(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 992 056 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
04.05.2022 Bulletin 2022/18

(21) Application number: **21204920.9**

(22) Date of filing: **27.10.2021**

(51) International Patent Classification (IPC):
B61L 15/00 *(2006.01)* ***B61L 25/02*** *(2006.01)*
B61L 25/06 *(2006.01)* ***B61L 25/08*** *(2006.01)*
B61L 27/40 *(2022.01)*

(52) Cooperative Patent Classification (CPC):
B61L 15/009; B61L 15/0072; B61L 25/025; B61L 25/026; B61L 25/06; B61L 25/08; B61L 27/40

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(30) Priority: **30.10.2020 IT 202000025936**

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(54) **A COMPUTER IMPLEMENTED METHOD TO PRODUCE A MAP OF A RAILWAY LINE AND RELATED COMPUTER PROGRAM**

(57) This disclosure relates to a computer implemented method to produce an output file representing a map of a railway line which connects a signaling device or infrastructure device of departure to a signaling device or infrastructure device of arrival of the railway line. This method makes use of a database of a railway network comprising a respective record of a database for each registered signaling device and/or structure device on the railway network.

According to one aspect, such a database may be realised by processing at least one CAD, or Excel or text file, containing at least position and elevation information of the signaling devices and infrastructure devices of the railway network, to identify at least one signaling device or at least one infrastructure device described therein and the respective position and elevation information, then filling in at least one respective record of a database for each registered signaling device or infrastructure device, the record containing at least a name field containing a name of the registered device, a position field containing respective GPS position information, and an elevation field containing respective elevation information.

The methods of this disclosure may be implemented via software executed by computer.

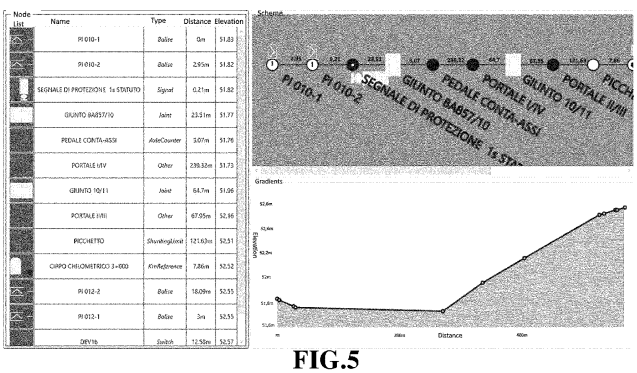

FIG.5

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Description

TECHNICAL FIELD

[0001] The present disclosure relates in general to computer implemented methods and more particularly to a method to produce an output file representing a map of a railway route which connects a departure device to an arrival device.

BACKGROUND

[0002] Railway signaling is the set of devices that serve for a correct and safe railway traffic. Over the years, increasingly accurate and safe traffic management and control systems have been developed, so that the systems can almost prevent human error.

[0003] The most widely used in Italy is the SCMT (Train Speed Control System), which uses different elements located along the railway infrastructure that allow the system, for example, to assess whether the speed of the trainset is adequate for the line it will have to face, otherwise it will implement automatic corrective manoeuvres, up to the complete stop of the train in case of excessive values exceeding the threshold. The achievement of these objectives was possible thanks to transponders (Balises) placed along the tracks, which allow the railway's technology premises to transmit to the train the details of what is ahead along the line, enabling the on-board computer to process these data and define the safety thresholds for traffic.

[0004] However, a new model for managing and controlling rail traffic, known as ERTMS (European Rail Traffic Management System), has been introduced on high-speed lines. The workflow depends very much on how the survey data are reported and the technologies used to perform it, but broadly speaking it can be schematised as follows:

1) Survey;
2) Measurement analysis;
3) Project.

[0005] A fundamental phase in the execution of any project is that of surveying the devices present along the railway lines of a railway network. These devices can ideally be divided into:

- signaling devices;
- infrastructure devices.

Signaling devices

[0006] The set of signaling devices encloses all the information and logical functions linked to the signaling systems, which are fundamental for the safety functions of rail traffic. At least the following devices belong to this set:

- *Joints:* The joints are the elements that physically separate the steel tracks, they serve to create an electrical separation of the track circuits, that is the track sections that serve to transmit information such as the occupation of the train (the physical presence).
- *Axle counter pedals:* The axle counter pedals are devices that detect the passage of the train, counting the number of axles in a trainset either positively or negatively. They are used to understand when a train transits within a certain section of the line, also assessing its integrity.
- *Information points:* The information points are pairs of balises which allow the transmission of the telegrams to the system passing over them, they can be of two types: fixed, i.e. they do not vary the telegram, or switched, whose telegram is decided by the upstream technological system according to need.
- *Signals:* The signals are the most important means of visual communication towards the driver, they can have different light compositions, while maintaining the rigour of the three colours: red, yellow and green. They warn the driver how he should proceed in the next section of the trail.
- *HS signs:* This is a type of non-illuminated signage used in high-speed trains that allows the driver to be warned about operations that are not common on normal lines.
- *Limit-of-shunt signals:* The limit signal is a particular device that is placed at a specific distance (usually 100m) from the protection signals at the entrance to a station to delimit the "safe" area, that is the maximum area that can be occupied by trainsets inside it.
- *Speed signs:* These signs define the speed limits for each category of trainset (up to 4), the driver must respect them and update the speed at each new sign encountered.

Infrastructure devices

[0007] The set of infrastructure elements gathers all the elements relating to the railway infrastructure and some main elements of the stations, useful for the analysis of the passenger flow. At least the following devices belong to this set:

- *Switches:* These are the railway switches, i.e. devices which, through the movement of moving parts, put two tracks in communication, allowing the train to pass from one to the other.
- *Fouling point indicators:* The fouling point indicators are objects placed between two sections of track that join in a switch, they serve to delimit the maximum stopping distance within which a collision between two trains is avoided.
- *Dead-end tracks:* The dead-end tracks are considered to be the end parts of a track, usually ending in buffers and beyond which the train can no longer

advance.

- *Gradient changes:* A gradient is a railway stretch that does not have a variation in the slope, it is usually expressed in metres per kilometre (‰), the gradient change is the point at which this variation occurs, the prediction of which is fundamental in railway design as it affects the braking performance of a trainset based on its mass.
- *Kilometre milestones:* This is a type of signage to indicate the kilometre at which one is.
- *Acoustic signaling areas:* These are the zones where, for security reasons, there are audible messages and warnings.
- *Exit points:* These are the zones intended, at safety level, as points of escape for travelers from a line or tunnel.
- *Level crossings:* Level crossings are road transit zones on railway site and are protected on both sides by light signals and stop bars.
- *Bridges:* Railway bridges can generally be of three types: of iron, masonry or reinforced concrete, each with its strengths and weaknesses.
- *Traveler Buildings:* The traveler building is the entire part of the wall used by people to access the station, the most important in the design is the axis of the building, which is an imaginary line that divides the building and the tracks in front in two.
- *Platforms:* The platform is the walkable part along the track for travelers, and is accessed through the traveler building or from the street by means of ramps or underpasses.
- *Tunnels:* The railway tunnels, as well as the road counterpart, is a section of line that passes through an underground tunnel.

The survey and its methods

[0008] The survey is a fundamental phase in the railway engineering process, in fact it allows to have all the input information about the existing infrastructure.

[0009] There are several technologies and methods used for the execution, the combination of which defines the output format, the precision achieved and the speed of execution.

[0010] The most direct one for having a measurement plan among the devices that make up the infrastructure is the metric wheel, i.e. an instrument that, operated by an operator, allows, by walking, to easily measure the distance between two objects, being a method rather subject to systematic errors, it is good practice to perform several samplings in order to reduce the error. This method is quite straightforward, as there is no need for post-processings, but it does not allow the accuracies that may be needed by the requirements of some signaling systems to be achieved.

[0011] Another commonly used method is measuring by GPS-based instrumentation, i.e. an instrument that, when placed on an object, can define its position in a known reference system through triangulation between satellites and known fixed points within the territory. This system is very accurate but requires further processing on the beaten points and has the major disadvantage that it cannot be used indoors (buildings, tunnels, etc.).

[0012] In order to solve the problem of indoor surveys, it is possible to use the total station, i.e. an instrument which, unlike traditional theodolites, is able to calculate, in a computerised manner, the distances between the points taken and the points beaten, including differences in elevation measurements (an element on which the survey by GPS is not very precise).

[0013] Finally, there is the laser-based survey, which allows a very precise and rapid survey of an entire environment to be carried out, the latest systems have also introduced the automatic reconstruction of the survey so that the procedural step in which the user had to find homologous points between the various taken points in order to reconnect the individual scans into one large reconstruction of the scene can be eliminated. It has the advantage that it can be used in any light condition, but as a result of the excess of scanned material, it requires a lot of post-processing work in order to remove all unnecessary content.

Measurement analysis and exchange formats

[0014] Once the survey data have been obtained, the next step includes processing and analysing the latter in order to have an input format that is as essential and useful as possible for the actual design.

[0015] From this it can be seen that both the format of interchange between the survey and analysis phase and the one between the analysis and design phase play a fundamental role in the fluidity of the whole process. A form of optimisation of this result would be achievable by exploiting a coded and rigid format allowing each party to already know what to expect so as not to have to heavily modify their procedures.

Design phase

[0016] Once the measurement tables are ready to be used to research and obtain the distances between the railway devices along the infrastructure, the design process can begin. The engineering team will carry out the modifications requested by the client based on the signaling rules and regulations; therefore, for the current railway network to be updated, new devices will be inserted along the line at regulated distances, for which purpose measurement tables will be used to understand at which precise geographical point these new devices will be placed.

[0017] As already mentioned before, during the design phase, it is essential to have the possibility of being able to take measurements on the infrastructure on which the works are carried out. This is because for signaling purposes, the communication between technological

premises and the system takes place through the exchange of telegrams, i.e. coded computer packets, in which information on distances between the train and the devices along the line ahead of it can be found. The design, and the measurements as a result, must be certified in order to have a very small measurement error (a few cm per kilometre) precisely because the train must be sure of what type of line it is facing for railway safety purposes. These distances are often referred to as the "meeting" distance or target distance, and are loaded into the on-board computer to start a "metric" countdown, within which the train must find the device that has been defined in the telegram, if this does not happen, both because of infrastructure tampering (device removal/displacement) and because of some problem on board (odometer failure, failure of the communication system with the "ground"), the train will automatically intervene on the cruise status, acting on the brakes until it comes to a complete stop.

[0018] The advent of ERTMS has brought a technological advancement to railway signaling, introducing the possibility of allowing trains to run at a higher density on a railway line while maintaining, if not increasing, the levels of safety on traffic.

[0019] However, this has also led to an increase in the level of requirements in the design phase, it was no longer enough to have a picture of the line but the need to calculate and manage numerous new parameters such as elevation or the conversion of distances into progressive railway kilometres was also introduced (i.e. the incremental unit of measurement with which devices along the tracks are traced). This necessity meant that data management and manipulation slowed down due to the technologies with which they were produced.

[0020] The traditional workflow illustrated above has been improved and some ways of approaching the phases have been developed by inserting additional processings in order to standardise the data coming from the survey to then facilitate the use of the search techniques on the distance tables, according to the following scheme:

1) Survey;
2) Planimetry;
3) Measurement analysis;
4) Project.

[0021] The survey data are processed to generate a CAD planimetry in order to have a complete visual picture of the line on which the works are to be carried out. The choice to use a CAD format means that it is possible to conveniently take advantage of the integrated tools to perform calculations and measurements on the distances.

[0022] In summary, the following management formats are used:

- Survey - once the data obtained from the survey campaign have been processed, they are transcribed in some possible formats, all of which referring to the device - relative coordinates coupling:
    - o Text
    - o Excel
    - o CAD (planimetry)
- Measurements - the measurements obtained from the survey can be manually transposed as a distance between individual devices on a planimetry or through the use of tools that manage one of the survey output formats in a more or less automated manner;
- Project - the project files are generally in CAD format, but recently a new software has been introduced for ERTMS design which, being disconnected from the CAD format, requires a manual drawing, unless the data are previously processed and coded.

[0023] Although the workflow is very linear and helpful to the designer, unfortunately the weakness of the process is immediately perceivable due to the strong link between the survey and the need of having reproduce it in the form of a planimetric drawing. Consequently, further processings and/or revisions of a project should necessarily require the generation from scratch of planimetries from subsequent surveys.

[0024] The need is therefore felt to easily produce maps of railway lines of a railway network with all the devices appearing along them.

SUMMARY

[0025] It has been devised, and is an object of the present disclosure, a computer implemented method to produce an output file representing a map of a railway line which connects a signaling device or infrastructure device of departure to a signaling device or infrastructure device of arrival of a railway line. This method, defined in the appended claim 1, uses a database of a railway network comprising a respective record of a database for each registered signaling and/or structure device of the railway network, the record containing at least:

- a name field containing a name of the registered device,
- a position field containing respective position information, preferably of GPS type,
- optionally, an elevation field containing respective elevation information,
- at least one given identifier of a first record, relating to a first signaling device or infrastructure device of the railway network which follows the registered signaling device or infrastructure device in the direction of travel of a railway line of said railway network, and of a second record relating to a second signaling device or infrastructure device of the railway network

which precedes the registered signaling device or infrastructure device in the direction of travel of the railway line.

[0026] According to one aspect, each record comprises:

- a first pointer to the first record relating to the first signaling device or infrastructure device,
- a second pointer to the second record relating to the second signaling device or infrastructure device.

[0027] According to one aspect, such a database may be realised by processing at least one CAD, or Excel or text file, containing at least position and elevation information of the signaling devices and infrastructure devices of the railway network, to identify at least one signaling device or at least one infrastructure device described therein and the respective position and elevation information, then filling in at least one respective record of a database for each registered signaling device or infrastructure device, the record containing at least a name field containing a name of the registered device, a position field containing respective GPS position information, and an elevation field containing respective elevation information.

[0028] The methods of the present disclosure may be implemented via software executed by computer.

[0029] Each output file representing a map of a railway line may be printed in graphic or text form on a sheet of paper or other printable medium in order to produce a paper map of the desired railway line. Alternatively or additionally, the output file may be displayed on a screen in graphical or text form, e.g. on a PC display or on a tablet, in order to produce a map of the railway line in paperless mode.

[0030] Further embodiments are defined in the dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0031]

Figure 1 shows schematically how a database of the registered devices is realised from the physical surveys on the railway network.

Figure 2 shows a flow chart illustrating how a database is created.

Figure 3 shows the functional sections of the dedicated software according to this disclosure.

Figure 4 shows some records of a database of registered devices along a railway network.

Figure 5 shows an example of output file displayed on the screen obtained according to the method of the present disclosure.

Figure 6 shows an example of XML code that can be used to define all the information required for the operation and description of an itinerary.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0032] In order to solve at least part of the problem faced, a database is created containing all the survey data, keeping them updated and allowing a quick and targeted use for design purpose.

[0033] The use of this database fits directly between the survey and the design phase, replacing the current methods of data and measurement management, through a complete user interface platform and various design aid tools. Whereas previously each step was somewhat unrelated to the subsequent one, thanks to the database of the devices identified during the survey it is easier to adapt to the - sometimes unpredictable - developments of the project. Even if a new survey campaign were required, this should not produce an output from scratch, forcing the design to make heavy changes, but it will allow the assessment of the changes made by fitting the new data to the existing model.

[0034] The workflow is modified by inserting an automatic transcoding phase of the data that will be made viewable in the platform, thus disconnecting the process from any use of CAD software, as schematically shown in figure 1.

[0035] The process referred to as "transcoding" in figure 1 is substantially a computer implemented method to create a record database, each containing position and elevation information of signaling devices and infrastructure devices of a railway network.

[0036] A more detailed flow chart explaining how the database is created is shown in figure 2. Once a signaling device or infrastructure device of the railway network and the respective geographic position information and, optionally, elevation information of the device have been identified, a respective record is filled in for each identified signaling device or infrastructure device, wherein the record contains at least a name field containing a name of the identified device, a position field containing respective GPS position information of the identified device, and optionally an elevation field containing the respective elevation information of the identified device.

[0037] According to one aspect, for each registered signaling device or infrastructure device in the previous step, the following operations are carried out:

- a railway line of the railway network passing through the registered signaling device or infrastructure device surveyed is identified;
- a first signaling device or infrastructure device which follows the registered signaling device or infrastructure device along a direction of travel of the railway line is identified;
- a second signaling device or infrastructure device which precedes the registered signaling device or infrastructure device along the direction of travel of the same railway line is identified;
- at least one identifier datum of the respective record of the first signaling device or infrastructure device

and of the respective record of the second signaling device or infrastructure device is added to the record being filled in.

[0038] According to one aspect, the identifier datum is a progressive number that identifies a position of the database record in the ordered succession between the departure record and the arrival record.

[0039] According to one aspect, a first pointer is added to the respective record of the first signaling device or infrastructure device, and a second pointer is added to the respective record of the second signaling device or infrastructure device.

[0040] The database to be created and which will be saved on a storage medium so that it can be consulted and updated, will contain records that will identify the registered signaling or infrastructure devices with all the properties that characterise them, and it will also identify the records of the nearest device which precedes or follows along the direction of travel of a railway line passing through them.

[0041] In the case of new partial surveys or the need to update existing surveys, only an integrative transcoding phase is carried out on the encoded data already present. The designer can in fact compare the old data with the new ones and update the project accordingly, or choose to export the concerned part in the possible formats.

[0042] It is important to bear in mind that bridges, traveler buildings, platforms and tunnels are devices that are detected through several measurements, precisely defining the start and end on the length of the track, while all the other devices listed are detected through a punctual measurement. This is because the view from the train side is even more important than designing from a "global" view of the system/track, i.e. having a distinct succession order of devices that the train will encounter as it proceeds along its itinerary.

[0043] A database of a railway network structured as follows is therefore available, in which each record of the database comprises at least, as shown in figure 4:

- a name field containing a name of the registered device,
- a position field containing respective geographical position information, e.g. of GPS type,
- optionally, an elevation field containing respective elevation information.

[0044] Furthermore, each record in the database has at least one given identifier of a first record, relating to a first signaling device or infrastructure device which follows the registered signaling device or infrastructure device along the direction of travel of a railway line, and of a second record relating to a second signaling device or infrastructure device which precedes the registered signaling device or infrastructure device along the direction of travel of the railway line.

[0045] According to one aspect, each record in the database comprises:

- a first pointer to a first record relating to a first signaling device or infrastructure device which follows another registered signaling device or infrastructure device along a direction of travel of a railway line of said railway network,
- a second pointer to a second record relating to a second signaling device or infrastructure device which precedes this other registered signaling device or infrastructure device along a direction of travel of said railway line of the railway network.

[0046] It thus becomes possible to generate, by means of a dedicated software, an output file which represents a map of a railway line connecting a signaling device or infrastructure device of departure of the railway line to a signaling device or infrastructure device of arrival of the railway line. In general, the dedicated software will be organised in four functional sections interfaced with each other as shown in figure 3. The entire platform revolves around the database, which is populated first of all by the transcoding operation of the survey data, and which is then managed and displayed through the appropriate user interfaces.

[0047] When a map of a railway line between a departure device and a destination device, to be displayed on a screen or printed in graphic or text format, is wished to be realised, according to this disclosure, the database is processed to identify:

- a respective departure record of the signaling device or infrastructure device of departure of the railway line;
- a respective arrival record of the signaling or infrastructure device of arrival of the railway line;
- the railway line of the railway network which connects the signaling device or infrastructure device of departure to the signaling device or infrastructure device of arrival, wherein the signaling device or infrastructure device of departure and the signaling device or infrastructure device of arrival define a direction of travel of the railway line;
- at least an ordered succession of intermediate records between the departure record and the arrival record relating to registered signaling devices or intermediate infrastructure devices along the railway line according to this direction of travel.

[0048] According to one aspect, a first intermediate record of the ordered succession of intermediate records is pointed to by the given identifier of the departure record, wherein the last intermediate record of the ordered succession of intermediate records is pointed to by the given identifier of the arrival record, and wherein every other intermediate record is pointed to by the given identifier of the intermediate record which precedes in

the succession and by the given identifier of the intermediate record which follows in the succession.

[0049] According to one aspect, a first intermediate record of the ordered succession of intermediate records is pointed to by a first pointer of the departure record, wherein a last intermediate record of the ordered succession of intermediate records is pointed to by a second pointer of the arrival record, and wherein every other intermediate record is pointed to by a first pointer of the intermediate record which precedes in the succession and is pointed to by the second pointer of the intermediate record which follows in the succession.

[0050] This produces an output file representing the map of the railway line, which can be saved on a storage medium or can be displayed on the screen as a map that can also be printed on a sheet of paper in graphic or text form, in which the map of the railway line is represented in the form of a weighted graph defined by the ordered succession of records, in which:

- the signaling device or infrastructure device of departure is represented as the starting node of the graph,
- the signaling device or infrastructure device of arrival is represented as the destination node of the graph,
- the signaling devices or infrastructure devices corresponding to the intermediate records are represented in an orderly manner as intermediate nodes of the graph according to the ordered succession,
- each arc of the graph connecting two consecutive nodes according to the ordered succession is weighted with a relative distance between the signaling devices or infrastructure devices corresponding to the two consecutive nodes of the graph.

[0051] In order to update the database by inserting the references of a signaling device or infrastructure device not previously identified along a railway line, it will be sufficient to insert a new record relating to this device not previously identified, then update the pointer of the record which precedes in the succession and the pointer of the intermediate record which follows in succession according to the direction of travel of the railway line so that they point to this new record.

[0052] According to one aspect, illustrated schematically in figure 5 with reference to the database in figure 4, each signaling device or infrastructure device of the graph is represented together with its symbol, name and respective elevation information. According to one aspect, a graph is produced that can be displayed on the screen or printed in graphic or text form of the elevation values contained in the records of the output file which represents said map of the railway line.

Database

[0053] Until now, the large amount of data coming from the surveys was not ordered according to rules: each company in fact produces an output format according to its own technologies and needs, for example output in text, tabular, or CAD format. Consequently, the approach to be used changes depending on the format in which the data to be used were represented. In fact, each format is unrelated to the other one and does not provide for the possibility of updates following new survey campaigns.

[0054] In addition, for each new job there was a strong component of data analysis, aimed at understanding their structure and method of use. As the datum is mainly composed of the coordinates of the beaten point, the elevation and its denomination, with the method of this disclosure a common structure is used which allows for a conversion and encoding.

[0055] According to one aspect of the present disclosure, database records are generated starting from at least one CAD, or Excel or text file containing position and elevation information of the signaling and infrastructure devices of a railway network. In one aspect, the above-mentioned files are processed to identify the signaling or infrastructure devices described therein and the respective geographic position and elevation information; then the respective records of a database for each signaling device or infrastructure device identified are filled in in the manner indicated above. The procedure used for reading input data from CAD, Excel or text documents is based on the identification of the coordinate fields, expressed in a standard format. The points represented will then be reconnected where possible automatically, otherwise a wizard will allow an operator to establish the joining rules. Furthermore, the software will allow the automatic conversion between a standard and another format so that the operator is completely relieved of this burden for the delivery of the final paper.

[0056] Given the complexity of linking the input data, a relational database was chosen that would allow devices with common attributes to be linked together, by using a SQL (Structured Query Language) type language to interface with the database structure allowing the operations of data creation, insertion and query to be carried out accurately and quickly. Although the database is an integral part of the dedicated software, it can be exploited by the software to generate specific outputs in order to be interoperable with other proprietary applications.

[0057] According to one aspect, both the *topographical features,* i.e. geolocation, elevation and actual position within the survey, and the *schematic features,* typology of the various devices, physical connections and of the railway line, belonging track, are processed and stored.

[0058] According to one aspect, the sequence of gradient changes (variations in thousandths of the elevation profile) is very important for the configuration of the system settings.

[0059] By exploiting the logics of relationships built between the data contained in the database it is possible to both carry out the inverse process and decode the information to recover the structure of the survey used as input, and to structure a preliminary version of a sche-

matic plan, useful for railway engineering processes. Thanks to this feature, by adding documentation to the database, it is possible to update the one with information of the other one; for example, it is possible to implement all the physical characteristics of the various devices on a schematic plan, which would have been impossible to obtain.

Transcoding

[0060] As already mentioned earlier, the input datum from a survey has a structure dependent on who produced it, so unless tools were provided to assist the designer, the approach and use method had to be completely manual, the operator had to find the points of interest within the data structure and manually reconnect the line of the devices in order to obtain the measurement concerned. This procedure obviously introduced a human error factor that should not have been considered within the accuracies required by the design.

[0061] The dedicated software that implements the method of this disclosure, through its transcoding engine, provides for the management of any type of input data, by extrapolating the useful detail of the information and preparing the data for archiving in the database. As it is an automated procedure, it frees the user from the recognition of useful content for design purposes, allowing not only a saving in time factor, but also the reduction of error induced by the human control.

Viewer

[0062] The display of the data as a whole was limited to the manual creation of a planimetry in CAD format, which, although it was easy to consult and allowed the representation of large parts of the railway line, both its generation and possible revisions as a result of new surveys had to be processed manually a user. Starting from the beaten points of the tracks, the operator had to use a vast library of blocks (graphic representation of the devices) and insert them at the respective points surveyed, in order to show the arrangement of the devices along the line at a glance, without having to go through a 1-to-1 search between the nomenclature on the planimetry and the table of the devices surveyed.

[0063] The database data are automatically interpreted and converted into a weighted undirected graph, i.e. a configuration formed by a set of nodes (the devices we have chosen as input) and a set of arcs connecting them (relationships between the devices chosen based on the type of functionality chosen).

[0064] The display software makes it possible to reconstruct, using only the data present in the database, the complete geographical survey, complete with devices and connections, displayed in a graph, allowing an easy navigation and query of the information. The data are organised and connected according to precise criteria, so that, once two nodes have been chosen, all the connections within them can be extrapolated, the software will construct the train lines within the graph and will obtain the list of the devices crossed, the distances between them, and, since the whole system is georeferenced, also the variations in measurement of the profile. All devices are displayed with their symbol, allowing to distinguish the type of device and, through the list of the various types of devices, to filter the graph, by displaying only what one is interested in. The node list reflects the sequence of the devices that will be encountered by the train while crossing the line, each of which is accompanied by the type and distance from the previous device in metres.

[0065] According to one aspect, the display software also allows the export of data stored in the database both in the XLS and in the XML format, compatible with both the project and European specifications.

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[0066] Until now, it was not possible to manipulate the data by single object, but it could only be done en masse following a further survey, then a new table of measurements or a new planimetry on which to perform the distance calculations was generated.

[0067] The dedicated software according to this disclosure also offers the possibility to modify and manage the data in the database, in fact it is sometimes required to modify the planimetry by the engineering following developments and analyses while designing. This intervention is not always linked to a further survey of the railway trail but it must be punctual in adding, removing or modifying the coding and position of some devices. In fact, through an interface that accepts user inputs, the planimetry is made manageable as if it were a normal design table.

[0068] As well as the coding and the association of parts of the survey to a railway logic that is determined by the requirements and specifications of the device in need of the works. Each rail network managed by a territory, whether at regional or national level, it has in fact different regulations both on the organisation of the surveys and on the management of the design of signaling systems.

[0069] Through the dedicated software of this disclosure the user will be able to fit the survey input into reality in which it will have to be presented and used.

XML format

[0070] In order to be able to categorise all the information necessary for the operation and description of an itinerary, an XML format, of the type illustrated for example in figure 6, can be used. Each progressive line number of the XML code is a datum that identifies the position of the identified device in an ordered succession of devices identified along a given railway line, therefore it allows to locate both the immediately preceding device and the

immediately following device along the railway line. In the example shown, there is a distance field that identifies the distance between the device to which it refers and the device that precedes it in the ordered succession.

[0071] It is in fact possible to export the survey data in an XML file, which makes it possible to describe the entire survey complete with all the information, including the characteristics of each device and the order in which these devices are encountered while crossing, including the distance between them.

[0072] Each device is represented as an XML element with all its typical characteristics of that device. For example, for the Joint XI/55
<JOINT ... /> the code of the previous and next track circuit (railway device used to verify track occupation) is stored, in a manner consistent with the direction of travel of the joint i.e. XI -> 55, in addition to the distance from the previous device.

[0073] Similarly, with regards to the switches it is stored in which way they are crossed, i.e. in straight or diverging track.

[0074] In this way it will be possible to reconnect the survey with the subsequent communication paths.

Claims

1. A computer implemented method to produce an output file representing a map of a railway line comprised between a signaling device or infrastructure device of departure of said railway line and a signaling device or infrastructure device of arrival of said railway line, said signaling device or infrastructure device of departure and said signaling device or infrastructure device of arrival defining a direction of travel of said railway line, said method comprising the following operations:

providing a storage medium containing a database relating to a railway network, said railway network comprising a plurality of registered signaling devices or infrastructure devices including at least said signaling device or infrastructure device of departure and said signaling device or infrastructure device of arrival, wherein said database comprises a respective database record for each registered signaling device or registered infrastructure device of said railway network, said respective record containing at least:

- a name field containing a name of the registered signaling device or infrastructure device,
- a position field containing respective geographical position information of the registered signaling device or infrastructure device,
- at least one identifier datum of a first record, relating to a first signaling device or infrastructure device of the railway network which follows said registered signaling device or infrastructure device along the direction of travel of a railway line of said railway network passing through said registered signaling device or infrastructure device, and of a second record relating to a second signaling device or infrastructure device of the railway network which precedes said registered signaling device or infrastructure device along said direction of travel of said railway line;

choosing, from the signaling devices or infrastructure devices registered in said database, the signaling device or infrastructure device of departure of the railway line and the signaling device or infrastructure device of arrival of the railway line;
processing said database to identify:

- a respective departure record relating to said signaling device or infrastructure device of departure;
- a respective arrival record of said signaling device or infrastructure device of arrival;
- said railway line of said railway network which connects said signaling device or infrastructure device of departure to said signaling device or infrastructure device of arrival;

an ordered succession of intermediate records relating to signaling or infrastructure devices which are crossed by said railway line and comprised between said signaling device or infrastructure device of departure and said signaling device or infrastructure device of arrival, wherein a first intermediate record of said ordered succession of intermediate records is pointed to by the identifier datum of the departure record, wherein a last intermediate record of said ordered succession of intermediate records is pointed to by the identifier datum of the arrival record, and wherein every other intermediate record is pointed to by the identifier datum of the intermediate record which precedes in said succession and by the identifier datum of the intermediate record which follows in said succession;
producing an output file as output which contains data stored in the fields of said departure record, of said intermediate records and of said arrival record, said output file being viewable on a screen or printable in graphical or text form and which represents said map of the railway line in the form of a weighted graph defined by said

ordered succession of records, in which:

- said signaling device or infrastructure device of departure is represented as the starting node of the graph,
- said signaling device or infrastructure device of arrival is represented as the end node of the graph,
- registered signaling devices or infrastructure devices corresponding to said intermediate records are represented in an orderly manner as intermediate nodes of the graph according to said ordered succession,
- each arc of the graph connecting two consecutive nodes of the graph according to said ordered succession is weighted with a relative distance between the signaling devices or infrastructure devices corresponding to said two consecutive nodes of the graph.

2. A computer implemented method to produce a map of a railway line comprised between a signaling device or infrastructure device of departure of said railway line and a signaling device or infrastructure device of arrival of said railway line, said signaling device or infrastructure device of departure and signaling device or infrastructure device of arrival defining a direction of travel of said railway line, said method comprising the following operations:

producing an output file representing said map by executing the method according to claim 1; and
printing or displaying on a screen, in graphic or text form, said map of the railway line in the form of a weighted graph defined by record fields relating to said output file which represents said map of the railway line.

3. A computer implemented method to produce a second storage support medium containing a file representing a map of a railway line comprised between a signaling device or infrastructure device of departure of said railway line and a signaling device or infrastructure device of arrival of said railway line, said signaling device or infrastructure device of departure and signaling device or infrastructure device of arrival defining a direction of travel of said railway line, said method comprising the following operations:

providing and installing said second storage medium;
producing an output file representing said map by executing the method according to claim 1; and
writing said output file on said second storage medium.

4. The method according to one of claims 1 to 3, wherein at least one of the following characteristics is verified:

- said at least one identifier datum is a progressive number which identifies a position of said database record in said ordered succession between said departure record and said arrival record;
- said position field contains GPS position information of the registered device and/or distance information of the registered device from another registered device that precedes in said ordered succession;
- each record of said database records comprises at least one elevation field containing respective elevation information of a relating registered device.

5. The method according to one of claims 1 to 4, wherein each of said records comprises:

- a first pointer to said first record relating to the first signaling device or infrastructure device of the railway network reachable starting from the registered signaling device or infrastructure device and traveling along said railway line of said railway network in the first direction,
- a second pointer to said second record relating to the second signaling device or infrastructure device of the railway network reachable starting from the registered signaling device or infrastructure device and traveling along said railway line in the second direction;

and wherein a first intermediate record of said ordered succession of intermediate records is pointed to by a first pointer of the departure record, wherein a last intermediate record of said ordered succession of intermediate records is pointed to by a second pointer of the arrival record, and in which every other intermediate record is pointed to by a first pointer of the intermediate record which precedes in said succession and is pointed to by the second pointer of the intermediate record which follows in said succession.

6. The method according to one of claims 1 to 5, wherein each signaling device or infrastructure device of the graph is represented in said output file along with its symbol, name and respective elevation information.

7. The method according to one of claims 1 to 6, wherein said filled in record comprises an elevation field containing respective elevation information of said

registered signaling device or infrastructure device.

8. The method according to one of the preceding claims, comprising the operation of defining said records with a Structured Query Language.

9. The method according to one of the preceding claims, comprising the preliminary phase of creating a database composed of records, each record containing at least geographic position information and optionally elevation information of signaling devices and infrastructure devices of a railway network, said preliminary phase comprising the following operations:

identifying at least one signaling device or at least one infrastructure device of said railway network and said respective geographic position information and optionally elevation information, then filling in at least one respective record generating a filled in record of said database for each registered signaling device or structure device, said filled in record containing at least a name field containing a name of the registered device, a position field containing respective geographic position information, preferably of GPS type, and optionally an elevation field containing respective elevation information;
for each signaling device or infrastructure device registered in the previous step:

- identifying at least one railway line of said railway network passing through the registered signaling device or infrastructure device,
- identifying a first signaling device or infrastructure device which follows said registered signaling device or infrastructure device along the direction of travel of said railway line,
- identifying a second signaling device or infrastructure device which precedes said registered signaling device or infrastructure device along said direction of travel of said railway line;
- to the respective filled in record, adding at least one identifier datum of a respective record of the first signaling device or infrastructure device, and of a respective record of the second signaling device or infrastructure device;

saving said database containing said filled in records on a storage medium.

10. A computer implemented method to create a database composed of records, each record containing at least geographic position information and optionally elevation information of signaling devices and infrastructure devices of a railway network, said preliminary phase comprising the following operations:

identifying at least one signaling device or at least one infrastructure device of said railway network and said respective geographic position information and optionally elevation information, then filling in at least one respective record generating a filled in record of said database for each registered signaling device or structure device, said filled in record containing at least a name field containing a name of the registered device, a position field containing the respective geographic position information, preferably of GPS type, and optionally an elevation field containing the respective elevation information;
for each signaling device or infrastructure device registered in the previous step:

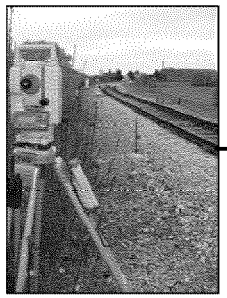
- identifying at least one railway line of said railway network passing through the registered signaling device or infrastructure device,
- identifying a first signaling device or infrastructure device which follows said registered signaling device or infrastructure device along a direction of travel of said railway line,
- identifying a second signaling device or infrastructure device which precedes said registered signaling device or infrastructure device along said direction of travel of said railway line;
- to the respective filled in record, adding at least one given identifier of a respective record of the first signaling device or infrastructure device, and of a respective record of the second signaling device or infrastructure device;

saving said database containing said filled in records on a storage medium.

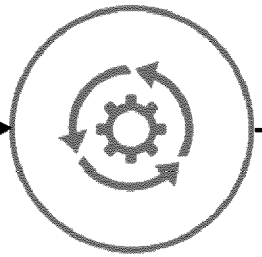
11. The method according to claim 9 or 10 comprising the operation of:
processing at least a CAD, or Excel or text file, said at least one file containing at least position and elevation information of the signaling devices and of the infrastructure devices of the railway network, to identify at least one signaling device or at least one infrastructure device described therein and said respective geographic position and elevation information, then filling in one respective record of a database by generating a filled in record for each registered signaling device or infrastructure device, said filled in record containing at least one name field containing a name of the registered device, a position

field containing respective geographic position information, preferably GPS information, and optionally an elevation field containing respective elevation information.

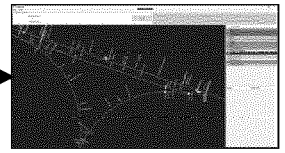
12. A computer program loadable into an internal memory of a computer, comprising a software code configured to perform the operations of the method according to one of the preceding claims when executed by the computer.



Survey
A field survey is carried out including trail data and information on devices



Transcoding
The data collected is coded, storing all useful information



Display
The encoded data is used as input for the visualisation software

FIG. 1

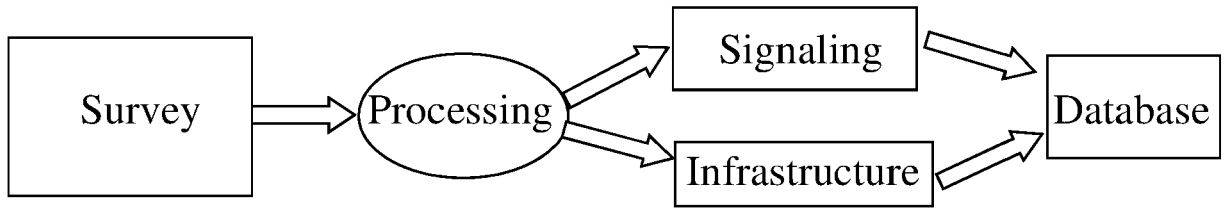

Survey
Processing
Signaling
Infrastructure
Database

FIG.2

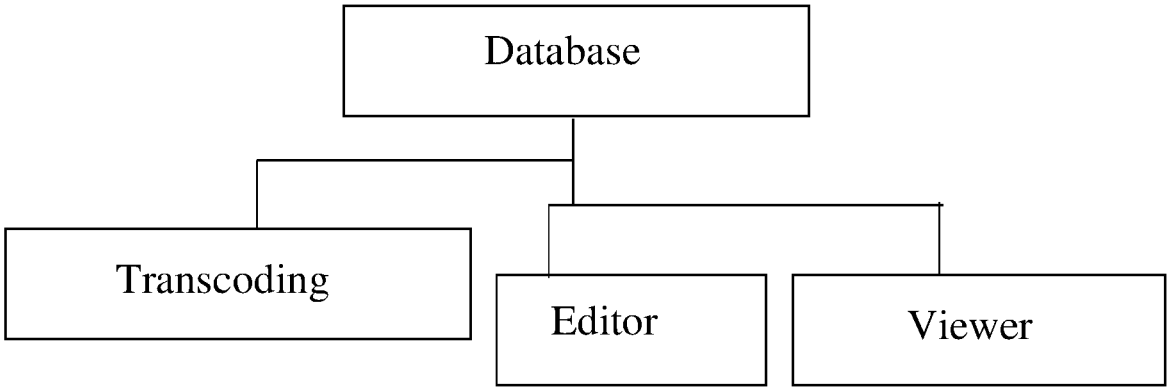

Database
Transcoding
Editor
Viewer

FIG.3

Node list

Name	Type	Distance	Elevation
PI 010-1	*Balise*	0m	51.83
PI 010-2	*Balise*	2.95m	51.82
SEGNALE DI PROTEZIONE 1s STATUTO	*Signal*	0.21m	51.82
GIUNTO BA857/10	*Joint*	23.51m	51.77
PEDALE CONTA-ASSI	*AxleCounter*	3.07m	51.76
PORTALE I/IV	*Other*	239.32m	51.73
GIUNTO 10/11	*Joint*	64.7m	51.96
PORTALE II/III	*Other*	67.95m	52.16
PICCHETTO	*ShuntingLimit*	121.63m	52.51
CIPPO CHILOMETRICO 3+000	*KmReference*	7.86m	52.52
PI 012-2	*Balise*	18.09m	52.55
PI 012-1	*Balise*	3m	52.55
DEV1b	*Switch*	12.58m	52.57

FIG.4

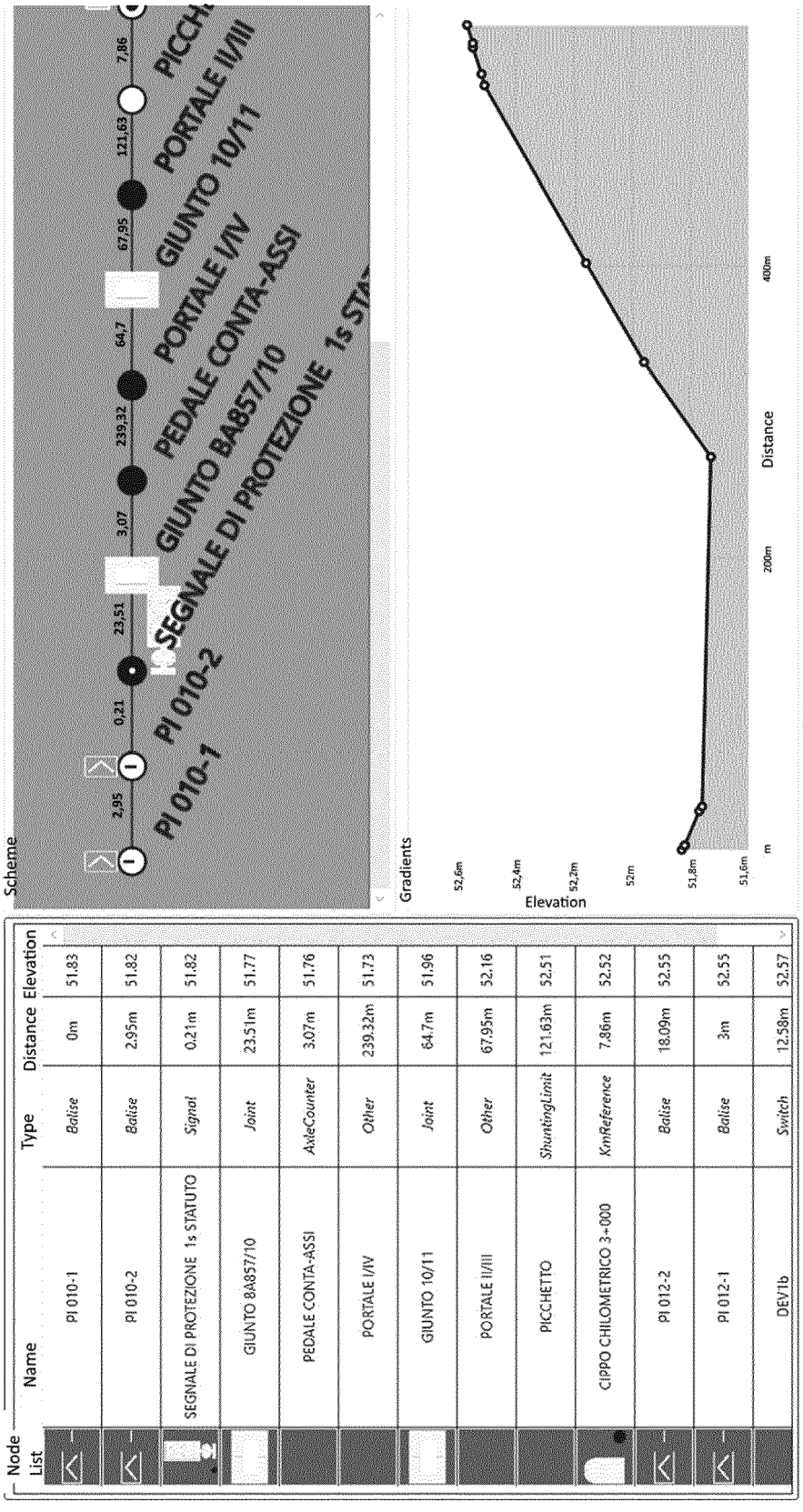

Node List
Name
Type
Distance
Elevation
PI 010-1
Balise
0m
51.83
PI 010-2
Balise
2.95m
51.82
SEGNALE DI PROTEZIONE 1s STATUTO
Signal
0.21m
51.82
GIUNTO 8A857/10
Joint
23.51m
51.77
PEDALE CONTA-ASSI
AxleCounter
3.07m
51.76
PORTALE I/IV
Other
239.32m
51.73
GIUNTO 10/11
Joint
64.7m
51.96
PORTALE II/III
Other
67.95m
52.16
PICCHETTO
ShuntingLimit
121.63m
52.51
CIPPO CHILOMETRICO 3+000
KmReference
7.86m
52.52
PI 012-2
Balise
18.09m
52.55
PI 012-1
Balise
3m
52.55
DEV1b
Switch
12.58m
52.57
Scheme
2.95
0.21
23.51
3.07
239.32
64.7
67.95
121.63
7.86
PI 010-1
PI 010-2
SEGNALE DI PROTEZIONE 1s STA
GIUNTO 8A857/10
PEDALE CONTA-ASSI
PORTALE I/IV
GIUNTO 10/11
PORTALE II/III
PICCH
Gradients
52,6m
52,4m
52,2m
52m
51,8m
51,6m
Elevation
m
200m
400m
Distance

FIG.5

```
129   <PATH ID="(S1 B3)" STATION="1" name="PARAURTI --- SEGNALE DI ARRESTO F11"
    length="615.6" date="[data]">
130     <BUFFER_STOP name="PARAURTI" station="" distance="0" />
131     <AXLE_COUNTER station="" distance="47.69" />
132     <FOULING_POINT ref_switch="981" name="TRAVERSA LIMITE DEV 981" station=""
    distance="9.95" />
133     <SWITCH name="PS DEV 981" passed="true" station="" distance="43.08" />
134     <AXLE_COUNTER station="" distance="3.96" />
135     <BALISE NID_C="" NID_BG="" N_PIG="" station="" distance="2.11" />
136     <BALISE NID_C="" NID_BG="" N_PIG="" station="" distance="3" />
137     <AXLE_COUNTER station="" distance="131.59" />
138     <SIGNAL name="SEGNALE DI PARTENZA H11" direction="" station="" distance="2.59" />
139     <BALISE NID_C="" NID_BG="" N_PIG="" station="" distance="0.06" />
```

FIG. 6

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EUROPEAN SEARCH REPORT

Application Number
EP 21 20 4920

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	BITTERBERG U: "WISSENBASIERTE FAHRZEUGSTEUERUNGEN – DATENBASIS UND POTENZIELLE ANWENDUNGEN//KNOWLEDGE-BASED TRAIN CONTROL SYSTEMS – DATA BASIS AND POTENTIAL APPLICATIONS", ZEVRAIL – GLASERS ANNALEN, GEORG SIEMENS VERLAG, BERLIN, DE, vol. 128, no. 6/07, 1 June 2004 (2004-06-01), pages 240-246, 248, XP001196510, ISSN: 1618-8330 * figures 2 and 4; sections 3 and 4 *	1-12	INV. B61L15/00 B61L25/02 B61L25/06 B61L25/08 B61L27/40
A	US 2019/197923 A1 (JOVENALL JEREMY [US]) 27 June 2019 (2019-06-27) * figures 1 – 8; paragraphs [0017] – [0053] *	1-12	
A	CN 111 382 483 A (BYD CO LTD) 7 July 2020 (2020-07-07) * figure 1 and corresponding parts of the description; section "background technique" *	1-12	TECHNICAL FIELDS SEARCHED (IPC) B61L

-/--

2 The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	9 March 2022	Plützer, Stefan

CATEGORY OF CITED DOCUMENTS

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T : theory or principle underlying the invention
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D : document cited in the application
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& : member of the same patent family, corresponding document

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EUROPEAN SEARCH REPORT

Application Number
EP 21 20 4920

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	VOSS G ET AL: "FAHRZEUGORTUNG MIT DEM GLOBAL POSITIONING SYSTEM FUER DEN ELEKTRONISCHEN BUCHFAHRPLAN UND LA//GPS-BASED VEHICLE LOCATION FOR EBULA (ELECTRONIC TIMETABLE BOOK AND LIST OF SECTIONS WITH TEMPORARY SPEED RESTRICTIONS)//LOCALISATION DES VEHICULES PAR L'INTERM", ZE VRAIL - GLASERS ANNALEN: ZEITSCHRIFT FUER DAS GESAMTE SYSTEM BAHN, GEORG SIEMENS VERLAG GMBH & CO. KG, DE, vol. 125, no. 11, 1 November 2001 (2001-11-01), pages 502-506, XP001107803, ISSN: 0941-0589 * figure 4 and corresponding parts of the description *	1-12	
A	DE 10 2009 006085 A1 (VOITH PATENT GMBH [DE]) 29 July 2010 (2010-07-29) * figure 4; claim 1; paragraphs [0039] - [0041] *	1-12	TECHNICAL FIELDS SEARCHED (IPC)
A	CN 111 824 216 A (UNIV BEIJING JIAOTONG) 27 October 2020 (2020-10-27) * step (3); figure 4 *	1-12	

2 The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	9 March 2022	Plützer, Stefan

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& : member of the same patent family, corresponding document

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09-03-2022

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2019197923 A1	27-06-2019	US 2019197923 A1	27-06-2019
		WO 2019125592 A1	27-06-2019
CN 111382483 A	07-07-2020	NONE	
DE 102009006085 A1	29-07-2010	DE 102009006085 A1	29-07-2010
		WO 2010083946 A1	29-07-2010
CN 111824216 A	27-10-2020	NONE	

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