

(19)



Europäisches Patentamt
European Patent Office
Office européen des brevets



(11)

EP 1 642 800 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
05.04.2006 Bulletin 2006/14

(51) Int Cl.:
B61L 25/02 (2006.01)

(21) Application number: **04447215.7**

(22) Date of filing: **29.09.2004**

(84) Designated Contracting States:
**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR
HU IE IT LI LU MC NL PL PT RO SE SI SK TR**
Designated Extension States:
AL HR LT LV MK

(72) Inventors:
• **Rousseau, Michel**
4800 Verviers (BE)
• **Starck, Antonin**
1380 Lasne (BE)

(71) Applicant: **ALSTOM BELGIUM S.A.**
6001 Charleroi (BE)

(74) Representative: **Blot, Philippe Robert Emile et al**
Cabinet Lavoix
2, place d'Estienne d'Orves
75441 Paris Cedex 09 (FR)

(54) Method and system for determining the position of an object moving along a course

(57) The present invention is related to a method for determining the location and/or the positioning of an object, in particular a vehicle such as a train, moving along a known course, comprising the following steps :

- determining an absolute position of the object with a first confidence interval,

- determining a relative position of the object with a second confidence interval,
- selecting the smaller confidence interval among the first and the second confidence interval,
- determining said location and/or positioning of the object by means of the position corresponding to said smaller confidence interval.

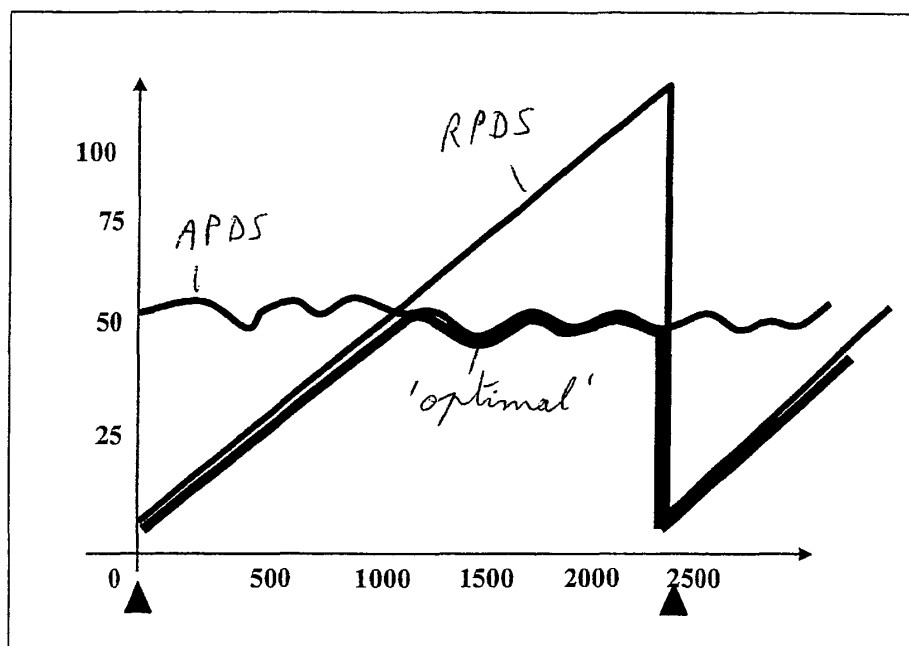


Fig. 2

EP 1 642 800 A1

Description

Field of the invention

[0001] The present invention relates to a method for securely determining the position of an object moving along a course which is known by the location device.

[0002] The term "course" is intended to mean a subset of the space delimited by a tubular surface of arbitrary and variable cross section, in which the vehicle is strictly constrained to move. In the event that the cross section of this tube can be neglected, this gives two equations linking longitude, latitude and altitude of the moving object.

[0003] The present invention relates more precisely to a method for determining the location of a train moving on a railway track of which the exact path is known.

[0004] The present invention relates to a method for determining the location and/or the positioning of a vehicle in terms of railway transport security. It involves being able to determine in a quasi-instantaneously way and with a given probability the location of a vehicle moving on a known course, or more precisely the zones of non-presence of said vehicle on a section.

State of the art

[0005] In railway signalling, a train is not allowed to enter a specific section of track until it is certain that the train in front has departed therefrom, i.e. the track section in question is free. To that end, it is necessary to ascertain with a predetermined, extremely small margin of error (for example with a maximum error level in the order of 10^{-9} and preferably in the order of 10^{-12}) the zones in which non-presence of a train can be relied upon, and to do so at each iteration of the calculation.

[0006] It is known to determine the precise location of a vehicle, and in particular of a train, with trackside detection devices (track circuits, axle counters, ...) for train detection purposes.

[0007] It is also known to use train borne train position determination systems for fail safe train control purposes. These train position determination systems are based on train borne sensors (wheel sensors, radars,...) which give the relative position of the train with reference to trackside location materialised by trackside installed beacons (or equivalent devices). These trackside reference points are required because of the nature of the applied sensors, in order to allow resetting the error accumulated by the train location system over time (radars) and/or distance (wheel sensors).

[0008] Those solutions have important impact on the life cycle cost of a train control/command system :

- Trackside detection systems have important acquisition, installation and maintenance cost, due to the quantity of equipment to be installed and their connection by cable to an interlocking system.

- Existing train borne solutions, based on wheel sensors and/or radar sensors also have important acquisition, installation and maintenance costs, mainly due to their location as they are mounted below the locomotive.

[0009] The position of a vehicle can be determined using a satellite communication system by means of a GNSS (Global Navigation Satellite System) like GPS, GLONASS, and the future Galileo system. WO 02/03094 discloses a method for secure determination of an object location, preferably a vehicle moving along a known course. This method takes advantage of the deterministic trajectory of the train to reach an optimal compromise between safety, availability and accuracy. However, this system cannot provide a higher accuracy where needed, e.g. near stations or crossings.

[0010] EP-B-0825418 discloses the use of several sensors to determine the position of a train. Data relating to position and error interval from several sensors, comprising beacons and GPS, is used to determine the position of the train. However, this system implies a calculation involving several operations including integration. It is therefore considered as complex.

Aims of the invention

[0011] It is therefore an aim of the present invention to provide a method and a device which permits secure location and/or positioning of an object, and thus a fortiori of a vehicle such as a train, moving on a known course.

[0012] The term secure location is intended to mean the location, or more exactly the non-presence of a train outside a zone which is redefined at each calculation, with a error level of less than 10^{-9} and preferably capable of reaching 10^{-12} .

[0013] Another aim of the invention is to improve the localisation accuracy of a train, and to improve the throughput performance of a course such as a railway line.

[0014] Others aims of the invention are to improve the life cycle cost of a train/command system, to reduce the amount of equipments installed below the locomotive, to reduce the amount of equipments installed along the tracks.

Summary of the invention

[0015] The present invention relates to a method for determining the location and/or the positioning of an object, in particular a vehicle such as a train, moving along a known course, and this securely in terms of railway transport. The method comprises the steps of

- determining an absolute position of the object with a first confidence interval,
- determining a relative position of the object with a second confidence interval,

- selecting the smaller confidence interval among the first and second confidence interval,
- determining the location and/or positioning of the object by means of the position corresponding to said smaller confidence interval.

[0016] Preferably said absolute position is determined by a railway-safe positioning method involving a digital mapping of the possible trajectories, and at least one satellite communication receiver, e.g. a GNSS receiver or an equivalent device.

[0017] In a preferred embodiment, said relative position is calculated by detecting the presence of a beacon, and by integrating the speed of the object, with reference to the location of said beacon.

[0018] Preferably, said speed is calculated via the GNSS Doppler signal.

[0019] In a typical embodiment the first confidence interval for the absolute position is in the order of 50 m.

[0020] In another object the present invention is also related to a location device implementing the method as previously described.

Short description of the drawings

[0021] Fig. 1 represents trains using the invention.

[0022] Fig. 2 represents a graph showing the principles of the invention.

Detailed description of the invention

[0023] The present invention will be described with reference to a train moving on a track, but it must be understood that it can be generalised within the terms of the claims.

[0024] Fig. 1 shows a train moving on a track. The track is subdivided in sections, and when the train leaves a section, another train can be allowed to enter this section. Therefore the position of the train needs to be determined.

[0025] This position is determined, in terms of railway safety, with absolute error length, called confidence interval. This means that the train is in the confidence interval with a probability of error of less than 10^{-9} and preferably of less than 10^{-12} . The smaller the confidence interval, the sooner the section can be used by another train. The line/track throughput is therefore improved.

[0026] The train is equipped with an absolute position determining system (APDS). The APDS comprises means to access a digital mapping of the possible trajectories, and at least one GNSS receiver or equivalent device. The APDS allows to determine the position of the train, with a confidence interval of around 50 m. This can be achieved by applying the method described in WO 02/03094.

[0027] The train is also equipped with a relative position determining system (RPDS). The RPDS comprises means for detecting the presence of a beacon along the

track. When a beacon is detected, the RPDS knows that the position of the train corresponds to the position of the beacon, with a confidence interval of for example around 5 m. The position of the beacon can be sent by the beacon itself, or stored in a database accessible from the train. The RPDS also comprises means to measure the speed of the train. Those means can be for instance the GNSS equipment of the APDS, allowing a speed determination by the GNSS Doppler signal.

[0028] The relative position is calculated by the RPDS by integrating the speed of the train, with reference to the position of the beacon. The confidence interval, which is very small when a beacon has just been passed, increases with the movement of the train because of the accumulation of errors.

[0029] The APDS and the RPDS are part of a train borne location system. The train borne location system determines the position of the train according to the method of the invention.

[0030] The principle of the invention is shown Fig. 2. The confidence interval of the position a train moving on a track is shown with respect to the distance ran by the train. A first curve ('APDS') shows the confidence interval of the APDS. The confidence interval is in this example about 50 meter. A second curve ('RPDS') shows the confidence interval of the RPDS. When a first beacon is passed, the confidence interval is of for example from 1 to 5 m. When the train moves further on, the confidence interval increases, due to the accumulation of errors, until another beacon is met.

[0031] The method of the invention consists in determining the position of the train according to the following principle : each time a beacon is met by the train, the train borne location system operates in an beacon augmented mode, using the RPDS : the beacon position is used as a reference and the actual train position is computed with reference to this beacon, by integrating the actual speed of the train. When the accuracy provided in this way falls under the accuracy provided by the APDS, or, in other words, when the confidence interval provided by RPDS exceeds the confidence interval one can achieve with APDS, the train borne location system stops using the beacon augmented mode information and switches to the use of the APDS. It then keeps operating in APDS mode until a next beacon is met.

[0032] As a result, the position of the train is determined with a confidence interval shown by the 'optimal' curve in Fig. 2.

[0033] The present invention allows to determine the position of a train with a high accuracy by placing beacons where needed, for example near stations or crossings of tracks, and with a good accuracy and without the need of beacons, where such a higher accuracy is not needed.

Claims

1. Method for determining the position of an object, in

particular a vehicle such as a train, moving along a known course, **characterised by** the following steps

- determining an absolute position of said object with a first confidence interval,
- determining a relative position of said object with a second confidence interval,
- selecting the smaller confidence interval among said first and said second confidence interval,
- determining said location and/or positioning of said object by means of the position corresponding to said smaller confidence interval.

and/or positioning of said object is determined according to the method of any of the claims 1 to 6.

2. Method according to claim 1, **characterised in that** said absolute position is determined by a railway-safe positioning method involving a digital mapping of the possible trajectories, and at least one satellite communication receiver.
3. Method according to claim 2, wherein said satellite communication receiver is a GNSS receiver.
4. Method according to claim 1, 2 or 3, **characterised in that** said relative position is calculated by detecting the presence of a beacon, and by integrating the speed of said object, with reference to the location of said beacon.
5. Method according to claim 4, **characterised in that** said speed is calculated via the GNSS Doppler signal.
6. Method according to any of the preceding claims, **characterised in that** said confidence intervals determine the position of said object with an error probability in the order of 10^{-9} , preferably 10^{-12} .
7. Method according to any of the preceding claims, **characterised in that** said first confidence interval for said absolute position is in the order of 50 m.
8. Location device for determining the position of an object, in particular a vehicle such as a train, moving along a known course, **characterised in that** it comprises an absolute position determining system yielding a first confidence interval and comprising means to access a digital mapping of possible trajectories, and at least one satellite communication receiver, and a relative position determining system yielding a second confidence interval and comprising means to detect the presence of beacons placed along said course.
9. Location device according to claim 8, **characterised in that** it further comprises means for selecting the smaller confidence interval among said first and said second confidence interval and wherein the location

10. Location device according to claim 8 or 9, wherein said satellite communication receiver is a GNSS receiver.

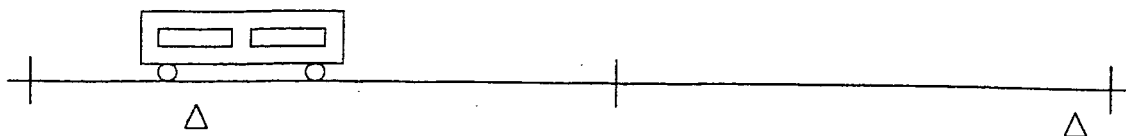


Fig. 1

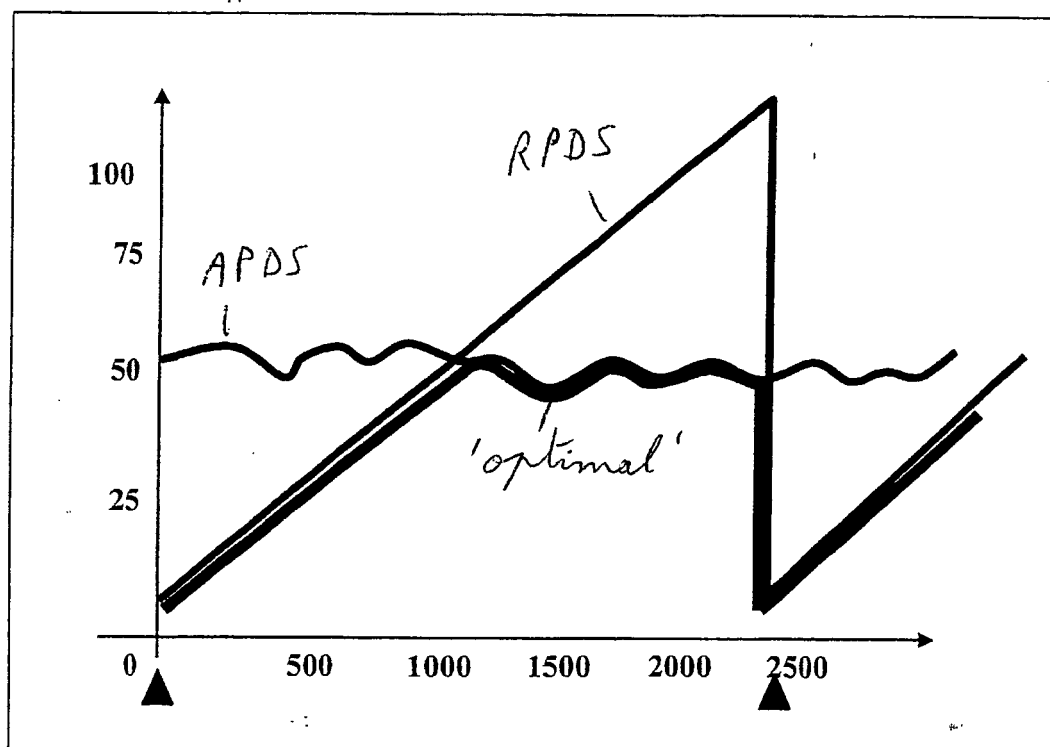


Fig. 2



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 04 44 7215

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	EP 0 881 136 A (SIEMENS AG) 2 December 1998 (1998-12-02)	1,4,5	B61L25/02
Y	* the whole document *	2,3,6-10	
Y	----- US 5 893 043 A (MOEHLENBRINK WOLFGANG ET AL) 6 April 1999 (1999-04-06) * column 2, line 50 - column 6, line 45; figure 2 *	2,3,6-10	
A	----- KIRICZI ET AL: "Signaltechnisch sichere Fehlergrenzen für die Erfassung der Bewegungszustände von Bahnen" FORTSCHRITT-BERICHTE VDI: REIHE 8, MESS-, STEUERUNGS- UND REGELUNGSTECHNIK, VDI VERLAG, DUESSELDORF, DE, 1996, pages 121-155, XP002264504 ISSN: 0178-9546 * page 141 - page 155 *	1,8	
			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
			B61L
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 21 January 2005	Examiner Janhsen, A
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

2

EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 04 44 7215

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

21-01-2005

Patent document cited in search report		Publication date		Patent family member(s)	Publication date
EP 0881136	A	02-12-1998	DE	19722899 A1	03-12-1998
			AT	230360 T	15-01-2003
			DE	59806784 D1	06-02-2003
			EP	0881136 A2	02-12-1998
			ES	2189999 T3	16-07-2003

US 5893043	A	06-04-1999	DE	19532104 C1	16-01-1997
			EP	0761522 A1	12-03-1997
			PL	315857 A1	03-03-1997
