, in response, “will activate the train brake subsystem.” Ghaly, [0038]. POSAs would have understood the activation of the VOBC’s automatic braking system based on a determination that the speed has exceeded the allowable speed limit to constitute determining one or more responsive actions and performing the responsive action(s) when at least one condition meets a particular criteria, as claimed.

## 8. Claim 4

- a. **[4A]: “The system of claim 3, wherein, when the one or more responsive actions comprise providing indication or feedback, relating to the at least one condition, to a train operator”**

310. Ghaly-Heddebaut’s VOBC includes and/or interfaces with a “train operator display” that provides information to the train operator. Ghaly, [0048]. POSAs would have understood that in Ghaly, Heddebaut, this display would have been used to provide feedback to the operator relating to the operation of the train. Such information would have included certain train “conditions,” such as the train’s location/speed and/or its compliance with a movement-authority limit or stopping profile.

311. Additionally, to the extent Ghaly-Heddebaut does not disclose providing an indication of train location/speed to the operator via the “operator display,” then POSAs would have reason to utilize the display in this way. For instance, POSAs would have understood that any train operator would need information about the train location/speed to ensure that the train was in compliance with applicable speed limits, stopping requirements, and the like. POSAs would have further understood that using an existing “train operator display” would have been a commonsense way to deliver that information to the operator because the information could be readily presented on any conventional display and because it

would be more efficient to utilize existing equipment than to require additional equipment to deliver this information.

**b. [4B]: “the train-mounted unit is configured to:  
monitor actions of the train operator”**

312. Additionally, the VOBC “enforces a safe speed profile” by providing “over-speed protection.” Ghaly, [0003], [0038]. The VOBC monitors and assesses whether the “speed of the train” has “exceed[ed] the allowable speed limit,” which results in an “over-speed condition.” Id., [0038].

313. POSAs would have understood that monitoring the speed of the train relative to the allowable speed limit constitutes monitoring the actions of the train operator insofar as the train operator has the capacity to control the speed of the train. Thus, the speed of the train provides an indication of the actions taken by the operator. Accordingly, monitoring the speed of the train constitutes monitoring the actions of the train operator, as claimed.

**c. [4C]: “assess based on the monitoring, the train  
operator’s compliance with at least one expected  
subsequent responsive action”**

314. If the “speed of the train” has “exceed[ed] the allowable speed limit,” the VOBC determines that the train has entered an “over-speed condition.” Id., [0038].

315. POSAs would have understood that when the speed of the train is approaching or has exceeded the allowable speed limit and the train operator is being

provided with an indication of this information, it would be expected that the train operator would take a responsive action by slowing the speed of the train. Thus, by continuing to monitor the speed of the train and by determining whether the train has entered an over-speed condition, the VOBC is assessing whether the train operator is complying with an expected subsequent responsive action, as claimed. That is, if the train continues to accelerate—or fails to decelerate—to bring the train’s speed into compliance with the allowable speed limit, then the train operator has failed to take the expected responsive action.

- d. **[4D]: “when the train operator fails to do so, directly perform the at least one expected subsequent responsive action or perform an alternative action.”**

316. If the VOBC determines that the train is in an “over-speed condition,” the VOBC responds by “activat[ing] the train brake subsystem.” Id., [0038].

317. POSAs would have understood the VOBC’s activation of the train’s brake subsystem to be the VOBC directly performing the action that was expected to be performed by the train operator in response to the train speed approaching and/or exceeding the allowable speed limit. That is, when the train operator fails to decelerate the train (the expected responsive action) and the train exceeds an allowable speed limit, the VOBC instead must automatically brake the train (directly performing the expected responsive action) to bring the train speed back into compliance with the allowable speed limit.

**9. Claim 5: “The system of claim 1, wherein the train-mounted unit is configured for utilizing non-UWB based signals for communicating at least some data with the wayside unit and/or another train-mounted unit.”**

318. Ghaly-Heddebaut’s VOBC includes a “data communication subsystem.” Ghaly, [0026]-[0027], [0038]. The VOBC uses the data communication subsystem to access a “data communication network,” which it uses to communicate with other system components. Ghaly, [0022], [0032].

319. To send and receive data, the data communication subsystem transmits/receives signals that are “normally in the form of a modulated carrier frequency.” Ghaly, [0027]. POSAs would have understood that signals in the form of a modulated carrier frequency would have included both UWB and non-UWB signals. POSAs would have also understood that the data communication subsystem could also be used to communicate information to/from wayside ranging units and/or other trains in the train-control system. Indeed, POSAs would have had reason to implement Ghaly-Heddebaut’s VOBC to use a non-UWB signal for data communications between the VOBC and other system components. First, providing multiple means of data communication between the VOBC and the wayside units would provide redundancy and make the system more resilient and reliable. Second, POSAs would have understood that it is common for a train-control environment to include trains with different communication capabilities. For example, as a new communications infrastructure is being installed, there may be times when the new

technology has been installed on only some of the trains in the system. Thus, POSAs would have appreciated that providing non-UWB communication capability in the VOBC would have enabled to VOBC to communicate with other trains in the system even if they had not yet been outfitted with the UWB-based communication technology.

**10. Claim 6: “The system of claim 1, wherein the train-mounted unit is configured for handling radio-frequency identification (RFID) based signals with RFID devices used within the railway network.”**

320. As I discussed in *supra* §VII.B.4, Ghaly-Heddebaut’s VOBC is equipped with Heddebaut’s ultra-wideband-based transmitting/receiving elements and uses these UWB-based elements to determine the train’s position and speed. POSAs would have understood that Ghaly-Heddebaut need not be limited to one position/speed-determination technique. Rather, POSAs would have understood that it was common for train-control systems of the type described in Ghaly-Heddebaut to include multiple location-determination techniques and would have had reasons to use multiple location-determination subsystems Ghaly-Heddebaut.

321. Using multiple distinct location and speed determination subsystems would have provide Ghaly-Heddebaut’s VOBC with multiple sources of information that could be used together to determine the train’s location/speed (which POSAs refer to as “sensor fusion,” as I discuss below). For example, the VOBC would use multiple techniques to determine location/speed and would, for example, take an

average of the two outputs to determine the train's location/speed for train-control purposes or would, as another example, determine which of the two outputs to use based on some other confidence indicator.

322. Additionally, POSAs would have appreciated that the use of multiple distinct location and speed determination subsystems would have been particularly advantageous—if not necessary—for an effective train-control system because many train-control systems operate in environments where the accuracy and reliability of a given location-determination technique may vary in different areas of the track. For example, a single train system may include some sections of track that are underground and other sections of track that are above-ground. In such a circumstance, POSAs would have appreciated that a first location-determination technique (e.g., UWB-based ranging) would typically provide accuracy and reliability advantages in underground portions of the system, while another location-determination technique (e.g., GPS) would typically be more accurate, more reliable, and/or cheaper to use in the above-ground portions of the system. Similarly, when a train traveling under a canopy of trees, as is typical of above-ground travel, or in mountainous areas characterized by steep cliffs, GPS signal may be greatly attenuated and POSA would have understood the benefits in including and, at times, relying on a redundant method such as RFID or UWB-based ranging for location determination.

323. My opinion on these points is corroborated by EX1024, which is U.S. Patent No. 9,606,217 to Bruemmer et al. (“Bruemmer”), titled “Collaborative Spatial Positioning.” Bruemmer “relate[s], in general to determining the relative position of an object . . . using a plurality of independent sources of positional data.” Bruemmer teaches that “[s]ensor fusion is the combining of sensory data or data derived from sensory data from disparate sources such that the resulting information is, in some sense, better than would be possible when these sources were used individually.” EX1024, 1:15-24. Bruemmer adds: “The data sources for a fusion process are not specified to originate from identical sensors. Indeed, one could argue that disparate data sources related to the same goal may provide a more accurate and more reliable product.” EX1024, 1:30-33. Bruemmer explains that using multiple position-determination techniques with different types of position-determining sensors “balances comparative variances of differing sensor platforms, as well as strengths and weaknesses of subsets of these sensor platforms, to arrive at a real-time optimal determination of an object's position.” EX1024, 12:27-31.

324. My opinion is further corroborated by EX1031, U.S. Patent No. 6,631,322 to Arthur et al. (“Arthur”), titled “Method and Apparatus for Vehicle Management.” Arthur specifically relates to the use of multiple position-determination techniques in a train-control environment. In particular, Arthur relates to using a combination of GPS-related data with other location-related data to

improve the accuracy of the location/speed determination. As Arthur explains, “[n]avigation data provided by GPS alone can be degraded due to operation in tunnels, lack of visibility of satellite constellation, multi-path interference in urban areas and other factors.” EX1031, 4:66-5:2. Therefore, to improve the location/speed-determination, Arthur discloses a system that uses “sensor fusion functionality,” which “integrates the raw GPS data with locomotive based speed and other data to provide location extrapolation during periods of high position uncertainty.” EX1031, 5:2-5.

325. Given these advantages, POSAs would have had reason to implement Ghaly-Heddebaut to include multiple location/speed-determination subsystems to provide multiple location/speed outputs to the VOBC to use for train-control functions.

326. POSAs would have appreciated that there are a number of different location/speed-determination subsystems that might be used alongside the UWB-ranging system in Ghaly-Heddebaut. However, POSAs would have appreciated that there are a couple of particularly well-known, conventional, and reliable location/speed-determination techniques that were commonly used in CBTC train control systems.

327. One such conventional, well-known location-determination subsystem was a system in which RFID transponders placed at fixed (and known) locations

along a track communicate with an RFID reader on-board the train to provide the train with information needed to determine its absolute position and speed within the system. POSAs would have understood that such an RFID system would provide reliable indications of the train's absolute position when passing the fixed RFID transponders and would have had a reasonable expectation of success in using a conventional RFID position-location subsystem in Ghaly-Heddebaut because such RFID-based systems were conventional, inexpensive, and readily affixed to common wayside infrastructure for ease of use, maintenance and replacement when necessary as RFID devices can be made in arbitrary footprints to meet the applications needs.

328. My opinion that RFID-based systems were commonplace, well understood, and would be combinable with other location-determination subsystems is corroborated by Bruemmer, which discloses how an RFID-based location-determination subsystem can be used in conjunction with other location-determination subsystems to determine the location of a moving object (e.g., animals, trains, etc.). As Bruemmer explains, “collaborative positioning” can be accomplished using a “radio frequency (RF) identification (ID) tag (collectively RFID).” The system comprises “[RFID] tags, a reader with an antenna, and software” and the “main function of the RFID system is to retrieve information (ID) from a tag (also known as a transponder).” The RFID tags are “affixed to objects . . .

so that it becomes possible to locate where the [objects] are without line-of-sight.”

EX1024, 9:39-50.

**11. Claim 7: “The system of claim 1, wherein the train-mounted unit is configured for handling satellite based signals.”**

329. As discussed above in connection with Claim 6, POSAs would have had reason to utilize multiple location-determination techniques in Ghaly-Heddebaut’s train-control system and would have recognized RFID-based techniques as a commonplace, well-understood technique that could have been readily implemented alongside Ghaly-Heddebaut’s UWB-based techniques.

330. POSAs would have also appreciated that another commonplace, well-understood location-determination technique in the train-control field would have been using global positioning devices (GPS). POSAs would have understood that GPS-equipped trains can obtain satellite-based positioning information from GPS satellites and use this information (either alone or in conjunction with other location-related data) to determine the position of the train.

331. Indeed, my opinion that GPS was a conventional location-determination technique in the train-control field is corroborated by Ghaly itself, which expressly suggests using GPS signals in its system as it identifies “global positioning devices” as one form of location-speed determination subsystem. Ghaly, [0011].

332. My opinion is further corroborated by both Bruemmer and Arthur, both of which describe using GPS in conjunction with other location-determination techniques to determine the location of a moving object. Bruemmer, EX1024, 1:53-57 (“GPS is an example of absolute positioning and provides the benefit of supporting path planning, facilitating communication about positioning over large distances, and providing a persistent understanding of where things are in the world.”); Arthur, EX1031, 4:24-28 (“In the exemplary embodiment, at least one locomotive 42 includes a GPS receiver antenna 17 for receiving GPS positioning data from GPS satellite 52.”) However, as Arthur notes, there are limitations of using GPS in a train control system, such as in tunnels or in other locations where satellite visibility is diminished, which further supports my opinion that POSAs would have appreciated the need to combine multiple location-determination techniques (e.g., UWB and GPS) rather than relying on any one independent technique.

333. POSAs would have reason, and reasonable expectation of success, in using a conventional GPS location-determination subsystem in conjunction with the UWB-based ranging system in Ghaly-Heddebaut because of the complementary nature of the ranging and distance determination advantages of both technologies where each individual technology when deployed under specific circumstances would not result in the most accurate determination of distance and ranging for those specific circumstances.

**12. Claim 8: “The system of claim 7, wherein the train-mounted unit is configured for obtaining from received satellite based signals information, and generating or adjusting the control information based on the obtained information.”**

334. As discussed supra § VII.B.11 (claim 7), POSAs would have had reason to utilize GPS-based location-determination techniques alongside the UWB-based ranging techniques in Ghaly-Heddebaut’s location and speed determination subsystem.

335. Accordingly, in the resulting Ghaly-Heddebaut system, the VOBC would determine the train’s “CBTC ... location” based on one or more of the location/speed based on the ultra-wideband-based transmitting/receiving elements and the location/speed determined based on received GPS satellite signals. In turn, the VOBC would use the “CBTC train location” to generate a movement authority limit for the train and/or to generate and enforce a stopping profile for the train. Ghaly, [0028], [0038]. POSAs would have understood the generation/enforcement of the movement authority limit and stopping profile to constitute generating or adjusting the control information based on the information obtained from the GPS satellite-based location-determination subsystem.

**13. Claim 9: “The system of claim 1, wherein the train-mounted unit is configured for connecting to and/or interfacing with other systems of the train.”**

336. Ghaly-Heddebaut’s VOBC includes “an interface to the traction, braking and other car subsystems.” Ghaly, [0010], [0026]. Using this car systems-

interface, the VOBC “provides over-speed protection by ensuring that the actual speed of the train as measured by the [location/speed-determination subsystem] does not exceed the allowable speed limit determined by the generated stopping profile.” [0038]. “In the event of an over-speed condition, the VOBC will activate the train brake subsystem.” [0038].

337. POSAs would have understood the interface between the VOBC and the braking subsystem and the activation of the train’s brake subsystem in an overspeed condition to constitute a connection and/or interface between the VOBC and the other systems of the train, as claimed.

**14. Claim 10: “The system of claim 1, comprising 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.”**

338. Ghaly-Heddebaut’s VOBC is associated with (i.e., includes or interfaces with) a “train operator display,” which provides information, such as “route information,” to the train operator. Ghaly, [0048]. Thus, Ghaly-Heddebaut comprises output components for providing output to the operator, as claimed.

339. Additionally, POSAs would have understood that the VOBC would have been capable of receiving input from the train operator, e.g., through the above-described operator display. For example, Ghaly provides that the VOBC can implement an “acknowledgement function...to ensure that the train operator is aware of” an updated movement authority limit. Ghaly, [0017], [0044]. POSAs

would have understood that to receive an “acknowledgement” from the train operator would have required providing the operator with a means to provide an input to the VOBC.

340. Alternatively, to the extent Ghaly-Heddebaut does not expressly disclose receiving input from the train operator, POSAs would have had reason to provide such conventional functionality. As one example, enabling the operator to acknowledge receipt of various train-control commands (e.g., MAL, stopping profile, speed limit, etc.) would make it possible to more quickly detect a situation when the operator is not alert or is incapacitated and to, in response, trigger automatic train-control functionality (e.g., automatic braking). As another example, the operator may be able to provide the system with important information about the train, such as change in the train’s intended route or a malfunction in certain equipment, such that the overall train-control system could update the MALs and stopping profiles of the train(s) in the system accordingly.

**15. Claim 11: “The system of claim 1, comprising a power component for supplying and/or obtaining power for components of the train-mounted unit.”**

341. Ghaly-Heddebaut’s VOBC is an “onboard computer.” Ghaly, [0003].

342. POSAs would have understood that to provide the power necessary to operate an “on-board computer” of the type described in Ghaly-Heddebaut, it would have been conventional to connect the computer to a “power component.”

- 16. Claim 12: “The system of claim 1, wherein the train-mounted unit is configured for communicating, directly or via at least one of the wayside unit and another train-mounted unit, with one or more other components or devices in the railway network, the one or more other components or devices in the railway network not being part of decentralized train control system.”**

343. Ghaly-Heddebaut’s train-control system may, in some instances, include an “Automatic Train Supervision System (ATS),” which is “enabled by [an] ATS dispatcher at a central control location” (Ghaly, [0017]) and which “provides information related to temporary speed restrictions, work zone limits, and status of interlocking devices.” Ghaly, [0009], [0032]. This centralized ATS dispatcher and the equipment used by the dispatcher to provide the above-described train-control information (e.g., speed restrictions, etc.) are components or devices in the railway network that are not part of the decentralized train control system, as claimed.

344. Ghaly-Heddebaut’s VOBC is configured to communicate directly or indirectly with these ATS components, as claimed. For example, Ghaly teaches that the “onboard CBTC computers could also communicate with an Automatic Train Supervision System (ATS)” (Ghaly, [0009]) and that the VOBC may receive “route data...from the ATS subsystem using the [VOBC’s] data communication unit” (Ghaly, [0032]).

- 17. Claim 13: “The system of claim 1, wherein the train-mounted unit is configured to substantially continually determine absolute position of the train, based on the ranging information obtained from ranging with wayside units.”**

345. Ghaly-Heddebaut’s VOBC “continuously calculates the location and speed of the train.” Ghaly, [0003], [0010]. In the Ghaly-Heddebaut system, the VOBC’s location and speed determination subsystem utilizes Heddebaut’s UWB-ranging-based location-determination techniques to determine the VOBC’s “distance relative to [] fixed reference[s] upstream and/or downstream,” which the VOBC, in turn, uses to “the absolute position of the [train].” Heddebaut, 6:3-9. POSAs would have thus understood Ghaly-Heddebaut’s VOBC to be continuously calculating the location and speed of the train based on the ultra-wideband-based signals exchanged between the train’s transmitting/receiving elements and the track-based transmitting/receiving elements and based on the time-of-flight ranging calculations performed on the basis of those signals.

- 18. Claim 14: “The system of claim 13, wherein the train-mounted unit is configured to determine the absolute position of the train based on the ranging information and positioning information obtained without ranging to wayside units.”**

346. While Ghaly-Heddebaut’s VOBC determines the absolute position of the train based on the ultra-wideband based signals exchanged between the train and the wayside (*supra* Claim 13), the VOBC also relies on information obtained without ranging to wayside units to make the above-described location/speed determination.

Specifically, because the VOBC determines the train's position based on the relative "distances to" the wayside stations at fixed locations, the VOBC must also determine the known location of these wayside units to determine the train's absolute position.

347. For this purpose, Heddebaut teaches that its UWB-transmitters/receivers maintain "in a storage memory the identifiers of the different transmission-reception ultra wide band means of the network." Heddebaut, 5:20-30. Similarly, Ghaly's VOBC includes a "vital data base that includes...location of wayside signal devices." Ghaly, [0010]. POSAs would have had reason to implement Ghaly-Heddebaut by storing the "identifiers" of Heddebaut's wayside UWB devices in Ghaly's "vital data base," which already contains similar information about the location of other devices in the train-control system.

348. POSAs would have understood that because this information is stored in local memory on the train (i.e., in association with the VOBC), this information would be obtained without ranging to wayside units, as claimed. POSAs would have further understood that because this information is used to determine the train's "distance to" the known locations of the wayside UWB transmitter/receivers, the VOBC would determine the absolute position of the train based on this information, as claimed.

**C. Ground 3: Claims 1-16 Obvious Over Carlson and Gantner  
Ground 4: Claims 1-14 Obvious Ghaly-Heddebaut and  
Gantner**

**1. Overview of Grounds 3 and 4**

349. For the reasons I discuss below, it is my opinion that (i) claims 1-16 would have also been obvious over Carlson in view of Gantner (EX1007) (*see* §§VII.C.4, VII.C.5 below) and (ii) claims 1-14 would have been obvious over Ghaly and Heddebaut in view of Gantner (*see* §§VII.C.4, VII.C.6 below).

**2. Gantner (EX1007): U.S. Patent Appl. Publ. 2009/0253439**

350. According to the face of the document, Gantner is a United States patent application publication that published on October 8, 2009 (code (44)), titled “Method and System for Carrying out a Two Way Ranging Procedure” (code (54)). Because Gantner published in 2009, I understand that Gantner qualifies as prior art even if the challenged claims were entitled to the August 4, 2017 filing date of Provisional Application No. 62/541,454 (*see* ’363 patent, code (60)). I understand that Gantner was not cited during prosecution of the ’363 patent. *See* ’363 patent, code (56) (references cited).

351. Gantner teaches “a Two Way Ranging Procedure” for “a blind node whose position is not known.” [0001],<sup>4</sup> [0012] (“The subject of this invention is a node (blind node) in a real time location system whose position is not known in a

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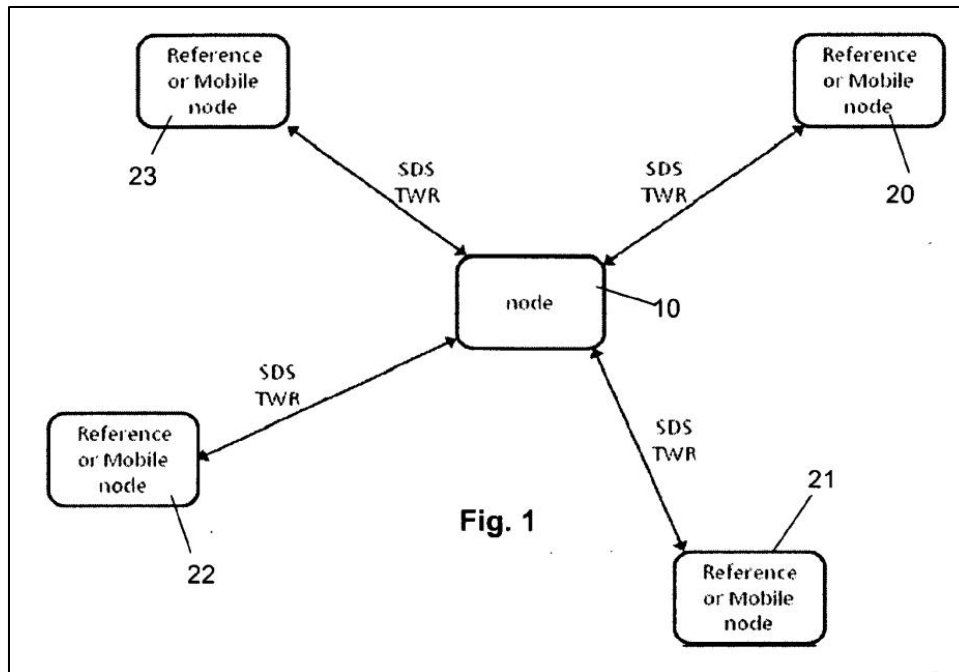
<sup>4</sup> All citations in this section are to Gantner unless I specify otherwise.

certain area.”). Gantner defines the “Blind Node” as an “element which is capable of transmitting and receiving, and whose location is changing and undefined.” [0071]. The blind node determines its position by ranging with “at least one reference or mobile node whose position is known.” [0001], [0004]. An exemplary ranging technique for use with Gantner’s system is “called Symmetrical Double-Sided Two Way Ranging, because”

it is symmetrical in that the measurements from a first wireless transceiver station to a second wireless transceiver station are a mirror-image of the measurements from the second wireless transceiver station to the first wireless transceiver station, it is double-sided in that always two transceiver stations are used for ranging measurement, and it is two-way in that a data packet (called a data or standard packet) and an acknowledge packet (Ack) are transmitted between the wireless stations.

[0004]. However, Gantner “is not limited to a SDS TWR method but also encompasses any other two way ranging method based on radio signals.” [0004].

352. Figure 1, which I have copied below, “shows a typical setup of a localization procedure of a node 10” using an SDS TWR technique. [0002]; *see also* [0067] (“Localization: process or result of at least three SDS TWR of a node with different Reference nodes or with one or several Mobile node at different point in time (considering that the mobile nodes are moving faster than the blind node).”). Node 10 in Figure 1 below is the blind node, and it determines its location by communicating with “one or several reference or mobile nodes” 20-23. [0003].



353. Like the '363 patent (at 15:24-39), Gantner discloses an initiating procedure wherein the blind node “broadcast[s] its identification (ID) within a data packet to all the reference or mobile nodes [20-23] in its range.” [0032]; *see also* [0063] (“Broadcast: to send a packet to all nodes in range”; “ID: identifier of the node”). The reference/mobile nodes that receive the blind node’s broadcast then “indicate their presence in response to [the] ID broadcast by the blind node.” [0035].

354. Upon receiving replies from the reference/mobile nodes, the blind node performs ranging with one or more reference/mobile nodes. [0038]. When the blind node receives “more replies than defined in its configuration” (e.g., more than three responses), the blind node will “select[]” a subset of responding nodes based on conventional “metrics like RSSI” (received signal strength indicator). [0038]-

[0039]; *see also* [0073] (“RSSI: Received signal strength indicator”). For example, 2D localization requires three responding nodes to perform trilateration, and thus the blind node need only select the three reference/mobile nodes with the highest RSSI levels (however, “more can be used for redundancy or accuracy purpose”). [0038], [0067].

355. After selecting the one or more reference/mobile nodes, the blind node performs two-way ranging with those node(s). [0041]. With two-way ranging, the blind node sends a data packet to a first-selected node and receives an acknowledgement packet back from it. [0041]. The blind node then calculates “the time required between the transmission of the first data packet and the reception of the acknowledgement packet.” [0041]. The blind node also takes into account the “processing delay” – which is “[t]he time to process the incoming data packet, generate the acknowledgement packet R1 (Ack packet), and prepare it for transmission.” This time is then used to “calculate the range (distance) between” the two nodes. [0041].

356. Gantner’s ranging is a **two**-way ranging technique because “a data packet (called a data or standard packet) and an acknowledge packet (Ack) are transmitted **between** the wireless stations.” [0004]. In Gantner’s exemplary technique, the selected node, like the blind node, sends a data packet to the blind node, receives an acknowledgement packet back, and calculates the distance

between the two nodes based on the corresponding transmission time. [0041]. The two nodes then share their two distance estimates, and “an average of the two can be used to achieve a fairly accurate distance measurement.” [0041].

357. Once distance is calculated for all selected nodes, the blind node “is able to define its location relative” to the selected nodes whose location is either “fixed and known” (reference nodes) or “changing but can be known at a certain time” (mobile nodes). [0054], [0069]-[0070]. For example, “[a] mobile node could be assisted with alternative technology [e.g., GPS] to find out its position at a given time.” [0057].

358. Gantner discloses that its technique “has several advantages.” [0013]. For example, it allows for two-way ranging “on demand,” *e.g.*, “based on an event at any point in time.” [0016]. It also results “in a simpler infrastructure” because pre-set “synchronization between the reference nodes” is unnecessary. [0015]. It likewise results in a more autonomous system because all processing needed to determine the blind node’s location is done “on board” that node. [0018]; *see also* [0014], [0017] (additional advantages: “All the information is gathered at the blind node (initiator); therefore it is possible to provide information to a user using an embedded display. It is also possible to attract user attention using an indicator like LED or buzzer if a distance to a reference or mobile node reached a triggered value or if the node is accessed.”).

### 3. The Carlson-Gantner and Ghaly-Heddebaut-Ganter Combinations

359. In my opinion, POSAs had reasons to implement (1) Carlson's system (which I discussed above in Ground 1, §VII.A) such that VMCS 10 used Gantner's two-way ranging technique (which I will refer to as the Carlson-Gantner combination), and (2) Ghaly-Heddebaut's system (which I discussed above in Ground 2, §VII.B) such that VOBC's UWB-transmitter/receiver used Gantner's two-way ranging technique (which I will refer to as the Ghaly-Heddebaut-Carlson combination).

360. **First**, as I discussed above (§VII.C.2), Gantner's two-way ranging technique permits a blind node to determine its location (e.g., Gantner, Abstract), and POSAs would have recognized that Gantner's technique would beneficially allow VMCS 10 or VOBC to determine their respective location when each lacked such information. For example, in Carlson's system, VMCS 10 generally will not know its location when the system is first initialized, when it loses its GPS signal in a tunnel, and/or when it loses access to its database of RFID locations that are also used to determine location, as I discussed above in §VII.A.8. Likewise, Ghaly-Heddebaut's VOBC may not know its location when the system is first initialized.

361. In these scenarios, Gantner's two-way ranging technique, in which the blind node (*i.e.*, Carlson's VMCS 10 or Ghaly-Heddebaut's VOBC) broadcasts its ID in a data packet and then selects from a subset of reference/mobile nodes (*i.e.*,

reporting stations and other VMCS modules in Carlson-Gantner; UWB-transmitters/receivers located on the track in Ghaly-Heddebaut-Ganter), would have permitted VMCS 10 and/or VOBC to determine its location thereby enhancing system safety. Implementing Gantner's two-way ranging technique in VMCS 10 and/or VOBC would also have been consistent with Gantner's teaching that the technique is useful as an "on demand" service that can be used "based on an event at any point in time," *e.g.*, points in time when VMCS 10 and/or VOBC lacked up-to-date location information. Gantner, [0016].

362. **Second**, apart from solving potential blind-node-type problems in Carlson's system, POSAs separately had reason to implement Gantner's teaching that an initiating node (*i.e.*, Carlson's VMCS 10 or Ghaly-Heddebaut's VOBC) performing two-way ranging with other nodes (*i.e.*, reporting stations and other VMCS modules in Carlson-Gantner; UWB-transmitters/receivers located on the track in Ghaly-Heddebaut-Ganter) need not perform two-way ranging with all nodes within range and can instead select a subset of such nodes based on, *e.g.*, signal strength. Gantner, [0038]. POSAs understood that, all other things equal, RSSI was inversely proportional to distance (*i.e.*, higher RSSI would generally be seen from closer devices). POSAs would have therefore recognized the benefit to Carlson's system and/or Ghaly-Heddebaut's system in using metrics like RSSI to select from among responding UWB radios, rather than simply perform ranging with all

responding units so that ranging is performed with the closest radios and not performed with radios who are significantly far away. Likewise, because positioning can be performed by ranging with as few as one or two devices (e.g., to determine distance to a particular node), selecting the one or two devices with the strongest signal-strength would have been a straight-forward way to pick with which minimally-necessary devices to range. Gantner also teaches selecting the number of nodes based on the desire for “redundancy or accuracy purpose[s].” Gantner, [0038].

363. **Third**, it would have been a simple substitution of one ranging technique (Carlson’s non-specified ranging technique and Heddebaut’s generic two-way ranging technique) for another (Gantner’s more-specific two-way ranging technique) to obtain the predictable result of Carlson’s VMCS 10 and/or Ghaly-Heddebaut’s VOBC performing ranging using Gantner’s two-way ranging technique. *See also* Gantner, [0002] (teaching that Gantner’s “invention is not limited to a SDS TWR method but also encompasses any other two way ranging method based on radio signals”).

364. In the Carlson-Gantner (§§VII.C.4, VII.C.5 below) and/or Ghaly-Heddebaut-Gantner (§§VII.C.4, VII.C.6 below) combinations, Carlson’s VMCS and/or Ghaly-Heddebaut’s VOBC would have used Gantner’s ranging technique to determine their respective speed, location, and relative distance to other UWB radios

in their respective systems, *i.e.*, reporting/signal stations and other VMCS modules in Carlson (*see, e.g.*, §VII.A.3.f.iv above), and UWB-transmitters/receivers on the tracks in Ghaly-Heddebaut (*see, e.g.*, §VII.B.4 above). All other aspects of Carlson’s system and Ghaly-Heddebaut’s system discussed in Grounds 1 and 2, respectively, would have remain unchanged.

365. POSAs would have reasonably expected success in the combination using their ordinary skill because Gantner, Carlson, and Heddebaut disclosed similar ranging techniques. Gantner, [0002] (“invention...encompasses ***any other two way ranging*** method based on radio signals”); Carlson, [0041] (“The present technology can use time of flight techniques...”); Heddebaut, 5:49-56 (two-way ranging); *see also* EX1013, [0020] (“The time-of-flight refers to an amount of time elapsed between the transmission of the outbound signal and the receipt of the inbound signal.”). Moreover, Gantner does not restrict its technique to a particular wireless technology (*see* Gantner, [0002] (technique only requires “radio [*i.e.*, wireless] signals”), and Carlson and Heddebaut both expressly discloses that their respective UWB-based communication signals could transmit the data used in Gantner’s technique, like an ID of the node desiring its location. Carlson, [0091] (VMCS and reporting stations can “send and receive information” via various wireless techniques), [0132] (“VMCS’s unique ID”); Heddebaut, Abstract (“signals transmitted...include[e] an identifier specific to the transmitter”)

366. Implementing Gantner’s technique in Carlson’s system and/or Ghaly-Heddebaut’s system would have required only ordinary programming skill to configure Carlson’s VMCS 10 and/or Ghaly-Heddebaut’s VOBC to transmit broadcasts and responses, as taught by Gantner. Gantner, [0068] (each node is simply an “element which is capable of transmitting and receiving”), claim 19 (“***Data processing software program comprising a program code*** which performs a method according to claim 1 when it is executed on a suitable data processing system.”).

**4. Claim 1 (Grounds 3 and 4)**

**a. [1PRE]-[1D]**

367. The Carlson-Gantner and Ghaly-Heddebaut-Ganter combinations each meet limitations [1PRE]-[1D] for the same reasons Carlson (§§VII.A.3.a-VII.A.3.e) and Ghaly-Heddebaut (§§VII.B.5.a-VII.B.5.e), respectively, meet these limitations for the reasons I discussed above.

**b. [1E]: “wherein obtaining the ranging measurements comprises:**

**i. [1E1]: “broadcasting ultra-wideband (UWB) based signals ...”**

368. As I discussed above (§VII.C.3), Carlson-Gantner’s VMCS 10 and Ghaly-Heddebaut-Gantner’s VOBC uses Gantner’s two-way ranging technique to obtain ranging measurements using UWB signals.

369. Using Gantner’s two-way ranging technique (*see* §VII.C.2 above), Carlson-Gantner’s VMCS and Ghaly-Heddebaut-Gantner’s VOBC would obtain ranging measurements by first “broadcasting its identification (ID) within a data packet to all the reference or mobile nodes [] in its range.” Gantner, [0032]; *see also* [0019], [0035], FIGS. 3-6, Claim 1 (“Two Way Ranging, TWR, between a blind node ... and to be determined and at least one reference or mobile node”), Claim 2 (“blind node initiates Two Ray Ranging by...broadcasting a data packet”).

370. In Carlson-Gantner, Gantner’s reference nodes receiving the broadcast signal are Carlson’s wayside reporting/signal stations (*see* §VII.A.3.d.i above) and Gantner’s mobile nodes are VMCS modules on other trains (*see* §VII.A.3.d.i above). Similar, in Ghaly-Heddebaut-Ganter the reference nodes receiving the broadcast signal are the UWB transmitters/receivers located along the tracks (*see* §VII.B.2-4, VII.B.5.d above) and the mobile nodes are UWB transmitters/receivers located on other intelligent trains (*see* §VII.B.2-4, VII.B.5.d above). *See also* Heddebaut, 2:8-10 (explaining its UWB system “enabled direct communication between vehicles”).

371. For at least these reasons, Carlson-Gantner and Ghaly-Heddebaut-Gantner each meet limitation [1E1].

**ii. [1E2]: “the UWB based signals comprising information identifying the train-mounted unit”**

372. As I discussed above, the UWB-based signals broadcast by VMCS 10 in Carlson-Gantner (*see* §VII.A.3.f.ii above) and by VOBC’s UWB-

transmitter/receiver in Ghaly-Heddebaut (see §VII.B.5.f.ii above) includes an “identification (ID)” (Gantner) or “identifier” (Heddebaut) that respectively identifies the transmitting VMCS or VOBC. Gantner, [0032], Claim 2 (“blind node ... broadcasting a data packet containing an Identifier ID”). This is consistent with Carlson’s teaching that UWB-signals can include a VMCS’s “unique ID.” Carlson, [0132]; Heddebaut, Abstract, 2:19-34 (“...each rail vehicle comprises second transmission-reception means of signals containing a specific identifier of the transmitter and at least one message...”), 3:7-12 (“...a specific identifier is determined for each of the first and second transmission-reception means...”), 4:23-38 (“Each fixed station 1, and hence each station, and each rail vehicle 4 may therefore be ascribed a single identifier...”). The identifier for each transmitting component is also a key aspect of Gantner’s two-way ranging because it requires that the reference/mobile nodes know to which blind node they are responding. Gantner, [0020] (reference/mobile nodes sends “packet back to the blind node”), [0041].

373. For at least these reasons, Carlson-Gantner and Ghaly-Heddebaut-Gantner each meet limitation [1E2].

**iii. [1E3]: “selecting based on received responses to the broadcast UWB based signals, one or more of the plurality of wayside units; and**

374. Carlson-Gantner’s VMCS 10 applies Gantner’s ranging technique to select one or more wayside reporting/signal stations based on their responses to the UWB-based broadcast signal, as claimed. Gantner, [0019], [0038]-[0039], [0045], claim 4 (“blind node selects at least one of these reference or mobile nodes for carrying out [two-way-ranging] procedures”). As Gantner taught ([0019], [0039]), selections would be based on conventional metrics, like the RSSI. For example, VMCS 10 would select only those responsive signals that exceeded a minimum RSSI level so as to exclude responses from distant reporting/signal stations and/or responses that would have been unnecessary for determining location/speed.

375. Similarly, Ghaly-Heddebaut-Gantner’s VOBC uses Gantner’s ranging technique to select one or more UWB-transmitters/receivers along the train track, i.e., wayside, as claimed. Gantner, [0019], [0038]-[0039], [0045], claim 4. As Gantner taught ([0019], [0039]), selections would be based on metrics, like the RSSI, so that, e.g., distant and/or unnecessary reporting/signal stations would be excluded.

376. For at least these reasons, Carlson-Gantner and Ghaly-Heddebaut-Gantner each meet limitation [1E3].

- iv. **[1E4]: “determining ranging information corresponding to each of the one or more wayside units, based on [UWB-signals] communicated respectively with each of the one or more of the plurality of wayside units.”**

377. As Gantner taught, “[a]fter the selection of reference or mobile nodes to be used for” ranging (Gantner, [0040]), Carlson-Gantner’s VMCS and/or Ghaly-Heddebaut-Gantner’s VOBC would have performed ranging with each of the one or more wayside reporting/signal stations selected above for limitation [1E3]. Gantner, [0040]-[0042] (“procedure is repeated between the blind node 10 and the remaining reference nodes”), FIG. 5, claim 5 (“blind node starts [two-way ranging] procedures with each of the selected reference or mobile nodes”). In Carlson-Gantner and Ghaly-Heddebaut-Gantner, ranging would have been based on UWB-based ranging signals communicated respectively with each of the selected reporting/signal stations (in Carlson-Ganter) or UWB-transmitters/receivers on the track (in Ghaly-Heddebaut-Gantner), as claimed. Gantner, [0041], claim 4 (“carrying out [two-way-ranging] procedures, respectively” with each node).

378. For at least these reasons, Carlson-Gantner and Ghaly-Heddebaut-Gantner each meet limitation [1E4]. Thus, for the reasons above, Carlson-Gantner and Ghaly-Heddebaut-Gantner would have rendered obvious claim 1.

**5. Claims 2-16 (Ground 3)**

379. Carlson-Gantner meets claims 2-16 for the same reasons Carlson discloses or renders obvious those claims, except all UWB-based ranging in the combination would have been obtained using the ranging procedures based on Gantner's teachings, as I discussed above for limitation [1E] (§VII.C.4.b).

**6. Claims 2-14 (Ground 4)**

380. Ghaly-Heddebaut-Gantner meets claims 2-14 for the same reasons Ghaly-Heddebaut renders those claims obvious, except all UWB-based ranging in the combination would have been obtained using the ranging procedures based on Gantner's discussed above for limitation [1E] (§VII.C.4.b).

## VIII. CONCLUSION

I declare that all statements made herein of my own knowledge are true, that all statements made on information and belief are believed to be true, and that these statements were made with the knowledge that willful false statements and the like are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

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

Dated: 01-09-2023

A handwritten signature in black ink, consisting of a stylized 'A' followed by a period and a horizontal line.

Aron Z. Kain, Ph.D.

## IX. CLAIM LISTING

The following claim listing assigns element labels (e.g., [1A1], [1A2], etc.) to certain claims for clarity.

|                                                                                                                                                                                                                                            |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Claim 1</b>                                                                                                                                                                                                                             |
| <b>[1PRE]</b> A system for providing decentralized control operations in a railway network, the system comprises:                                                                                                                          |
| <b>[1A]</b> a plurality of wayside units, each configured for placement on or near tracks in the railway network; and                                                                                                                      |
| <b>[1B]</b> one or more train-mounted units, each configured for deployment on a train operating in the railway network;                                                                                                                   |
| <b>[1C]</b> wherein each train-mounted unit is configured to:                                                                                                                                                                              |
| <b>[1C1]</b> communicate with any wayside unit or other train-mounted unit that comes within communication range of the train-mounted unit, wherein the communicating comprises use of ultra-wideband (UWB) based signals; and             |
| <b>[1C2]</b> generate based on the communication, control information configured for use in controlling one or more functions of the train in conjunction with operation in the railway network,                                           |
| <b>[1D]</b> wherein generating the control information comprises or is based on obtaining ranging measurements, and                                                                                                                        |
| <b>[1E]</b> wherein obtaining the ranging measurements comprises:                                                                                                                                                                          |
| <b>[1E1]</b> broadcasting ultra-wideband (UWB) based signals within a wireless range of the train-mounted unit,                                                                                                                            |
| <b>[1E2]</b> the UWB based signals comprising information identifying the train-mounted unit;                                                                                                                                              |
| <b>[1E3]</b> selecting based on received responses to the broadcast UWB based signals, one or more of the plurality of wayside units; and                                                                                                  |
| <b>[1E4]</b> determining ranging information corresponding to each of the one or more wayside units, based on ultra-wideband (UWB) based signals communicated respectively with each of the one or more of the plurality of wayside units. |

|                                                                                                                                                                                                                                                     |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Claim 2</b>                                                                                                                                                                                                                                      |
| The system of claim 1, wherein the train-mounted unit is configured to generate at least part of the control information based on sources other than processing of the ultra-wideband (UWB) based signals.                                          |
| <b>Claim 3</b>                                                                                                                                                                                                                                      |
| <b>[3A]</b> The system of claim 2, wherein the train-mounted unit is configured to: assess based on the processing of the ultra-wideband (UWB) based signals, one or more conditions relating to operation of the train within the railway network; |
| <b>[3B]</b> when at least one condition meets one or more particular criteria, determine one or more responsive actions;                                                                                                                            |
| <b>[3C]</b> and perform or cause performing each of the one or more responsive actions.                                                                                                                                                             |
| <b>Claim 4</b>                                                                                                                                                                                                                                      |
| The system of claim 3, wherein, when the one or more responsive actions comprise providing indication or feedback, relating to the at least one condition, to a train operator,                                                                     |
| <b>[4B]</b> the train-mounted unit is configured to: monitor actions of the train operator;                                                                                                                                                         |
| <b>[4C]</b> assess based on the monitoring, the train operator's compliance with at least one expected subsequent responsive action; and                                                                                                            |
| <b>[4D]</b> when the train operator fails to do so, directly perform the at least one expected subsequent responsive action or perform an alternative action.                                                                                       |
| <b>Claim 5</b>                                                                                                                                                                                                                                      |
| The system of claim 1, wherein the train-mounted unit is configured for utilizing non-UWB based signals for communicating at least some data with the wayside unit and/or another train-mounted unit.                                               |
| <b>Claim 6</b>                                                                                                                                                                                                                                      |
| The system of claim 1, wherein the train-mounted unit is configured for handling radio-frequency identification (RFID) based signals with RFID devices used within the railway network.                                                             |
| <b>Claim 7</b>                                                                                                                                                                                                                                      |
| The system of claim 1, wherein the train-mounted unit is configured for handling satellite based signals.                                                                                                                                           |

|                                                                                                                                                                                                                                                                                                                                                                       |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Claim 8</b>                                                                                                                                                                                                                                                                                                                                                        |
| The system of claim 7, wherein the train-mounted unit is configured for obtaining from received satellite based signals information, and generating or adjusting the control information based on the obtained information.                                                                                                                                           |
| <b>Claim 9</b>                                                                                                                                                                                                                                                                                                                                                        |
| The system of claim 1, wherein the train-mounted unit is configured for connecting to and/or interfacing with other systems of the train.                                                                                                                                                                                                                             |
| <b>Claim 10</b>                                                                                                                                                                                                                                                                                                                                                       |
| The system of claim 1, comprising 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.                                                                                                                                                                              |
| <b>Claim 11</b>                                                                                                                                                                                                                                                                                                                                                       |
| The system of claim 1, comprising a power component for supplying and/or obtaining power for components of the train-mounted unit.                                                                                                                                                                                                                                    |
| <b>Claim 12</b>                                                                                                                                                                                                                                                                                                                                                       |
| The system of claim 1, wherein the train-mounted unit is configured for communicating, directly or via at least one of the wayside unit and another train-mounted unit, with one or more other components or devices in the railway network, the one or more other components or devices in the railway network not being part of decentralized train control system. |
| <b>Claim 13</b>                                                                                                                                                                                                                                                                                                                                                       |
| The system of claim 1, wherein the train-mounted unit is configured to substantially continually determine absolute position of the train, based on the ranging information obtained from ranging with wayside units.                                                                                                                                                 |
| <b>Claim 14</b>                                                                                                                                                                                                                                                                                                                                                       |
| The system of claim 13, wherein the train-mounted unit is configured to determine the absolute position of the train based on the ranging information and positioning information obtained without ranging to wayside units.                                                                                                                                          |

**Claim 15**

The system of claim 14, wherein the train-mounted unit is configured to obtain at least portion of the positioning information from each wayside unit as the train passes the wayside unit.

**Claim 16**

The system of claim 15, wherein the train-mounted unit is configured to obtain at least portion of the positioning information from at least one wayside unit as the train passes that wayside unit using non-UWB communications.