



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
18.03.2020 Bulletin 2020/12

(51) Int Cl.:
B61L 17/00 (2006.01) B61L 27/00 (2006.01)

(21) Application number: **19159979.4**

(22) Date of filing: **28.02.2019**

(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

- **Tomiyama, Tomoe**
Tokyo 100-8280 (JP)
- **Handa, Takeshi**
Tokyo 100-8280 (JP)
- **Maekawa, Yuki**
Tokyo 100-8280 (JP)
- **Okada, Kenichirou**
Tokyo 100-8280 (JP)

(30) Priority: **11.09.2018 JP 2018169394**

(71) Applicant: **Hitachi, Ltd.**
Tokyo 100-8280 (JP)

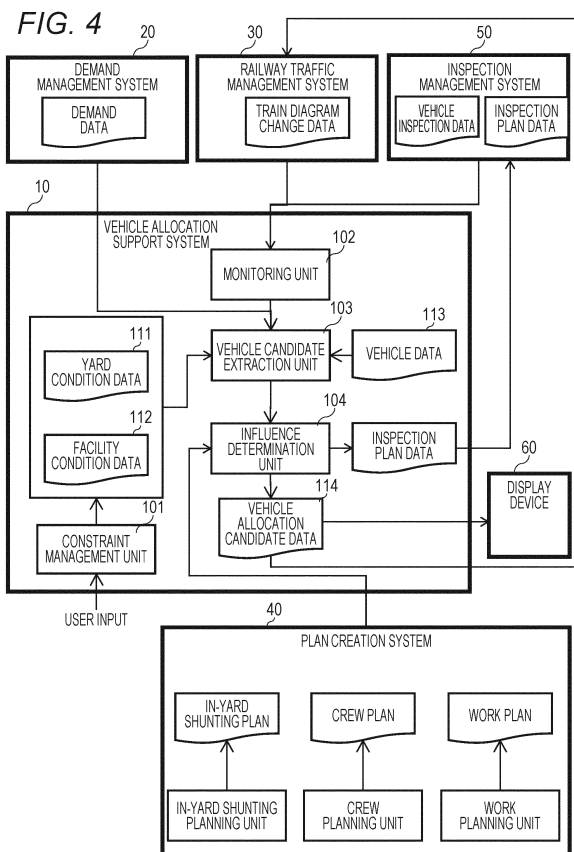
(72) Inventors:
• **Igawa, Hiromi**
Tokyo 100-8280 (JP)

(74) Representative: **Manitz Finsterwald**
Patent- und Rechtsanwaltspartnerschaft mbB
Martin-Greif-Strasse 1
80336 München (DE)

Remarks:
Amended claims in accordance with Rule 137(2) EPC.

(54) **VEHICLE ALLOCATION SUPPORT SYSTEM, METHOD, AND PROGRAM**

(57) Provided are: a constraint management unit that manages a constraint condition defined for each vehicle yard and a facility condition defined for each time and/or route; a vehicle candidate extraction unit that searches for a vehicle that is allocable to a train in a train diagram so as to satisfy the constraint condition and the facility condition and to be capable of transporting the given number of passengers with demand to extract a candidate of a vehicle to be allocated to the train; and an influence determination unit that calculates operation cost based on influence degrees which is degrees of influence on a shunting plan, a crew plan, and a work plan, for the extracted candidate.



Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a technique of supporting creation of a vehicle allocation plan at a railway vehicle yard.

2. Description of the Related Art

[0002] Each vehicle is inspected in a railway vehicle yard. The vehicle inspection is conducted based on an inspection plan that defines when and what vehicle is to be inspected. In addition, in the railway vehicle yard, a vehicle allocation is performed to determine which vehicle is to be allocated to each train on a train diagram. In the vehicle allocation, which vehicle to be allocated to each train on the train diagram planned in advance is determined based on a vehicle operation plan obtained by planning the operation of each vehicle in advance.

[0003] However, it is necessary to change the vehicle allocation or change the inspection plan defined in the vehicle operation plan when the train diagram is disturbed, or when a delay occurs in the vehicle inspection. In addition, if the plan of the vehicle operation or inspection is changed, there is also a possibility of affecting an inspection plan or a service plan of the next day.

[0004] JP 2014-151849 A discloses a technique of narrowing down a usable vehicle, when a vehicle suddenly needs to be used for train service on that day, by considering operations and inspection types of vehicles of the next day so as to reduce influence on the next day.

SUMMARY OF THE INVENTION

[0005] In the technique disclosed in JP 2014-151849 A, however, a vehicle allocation is determined based on a required time taken for the inspection of that day and an inspection plan of the next day, and there is no consideration on whether a vehicle to be allocated to a train is a train that satisfies the number of people with demand, which is the number of passengers that needs to be transportable by the train at that time, and a demand facility which is facility required for the train at that time.

[0006] For example, in the UK, it is common to provide catering service to commuters for trains in a commuting time zone. Thus, it is preferable to prioritize a vehicle equipped with a catering facility for carrying out catering service to the train in the commuting time zone. Meanwhile, there are many passengers using trains for the purpose of long distance travel in a daytime time zone, and such passengers may bring baggage or a bicycle into a train in some cases. Thus, there is a possibility that it is preferable to prioritize a vehicle equipped with space for putting baggage and bicycles as a facility in the daytime time zone. With the technique of JP 2014-151849

A, it is difficult to allocate a vehicle in consideration of such a demand facility.

[0007] In addition, on the vehicle yard side, there is a possibility that a constraint itself, which is a condition for determining a vehicle allocation, may change depending on a situation of the vehicle yard at the time when there arises a need of arranging a vehicle to be newly allocated to a train. For example, inspection planning and crew planning are comparatively easy during the daytime, and thus, it is sometimes possible to change a schedule to carry out an inspection of a vehicle and provide the inspected vehicle if an additional vehicle is requested for reasons of relaxation of congestion during the daytime. In the nighttime, however, there is a possibility that cost of providing vehicles is too high because additional work to the crew, such as forwarding of a train is generated due to dispatching a vehicle or it is difficult to carry out an inspection due to a lack of skill of maintenance workers or a lack of the number of maintenance workers. In such a case, there may also be a case where it is better not to provide a vehicle in accordance with a train diagram desired by a service provider.

[0008] In addition, when a company (service provider) that services trains is different from a company (vehicle management provider) that manages the vehicles, there is a possibility that a time zone during which a vehicle can be provided may be limited according to a request depending on what kind of contract has been made between these companies. In addition, when vehicle management providers of the respective vehicle bases are different from each other, there is also a possibility that it is necessary for the service provider to negotiate with each of persons in charge of the plurality of vehicle bases to search for a vehicle yard that can provide a vehicle under a better condition. Such a negotiation requires time.

[0009] An object of the present invention is to provide a technique of supporting implementation of a vehicle allocation in consideration of a constraint imposed on the vehicle allocation defined for each vehicle yard, a facility that needs to be provided in a vehicle defined for each time or route, the number of passengers who needs be transportable by a train, and cost required for an operation of the vehicle.

[0010] In order to achieve the above object, a vehicle allocation support system according to an aspect of the present invention is a vehicle allocation support system that supports work of allocating a vehicle to a train of a railroad, the system including: a constraint management unit that manages a constraint condition indicating an item that needs to be satisfied when allocating a vehicle at a vehicle yard to a train, the constraint condition being determined for each vehicle yard, and a facility condition indicating a facility that needs to be included in a vehicle to be allocated to a train, the facility condition being determined for each time and/or route; a vehicle candidate extraction unit that extracts a candidate of a vehicle to be allocated to the train on the train diagram, the candi-

date being extracted by searching for a vehicle that is allocable to a train on a train diagram so as to satisfy the constraint condition and the facility condition and to be capable of transporting a number of passengers with demand, when information on the number of passengers with demand, which is a number of passengers that needs to be transportable by the train, is given together with an allocation implementation request to implement allocation of a vehicle to a train on the train diagram; an influence determination unit that calculates, for the extracted candidate, an operation cost based on influence degrees, which are degrees of influence on a shunting plan which is a plan concerning circulation of vehicles, a crew plan which is a plan concerning an allocation of crews to a train, and a work plan which is a plan concerning work including a vehicle inspection; and a display unit that displays the operation cost relating to the candidate of the extracted candidate.

[0011] According to an aspect of the present invention, it is possible to implement the vehicle allocation in consideration of the constraint imposed on the vehicle allocation defined for each vehicle yard, the facility that needs to be provided in a vehicle defined for each time or route, the number of passengers who needs be transportable by a train, and the cost required for an operation of the vehicle.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012]

Fig. 1 is a diagram illustrating a vehicle allocation support system according to an embodiment;
 Fig. 2 is a diagram illustrating a hardware configuration of a server device including the vehicle allocation support system illustrated in Fig. 1;
 Fig. 3 is a diagram illustrating a software configuration of the vehicle allocation support system illustrated in Fig. 1;
 Fig. 4 is a diagram for describing a relationship between a processing flow and data in the vehicle allocation support system illustrated in Figs. 1 and 3;
 Fig. 5 is a table illustrating a data structure of yard condition data illustrated in Fig. 3;
 Fig. 6 is a table illustrating a data structure of facility condition data illustrated in Fig. 3;
 Fig. 7 is a table illustrating a data structure of vehicle data illustrated in Fig. 3;
 Fig. 8 is a table illustrating a data structure of vehicle allocation candidate data illustrated in Fig. 3;
 Fig. 9 is a view illustrating an operation flow until the vehicle allocation support system outputs a vehicle allocation candidate and completes an allocation in the vehicle allocation support system illustrated in Fig. 1;
 Fig. 10 is a view for describing an operation flow of a vehicle candidate extraction unit illustrated in Fig. 3;

Fig. 11 is a view for describing an operation flow of an influence determination unit illustrated in Fig. 3;
 Fig. 12 is a view for describing an operation flow of the vehicle allocation support system illustrated in Fig. 1 including data exchange among a vehicle allocation support system, a demand management system, a railway traffic management system, a plan creation system, an inspection management system, and a display device;

Fig. 13 is a view illustrating an example of a vehicle facility selection screen displayed on the display device illustrated in Fig. 1; and

Fig. 14 is a view illustrating an example of a yard management screen displayed on the display device illustrated in Fig. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0013] Hereinafter, a vehicle allocation support system according to an embodiment will be described with reference to the drawings.

[0014] Fig. 1 is a diagram illustrating a vehicle allocation support system according to the embodiment.

[0015] As illustrated in Fig. 1, the vehicle allocation support system according to the embodiment is configured such that a vehicle allocation support system 10, a demand management system 20, a railway traffic management system 30, a plan creation system 40, an inspection management system 50, and a display device 60 are connected via a network 70. Incidentally, a plurality of the display devices 60 may be used.

[0016] The demand management system 20 manages the number of passengers with demand for each time zone as demand information.

[0017] The railway traffic management system 30 is a system that manages service information of a train running on a main line, and notifies the vehicle allocation support system 10 of an allocation implementation request for implementing an allocation of a vehicle to a train on a train diagram when there occur a vehicle allocation change accompanying a failure of an accident of a vehicle and a vehicle allocation addition accompanying an increase of a service train accompanying a demand increase of passengers.

[0018] The inspection management system 50 is a system that manages an inspection plan and a progress status of an inspection performed in the vehicle yard as inspection information, and notifies the vehicle allocation support system 10 of the allocation implementation request for implementing an allocation of a vehicle to a train on the train diagram when there arises a need of changing the vehicle allocation that has been planned due to an inspection delay or the like.

[0019] The plan creation system 40 creates plan information in the vehicle yard.

[0020] The vehicle allocation support system 10 obtains demand information of a train from the demand management system 20, acquires traffic management

information of the train from the railway traffic management system 30, and further acquires inspection information of a vehicle managed at the vehicle yard from the inspection management system 50. Then, the vehicle allocation support system 10 is a system that generates vehicle allocation candidate information indicating a candidate of a vehicle to be allocated to a train of a railroad based on the plan information in the vehicle yard obtained from the plan creation system 40 and displays a result on the display device 60 operated by a user 80. Incidentally, the vehicle allocation support system 10 may be configured as one function on the plan creation system 40 or the inspection management system 50. When the vehicle allocation support system 10 is used in a plurality of vehicle bases, it may be configured to provide the vehicle allocation support system 10 for each control area, and in such a case, various devices to be connected can also be connected via a network.

[0021] The display device 60 displays the vehicle allocation candidate information generated by the vehicle allocation support system 10.

[0022] Fig. 2 is a diagram illustrating a hardware configuration of a server device including the vehicle allocation support system 10 illustrated in Fig. 1.

[0023] As illustrated in Fig. 2, the server device including the vehicle allocation support system 10 illustrated in Fig. 1 includes a main control unit 11, a main storage unit 12, an input unit 13, an output unit 14, and a communication unit 15.

[0024] The main control unit 11 controls information processing in a server device 10A by a processor executing a program code recorded in the main storage unit 12.

[0025] The main storage unit 12 stores information on the server device 10A in a nonvolatile manner.

[0026] When the input unit 13 needs to manually input the information on the server device 10A, the user inputs the information to the server device 10A.

[0027] When the output unit 14 needs to output the information on the server device 10A, the server device 10A outputs the information to the user.

[0028] The communication unit 15 is connected to the communication unit 15 of another server device via the network 70 and communicates information with another server device.

[0029] This configuration can be configured with conventionally well-known devices by realizing, for example, the main control unit 11 using a central processing unit (CPU) and a random access memory (RAM), the main storage unit 12 using a hard disk, the input unit 13 using the keyboard, the output unit 14 using a monitor, and the communication unit 15 using Ethernet (registered trademark).

[0030] Fig. 3 is a diagram illustrating a software configuration of the vehicle allocation support system 10 illustrated in Fig. 1.

[0031] As illustrated in Fig. 3, the vehicle allocation support system 10 illustrated in Fig. 1 includes a con-

straint management unit 101, a monitoring unit 102, a vehicle candidate extraction unit 103, an influence determination unit 104, yard condition data 111, facility condition data 112, vehicle data 113, and vehicle allocation candidate data 114. Actual state thereof are software programs and data stored in the main storage unit 12 illustrated in Fig. 3, and are executed by being read into the RAM and executed by the CPU (processor) at the time of execution.

[0032] The constraint management unit 101 manages a constraint condition which is defined for each vehicle yard and indicates an item that needs to be satisfied when a vehicle in the vehicle yard is allocated to a train and a facility condition which is defined for each time and route and indicates a facility that needs to be allocated to a train. The constraint management unit 101 receives an input of the constraint condition of the yard and the facility condition preferentially given to the vehicle set for each time, and stores both the conditions as the yard condition data 111 and the facility condition data 112, respectively.

[0033] The monitoring unit 102 monitors the allocation implementation request notified from the inspection management system 50 or the railway traffic management system 30, and the monitoring unit 102 operates the vehicle candidate extraction unit 103 when the allocation implementation request is notified from the inspection management system 50 or the railway traffic management system 30.

[0034] When the allocation implementation request is notified from the inspection management system 50 or the railway traffic management system 30 and the demand management system 20 gives information on the number of people with demand, which is the number of passengers that needs to be transportable by a train, the vehicle candidate extraction unit 103 searches for a vehicle, which satisfies the constraint condition and the facility condition managed as the yard condition data 111 and the facility condition data 112 by the constraint management unit 101 and can be allocated to a train on a train diagram so as to be capable of transporting the number of passengers with demand, from the service information to allocate the vehicle acquired from the railway traffic management system 30, and extracts a candidate of a vehicle to be allocated to the train on the train diagram based on the searched result.

[0035] For the candidate extracted by the vehicle candidate extraction unit 103, the influence determination unit 104 quantitatively calculates the influence on the vehicle yard when the candidate extracted by the vehicle candidate extraction unit 103 is selected, based on the inspection information acquired from the inspection management system 50 and presence or absence of a change of the inspection plan determined by the plan creation system 40. Specifically, the influence determination unit 104 calculates operation cost based on an influence degree which is the degree of the influence on a shunting plan, which is a plan concerning circulation of vehicles, a crew plan which is a plan concerning an al-

location of crews to a train, and a work plan which is a plan concerning work including a vehicle inspection. If there is a change in the inspection plan within the yard due to the vehicle candidate selection, the influence determination unit 104 causes the plan creation system 40 to calculate the plan again.

[0036] Next, a relationship between a processing flow and data in the vehicle allocation support system illustrated in Figs. 1 and 3 will be described in detail.

[0037] Fig. 4 is a diagram for describing the relationship between the processing flow and the data in the vehicle allocation support system illustrated in Figs. 1 and 3.

[0038] First, the constraint management unit 101 acquires the yard condition and facility condition input by the user, and updates the yard condition data 111 and the facility condition data 112, respectively.

[0039] Next, the monitoring unit 102 activates the vehicle candidate extraction unit 103 when receiving the vehicle allocation implementation request from the railway traffic management system 30 or the inspection management system 50. The monitoring unit 102 acquires train diagram change data from the railway traffic management system 30 when receiving the vehicle allocation implementation request, and transmits the train diagram change data to the vehicle candidate extraction unit 103. Further, when receiving the vehicle allocation implementation request from the inspection management system 50, the monitoring unit 102 acquires vehicle inspection data and transmits the vehicle inspection data to the vehicle candidate extraction unit 103.

[0040] Next, the vehicle candidate extraction unit 103 acquires the number of passengers with demand for each time zone, which is the demand information, from the demand management system 20, acquires the vehicle data 113 in the vehicle allocation support system 10, and extracts vehicles that can be allocated to the train on the train diagram as allocation candidate vehicles. Incidentally, details of the vehicle data 113 will be described later. At that time, the vehicle candidate extraction unit 103 determines whether the constraint condition and the facility condition managed as the yard condition data 111 and the facility condition data 112 by the constraint management unit 101 are satisfied for each of the extracted allocation candidate vehicles, and determines a satisfaction degree of the condition.

[0041] Next, the influence determination unit 104 determines the influence of allocating a candidate vehicle to the vehicle allocation candidate extracted by the vehicle candidate extraction unit 103. Specifically, the influence determination unit 104 specifies how much a scheduled inspection plan or occupancy plan of a track in a vehicle yard, or human resource plan of operators in a rail yard and crews has been changed by the vehicle allocation, calculates operation cost of the vehicle yard based on a task generated accompanying the plan change or the like, and updates the vehicle allocation candidate data 114. Incidentally, a vehicle has a higher

priority as the vehicle has a smaller difference in the operation cost from the scheduled plan and has less influence on the vehicle operation accompanying the change.

[0042] Thereafter, the influence determination unit 104 transmits the vehicle allocation candidate data 114 to the display device 60 to be displayed to the user. When the user selects a vehicle upon confirmation of the displayed vehicle allocation candidate and the influence on the vehicle yard at the time of selecting the vehicle allocation candidate, the display device 60 notifies the railway traffic management system 30 and the inspection management system 50 of the information on the vehicle selected by the user.

[0043] Fig. 5 is a table illustrating a data structure of the yard condition data 111 illustrated in Fig. 3.

[0044] The yard condition data 111 illustrated in Fig. 3 is configured to manage constraints of a vehicle yard, and has a yard ID 501 that can uniquely identify a vehicle yard, and stores a route ID 502, a constraint 503, a constraint evaluation value 504, and a priority 505 for each yard as illustrated in Fig. 5.

[0045] The route ID 502 sets a route ID (T or TT in the example illustrated in Fig. 5) if it is a constraint to be applied in a route limitation, and can be set with an expression such as "-" if it is a constraint that can be applied regardless of routes. For example, contents such as presence or absence of a vehicle allocation when changing an organization of vehicles constituting a train and the number of use conditions of a spare vehicle are set in the constraint 503. In the evaluation value 504, an evaluation value for determining the constraint set by the constraint 503 is stored. Incidentally, the evaluation value stores whether a constraint is applied ("present" or "none") or numerical values that can be used as upper and lower limits. The priority 505 is set according to the degree of priority, for example, 1 if a constraint needs to be always followed, and 2 if a constraint can be changed by adjustment.

[0046] When a description is given regarding each item of the yard condition data 111 illustrated in Fig. 5, for example, it is possible to allocate a vehicle by changing the vehicle organization for a route whose route ID is T in a vehicle yard whose yard ID is X, and a constraint condition at that time is set to have a high priority of 1 (MUST) in the first row illustrated in Fig. 5. In the second row illustrated in Fig. 5, the maximum number of vehicles to be used as spare vehicles is three vehicles per day for an arbitrary route in a vehicle yard whose yard ID is X, and a constraint condition at that time is set to have a priority of 2. In the third row illustrated in Fig. 5, it is possible to allocate a vehicle in middle of an inspection for a route whose route ID is TT in a vehicle yard whose yard ID is X, and a constraint condition at that time is set to have a priority of 3. In the fourth row illustrated in Fig. 5, an operation cost when allocating a vehicle to a train is set to +2000 for a route whose route ID is T in a vehicle yard whose yard ID is X, and a constraint condition at that time is set to have a high priority of 1 (MUST).

[0047] Fig. 6 is a table illustrating a data structure of the facility condition data 112 illustrated in Fig. 3.

[0048] The facility condition data 112 illustrated in Fig. 3 stores a facility condition of a vehicle concerning a passenger demand which is different for each route and time zone, and has the same route ID 601 as the yard condition data 111 illustrated in Fig. 5, and stores a time zone 602 and a facility list 603 for each of the route IDs 601 as illustrated in Fig. 6.

[0049] In the time zone 602, a time zone in which a vehicle having a facility described in the facility list 603 is desired is stored. The granularity of time zones can be flexibly changed, and may be divided between weekdays and holidays. In addition, the facility stored in the facility list 603 indicates an in-car facility and the number of organizations. Examples of the facility include a Wi-Fi facility, a bicycle, a wheelchair space, a catering facility, and the like. Incidentally, the facility list can be freely set and can be changed later.

[0050] For example, in the second row of the facility condition data 112 illustrated in Fig. 6, it is set that the Wifi and catering facilities are indispensable from 8 o'clock to 10 o'clock regardless of weekdays or holidays, it is preferable to have the wheelchair facility if possible, and the number of vehicles of eight or more is required.

[0051] Fig. 7 is a table illustrating a data structure of the vehicle data 113 illustrated in Fig. 3.

[0052] The vehicle data 113 illustrated in Fig. 3 is data capable of uniquely specifying an attribute and a state of a vehicle, and also sets data capable of uniquely specifying in the railway traffic management system 30 and the inspection management system 50. As illustrated in Fig. 7, the vehicle data 113 manages attribute information of a vehicle including a type 702 indicating a type of the vehicle, an organization ID 703, and inspection information of the vehicle including a supply number 704 indicating the number of people who can get on the vehicle, a cumulative travel distance 705 counted since a previous inspection, and a latest inspection completion date and time 706, and a state 707 of the vehicle in association with a vehicle ID 701 set for each vehicle.

[0053] The state 707 of the vehicle stores a train number if the vehicle is in the middle of service, and a number indicating a location if the vehicle is present inside the vehicle yard. That is, the state 707 of the vehicle is information indicating where the vehicle is located right now. The number indicating the location of the vehicle inside the vehicle yard is, for example, a track number or an inspection management number.

[0054] Incidentally, when an inspection cycle is managed by means other than the travel distance or the date and time according to an inspection regulation of the vehicle, a data item that can determine necessity of an inspection may be set.

[0055] Fig. 8 is a table illustrating a data structure of the vehicle allocation candidate data 114 illustrated in Fig. 3.

[0056] The vehicle allocation candidate data 114 illus-

trated in Fig. 3 stores a vehicle ID 801 similar to the vehicle data 113 illustrated in Fig. 7, a constraint satisfying number 802, a facility satisfying number 803, an excess boarding number 804, a minimum preparation time 805, a day inspection status 806, a shunting plan influence degree 807, a crew plan influence degree 808, a work plan influence degree 809, and an operation cost 810 as illustrated in Fig. 8.

[0057] A number satisfying the conditions of the yard condition data 111 is stored in the constraint satisfying number 802, and a number satisfying the conditions of the facility condition data 112 is stored in the facility satisfying number 803. A number that is likely to be failed in supply with respect to the number of passengers with demand acquired from the demand management system 20 when allocating the vehicle specified by the vehicle ID 801 is stored in the excess boarding number 804. That is, the excess boarding number 804 indicates the number of passengers who fails to board on the vehicle, and thus, the number is preferably minus as in the example illustrated in the third row of Fig. 8. However, when an absolute value is large even if the number is minus, the capacity of the vehicle is wasted. The minimum preparation time 805 indicates a time required from a determination of an allocation of the vehicle specified by the vehicle ID 801 to start of using the vehicle in the main line. There is also a case where it is difficult to immediately use the vehicle depending on an inspection status of the vehicle and the crew plan, and thus, results determined based on various plans and vehicle states are stored. The day inspection status 806 stores presence or absence of an inspection scheduled on the day when the vehicle is allocated or whether a vehicle is in the middle of the inspection. The shunting plan influence degree 807, the crew plan influence degree 808, and the work plan influence degree 809 are information necessary for service of the allocated vehicle and the inspection and vehicle management inside the vehicle yard, and are numerical values of degrees of changes caused by allocating the vehicle to the scheduled plans. The operation cost 810 is a numerical value of total cost generated by the plan changes and is calculated based on the shunting plan influence degree 807, the crew plan influence degree 808, and the work plan influence degree 809.

[0058] Hereinafter, an operation of the vehicle allocation support system configured as described above will be described.

[0059] First, the operation of the entire vehicle allocation support system will be described.

[0060] Fig. 9 is a view illustrating an operation flow until the vehicle allocation support system 10 outputs a vehicle allocation candidate and completes an allocation in the vehicle allocation support system illustrated in Fig. 1.

[0061] In the vehicle allocation support system illustrated in Fig. 1, when receiving the vehicle allocation implementation request from the railway traffic management system 30 or the inspection management system 50 (step 901), the vehicle allocation support system 10

first derives a vehicle allocation candidate that satisfies the constraint condition of the yard and the condition of the vehicle (step 902). Incidentally, such derivation of the vehicle allocation candidate will be described in detail with reference to Fig. 10.

[0062] After deriving the vehicle allocation candidate, the vehicle allocation support system 10 transmits the derived vehicle candidate to the display device 60 via the network 70, and causes the display device 60 to display the vehicle candidate.

[0063] Thereafter, when the user operates the display device 60 to determine a vehicle to be allocated (step 903), the vehicle allocation support system 10 notifies the railway traffic management system 30 of the determined vehicle information (step 904).

[0064] In addition, when the vehicle to be allocated is not determined based on the vehicle candidate displayed on the display device 60, change information input to the display device 60 by the user is received (step 905), and the processing returns to the process of step 902 to implement the process of deriving the vehicle allocation candidate again.

[0065] After the vehicle to be allocated is determined, the vehicle allocation support system 10 notifies the inspection management system 50 of presence or absence of a change in the inspection plan (step 906).

[0066] Next, an operation flow of the vehicle candidate extraction unit 103 illustrated in Fig. 3 will be described.

[0067] Fig. 10 is a view for describing the operation flow of the vehicle candidate extraction unit 103 illustrated in Fig. 3, and illustrates a detailed flow of the process in step 902 illustrated in Fig. 9.

[0068] First, the vehicle candidate extraction unit 103 acquires various types of information from the demand management system 20 and the railway traffic management system 30 connected via the network 70 (step 1001). More specifically, the vehicle candidate extraction unit 103 acquires the number of passengers with demand for each time zone from the demand management system 20, and acquires train diagram data to allocate the vehicle from the railway traffic management system 30. Incidentally, the train diagram data includes at least service information such as a route name, a service time, start and last stations, and whether a vehicle is express or not.

[0069] Next, the vehicle candidate extraction unit 103 updates each vehicle state with respect to the vehicles stored in the vehicle data 113, and extract vehicles allocable in a requested time zone by satisfying the number of people with demand and the train diagram data acquired from the demand management system 20 and the railway traffic management system 30 (step 1002). At this time, whether a vehicle is staying in the vehicle yard or being inspected is not concerned.

[0070] Next, the vehicle candidate extraction unit 103 extracts a vehicle satisfying at least one or more of the facility conditions and the yard constraint conditions from the vehicles extracted in step 1002 based on the yard

condition data 111 and the facility condition data 112 (step 1003).

[0071] Next, the vehicle candidate extraction unit 103 calculates a difference between the number of passengers with demand acquired from the demand management system 20 and the number of supply of vehicles extracted in step 1003 (step 1004). Incidentally, the difference serves as the excess boarding number of the vehicle allocation candidate data.

[0072] Next, the vehicle candidate extraction unit 103 acquires the vehicle inspection data including inspection history indicating history of inspections performed on all vehicles managed in the vehicle yard and an inspection plan indicating a plan of inspections to be implemented for all the vehicles from the inspection management system 50, and specifies an inspection state of the vehicle extracted in step 1004 (step 1005). In addition, the inspection state indicates presence or absence of a day inspection of each vehicle (whether the inspection is planned on a day when the vehicle is allocated) and whether the inspection has been completed if the inspection is planned.

[0073] After specifying the vehicles and the inspection states of the vehicles as described above, the vehicle candidate extraction unit 103 extracts a vehicle that can be allocated to a train from among vehicles whose inspections have been completed in a time zone in which the allocation of the vehicle to the train is requested by the allocation implementation request received from the railway traffic management system 30 or the inspection management system 50, extracts, from among the extracted vehicles, a vehicle that satisfies the constraint condition and the facility condition and enables the number of passengers with demand to be transported from the extracted vehicles, and stores vehicle data of the vehicle in the vehicle allocation candidate data 114 (step 1006).

[0074] As described above, the vehicle whose inspection has been completed by the time of the train is allocated to the train based on the inspection history and the inspection plan, and thus, it is possible to reliably implement the allocation of the vehicle to the train consistent with the implementation of the inspection.

[0075] Next, an operation flow of the influence determination unit 104 illustrated in Fig. 3 will be described.

[0076] Fig. 11 is a view for describing the operation flow of the influence determination unit 104 illustrated in Fig. 3.

[0077] First, the influence determination unit 104 acquires the vehicle data stored in the vehicle allocation candidate data 114 by the vehicle candidate extraction unit 103 (step 1101), and recalculates an in-yard shunting plan which is a plan concerning circulation of vehicles using the plan creation system 40 for each candidate vehicle (step 1102). The in-yard shunting plan is an implementation plan of work of moving vehicles in the yard of the vehicle yard. More specifically, information on the vehicle to be allocated and train diagram information are

transmitted to the plan creation system 40, and a result of recalculation is acquired. In the plan creation system 40, the recalculation is implemented such that only a plan of newly allocated vehicles can be added in order not to change the original plan as much as possible, that is, without changing the shunting plan of another vehicle. After acquiring the calculation result, the recalculated result is compared with the original plan to specify a changed point (step 1103).

[0078] Next, the influence determination unit 104 recalculates a crew allocation plan which is a plan concerning an allocation of crews to a train (step 1104). The crew allocation plan is a work plan of crews to be allocated to a service train. In this case, recalculation is implemented so as not to change the original plan as much as possible similarly to the in-yard shunting plan. After acquiring the calculation result, the recalculated result is compared with the original plan to specify a changed point (step 1105).

[0079] Next, the influence determination unit 104 acquires inspection plan data managed by the inspection management system 50, and refers to the inspection plan data to specify whether a work plan has been recalculated (step 1106). Incidentally, the work plan indicates an implementation plan of inspection or cleaning work with respect to a vehicle. Such work is usually implemented inside the vehicle yard before allocating a vehicle to a train. The influence determination unit 104 refers to the acquired inspection plan data, and when an inspection of the day is allocated to a candidate vehicle and is not yet implemented, transmits the information of the vehicle to be allocated and the train diagram information to the plan creation system 40 such that the work plan is recalculated (step 1107). After acquiring the calculation result from the plan creation system 40, the recalculated result is compared with the original plan to specify the changed point (step 1108).

[0080] Next, the influence determination unit 104 calculates plan influence degrees and a minimum preparation time based on change contents to the plans specified so far (step 1109). Incidentally, the plan influence degree is an index indicating how much operation cost is required for the vehicle yard by changing various plans as compared to before the change. For example, weighting is applied to a change content for each plan specified in steps 1103 and 1105, for example, one point if a plan of another vehicle is changed, five points if additional work is generated due to the plan change, and a degree of influence due to the plan change is calculated. In addition, the minimum preparation time indicates a time taken from a determination of an allocation as a result of the plan change to use of a vehicle. The minimum preparation time is specified from a re-planned shunting plan. That is, when the extracted candidate vehicle is allocated to the train, the influence determination unit 104 specifies changes generated, respectively, in the shunting plan, the crew plan and the work plan, and calculates cost required for the specified changes as the operation cost.

In this manner, the changes generated in the shunting plan, the crew plan and the work plan, respectively, are specified and the cost required for the changes is calculated as the operation cost so that it is possible to present the operation cost which is objectively comparable and which is a part caused by the changes.

[0081] In the above-described calculation of the operation cost, for example, it is conceivable to calculate cost required for a change of a shunting plan is taken as an influence degree on the shunting plan, cost required for a new allocation of crews and/or a change of an allocation of crews as an influence degree on the crew plan, and cost required for new work and/or a change of work as an influence degree on the work plan, and to total the influence degree on the shunting plan, the influence degree on the crew plan, and the influence degree on the work plan as the operation cost.

[0082] Since each of the degrees of influence on the shunting plan, the crew plan, and the work plan is calculated for the extracted candidate and the operation cost is calculated by totaling the influence degree on the shunting plan, the influence degree on the crew plan, and the influence degree on the work plan in this manner, it is possible to present the operation cost in consideration of the influence on the shunting plan, the influence on the crew plan, and the influence on the work plan.

[0083] In addition, if it is determined in step 1106 that work such as the inspection is not planned for the candidate vehicle, the process of step 1109 is performed without performing the processes of steps 1107 and 1108.

[0084] Thereafter, the influence determination unit 104 updates the vehicle allocation candidate data 114 based on the data specified in steps 1103, 1105, 1108, and 1109, and ends the processing (step 1110).

[0085] Next a description will be given regarding an operation flow of the vehicle allocation support system illustrated in Fig. 1 including data exchange among the vehicle allocation support system 10, the demand management system 20, the railway traffic management system 30, the plan creation system 40, the inspection management system 50, and the display device 60.

[0086] Fig. 12 is a view for describing the operation flow of the vehicle allocation support system illustrated in Fig. 1 including data exchange among the vehicle allocation support system 10, the demand management system 20, the railway traffic management system 30, the plan creation system 40, the inspection management system 50, and the display device 60.

[0087] First, a vehicle allocation implementation request is transmitted from the railway traffic management system 30 or the inspection management system 50 to the vehicle allocation support system 10 due to a train diagram change, an inspection delay or the like (step 1201).

[0088] When receiving the allocation implementation request, the vehicle allocation support system 10 acquires the demand information from the demand man-

agement system 20 (step 1202) and acquires the inspection information and inspection plan information from the inspection management system 50 (step 1203).

[0089] The vehicle allocation support system 10 derives a vehicle allocation candidate based on the acquired pieces of information (step 1204).

[0090] As a result of deriving the vehicle allocation candidate, when it is necessary to change a plan of a vehicle yard, the vehicle allocation support system 10 requests re-planning to the plan creation system 40 (step 1205) to acquire the recalculated plan data (step 1206).

[0091] Next, the vehicle allocation support system 10 transmits specified vehicle allocation candidate to the display device 60 (step 1207).

[0092] After the vehicle allocation candidate transmitted from the vehicle allocation support system 10 is displayed on the display device 60, the user 80 confirming the vehicle allocation candidate displayed on the display device 60 determines a vehicle to be allocated or requests re-allocation (step 1208).

[0093] When the user 80 requests the re-allocation of the vehicle, the vehicle allocation candidate deriving process in step 1204 is performed again (step 1209).

[0094] On the other hand, when the user 80 determines the vehicle to be allocated, the display device 60 notifies the vehicle allocation support system 10 of data of the determined vehicle to be allocated (step 1210).

[0095] When the vehicle to be allocated is determined, the vehicle allocation support system 10 notifies the railway traffic management system 30 of the vehicle data of the vehicle to be allocated (step 1211), notifies the inspection management system 50 of the inspection plan data, and ends the processing.

[0096] Hereinafter, a screen to be displayed on the display device 60 illustrated in Fig. 1 will be described.

[0097] First, a vehicle facility selection screen when a user selects a vehicle to be allocated to a train will be described.

[0098] Fig. 13 is a view illustrating an example of the vehicle facility selection screen displayed on the display device 60 illustrated in Fig. 1.

[0099] The display device 60 illustrated in Fig. 1 displays the vehicle facility selection screen displaying the vehicle allocation candidates derived by the vehicle allocation support system.

[0100] As illustrated in Fig. 13, a train name 1302 for which an allocation is requested, a facility condition 1303 required for the train, a vehicle name 1310 of an allocation candidate to be allocated to the train, facility information 1311 held by the allocation candidate vehicle with the vehicle name 1310, excess boarding number 1304 in service when the allocation candidate vehicle with the vehicle name 1310 is allocated to the train with the train name 1302, a minimum time 1305 until the train is dispatched from the yard to the main line when the allocation candidate vehicle with the vehicle name 1310 is allocated to the train with the train name 1302, and an allocation change button 1306 are displayed on the vehicle facility

selection screen displayed on the display device 60. Incidentally, the minimum time 1305 from the yard to the main line is set, for example, in advance to a time threshold (for example, 10 minutes). If time is within the threshold, it is determined to "seem to be immediately dispatched", which is displayed. In addition, the facility information 1309 constituting the facility condition 1303 displays a facility stored in the facility condition data 112, and setting can be canceled by pressing an icon if the facility is desirably removed from vehicle conditions. In addition, when it is desired to add a vehicle condition, it is possible to set a facility that is not displayed in the facility condition 1303 as a condition by pressing another facility selection button 1312 constituting the facility condition 1303. In contrast to the facility information 1309, the facility information 1311 in the candidate vehicle indicates presence or absence of a facility with "○", "△", or "×", but an expression method may use a description with characters or other symbols. In addition, regarding the excess boarding number 1304 and the time 1305 when a vehicle can be dispatched from the yard, the index to be displayed can be added or deleted according to the determination of the user referring to the screen if it is an item registered in the facility condition data 112 illustrated in Fig. 6. For example, it is conceivable to display a concrete numerical value such as five hours as the time 1305 when the vehicle is dispatched from the yard.

[0101] In addition, even vehicles other than a candidate vehicle having the highest priority are ranked based on the degree of satisfying the facility condition and the operation cost with respect to candidate vehicles to be arranged and displayed in order of the ranking on the vehicle facility selection screen 1301. This display can be hidden by pressing a close button 1314. In this manner, the candidate vehicles to be allocated to the train are displayed in the ranking order in consideration of the degree of satisfying the facility condition and the operation cost, and thus, the user can easily select a suitable candidate considering the degree of satisfying the facility condition and the operation cost. In addition, a maintenance influence confirmation button 1307 is displayed for each of vehicles other than the candidate vehicle with the highest priority in this display. When this maintenance influence confirmation button 1307 is pressed, a yard influence detail screen 1308 is popped up and can confirm detailed information on influence on the vehicle yard. A vehicle allocation inspector in the vehicle yard can perform selection while comparing the number of people that can be supplied with the vehicle displayed on this screen and presence or absence of a facility with a passenger demand, and the influence on the yard.

[0102] When the user confirms the above-described contents and presses the allocation change button 1306, it is determined that the vehicle with the vehicle name 1310 is allocated to the train with the train name 1302.

[0103] Incidentally, the operation in the case where the user referring to the screen is the vehicle allocation inspector of the vehicle yard has been described. When a

provider servicing a vehicle and requesting a vehicle arrangement uses this system, it is also possible to adopt a method of displaying results of other yards together and selecting a yard that demands a vehicle allocation together. In such a case, in requesting the vehicle arrangement, it is possible to determine which vehicle of which yard can be requested by displaying the yard name 1313 together in requesting the vehicle arrangement. When the provider requests the vehicle arrangement and desires to immediately a vehicle, the minimum time until the vehicle is dispatched from the yard to the main line is prioritized even if the influence on the vehicle yard is great. However, if there is a margin in the time until the vehicle is dispatched from the yard to the main line in using the vehicle or if some changes are allowed, it is also possible to make a determination by arranging a vehicle with little influence on the yard of the vehicle or by sending a request by giving priority to a vehicle with a facility that meets more demands of passengers.

[0104] Next, a yard management screen will be described.

[0105] Fig. 14 is a view illustrating an example of the yard management screen displayed on the display device 60 illustrated in Fig. 1.

[0106] The display device 60 illustrated in Fig. 1 displays a yard management screen 1401 illustrated in Fig. 14. The yard management screen 1401 is a screen configured to facilitate grasping of an operating state of the yard and a tendency of an index that needs to be shared with the service provider and displays a service state 1402 for each route and a KPI graph 1403 managed by the vehicle yard.

[0107] For an extracted candidate, the service state 1402 for each route displays a train diagram which is a service status with respect to a route name 14022 when the candidate is applied in a graph format, and properly updates the train diagram in accordance with a change of the service status. When the vehicle allocation request is notified, the screen is updated and displayed such that a train diagram requesting the vehicle can be distinguished by using bold characters or changing color so as to be distinguishable as a specific train diagram 14021.

[0108] The KPI graph 1403 of the vehicle yard graphically displays: an index that needs to be shared with the service provider, such as a congestion rate and an on-time service rate, relating to the train diagram when the candidate is applied; and an index that needs to be grasped and improved by a manager of the vehicle yard such as the operation cost, an inspection achievement rate, and a worker load.

[0109] In this manner, it is possible to graphically display the train diagram after the application of the extracted candidate vehicle and the index that needs to be improved, and favorably support the work of the user evaluating the candidate.

[0110] In addition, a current time 14023 illustrated in the service state 1402 for each route is changed, display of the KPI graph 1403 of the vehicle yard is updated to

the actual KPI if the it is the past time or to predicted KPI if it is time previous to the current time. As a result, the user can graphically view a value of the index at each time and its change and evaluate the candidate.

[0111] Incidentally, it is also possible to interlock the yard management screen 1401 illustrated in Fig. 14 with the vehicle facility selection screen 1301 illustrated in Fig. 13.

[0112] In that case, the display device 60 is caused to display the vehicle facility selection screen 1301 by pressing a vehicle facility selection screen interlocking button 14024 displayed on the yard management screen 1401. As a result, the display device 60 displays the vehicle facility selection screen 1301 such that the condition of the item included in the facility condition can be designated and changed. When a candidate vehicle whose KPI displayed in the KPI graph 1403 of the yard management screen 1401 is desirably confirmed is selected on the vehicle facility selection screen 1301 displayed on the display device 60, the display of the KPI graph 1403 of the yard management screen is updated in accordance with predicted change data, and a difference 1401 between the KPIs before and after the allocation is displayed. In the example illustrated in Fig. 14, a congestion rate 14026 before allocating the vehicle is 85%, but a congestion rate 14026 after allocating the vehicle is 80% so that it is possible to confirm that the congestion rate can be reduced by 5% as one of effects of the vehicle allocation. The user 80 confirms a change rate of the KPI graph 1403 when the vehicle allocation occurs while managing the KPI of the yard, and thus, can designate or change the condition of the item included in the facility condition using the vehicle facility selection screen 1301 so that it is possible to implement a better vehicle allocation. When the condition of the item included in the facility condition is designated or changed using the vehicle facility selection screen 1301, a candidate is extracted by the vehicle candidate extraction unit 103 under the new facility condition, and the display device 60 displays a train diagram when the candidate is applied and a KPI when the candidate is applied, for the extracted candidate. As a result, the user can confirm the train diagram and index for the candidate while designating or changing the facility condition and evaluate the candidate.

[0113] When the user needs the vehicle allocation, it is possible to determine what kind of facility a vehicle allocation candidate has and whether the facility is suitable for the requested diagram by performing the above-described series of processes. In addition, it is possible not only to confirm the passenger satisfaction but also to determine the vehicle allocation after grasping the degrees of the operation cost and the effect caused by the vehicle allocation as the influence on the yard, and thus, it is possible to reduce man-hours to review the vehicle allocation. That is, the vehicle candidate, which satisfies the constraint condition and the facility condition and is allocable to the train on the train diagram to be capable

of transporting the number of passengers with demand, is searched, the operation cost required to allocate the vehicle is calculated, and the vehicle candidate and the operation cost are displayed. Thus, it is possible to support the implementation of the vehicle allocation in consideration of the constraint imposed on the vehicle allocation defined for each vehicle yard, the facility that needs to be provided in the vehicle defined for each time and/or route, the number of passengers that needs be transportable by the train, and the cost required for the operation of the vehicle.

[0114] In addition, the example in which the user who performs the vehicle allocation in the vehicle yard uses the present system has been described in the above-described embodiment. However, the system can be used by a user such as the service provider who manages train service, determines the train diagram change, and requests the vehicle allocation to the yard. In that case, it is possible to display the screens illustrated in Fig. 13 and Fig. 14 corresponding relevant yards and to use the screen to select a yard that issues a request after grasping a load of the yard and availability of a vehicle that matches a passenger demand.

[0115] Incidentally, the present invention is not limited to the above embodiment as it is, and the constituent elements can be modified and embodied within a scope not departing from a gist thereof in the implementation stage. In addition, various inventions can be formed by appropriately combining the plurality of constituent elements disclosed in the above embodiment. For example, some constituent elements may be deleted from all the constituent elements described in the embodiment. Further, constituent elements in different embodiments may be appropriately combined.

Claims

1. A vehicle allocation support system that supports work of allocating a vehicle to a train of a railroad, the system comprising:

a constraint management unit that manages a constraint condition indicating an item to be satisfied when allocating a vehicle at a vehicle yard to a train, the constraint condition being determined for each vehicle yard, and a facility condition indicating a facility to be included in a vehicle to be allocated to a train, the facility condition being determined for each time and/or route; a vehicle candidate extraction unit that extracts a candidate of a vehicle to be allocated to the train on a train diagram, the candidate being extracted by searching for a vehicle that is allocable to the train on the train diagram so as to satisfy the constraint condition and the facility condition and to be capable of transporting a number of passengers with demand, when in-

formation on the number of passengers with demand, which is a number of passengers that needs to be transportable by the train, is given together with an allocation implementation request to implement allocation of a vehicle to a train on the train diagram;

an influence determination unit that calculates an operation cost, for the extracted candidate, based on influence degrees, which are degrees of influence on a shunting plan which is a plan concerning circulation of vehicles, a crew plan which is a plan concerning an allocation of crews to a train, and a work plan which is a plan concerning work including a vehicle inspection; and a display unit that displays the operation cost relating to the candidate of the extracted candidate.

2. The vehicle allocation support system according to claim 1, wherein the vehicle candidate extraction unit acquires inspection history indicating history of inspections performed on all vehicles managed in the vehicle yard, and an inspection plan indicating a plan of inspections to be implemented for all the vehicles, extracts vehicles allocable to the train from among vehicles whose inspections have been completed in a time zone in which an allocation of a vehicle to a train is requested by the allocation implementation request, and extracts, from among the extracted vehicles, a vehicle which satisfies the constraint condition and the facility condition and allows the number of passengers with demand to be transported.
3. The vehicle allocation support system according to claim 1, wherein the influence determination unit further calculates each of the degrees of influence on the shunting plan which is the plan concerning circulation of vehicles, the crew plan which is the plan concerning the allocation of crews to the train, and the work plan which is the plan concerning the work including the vehicle inspection, for the extracted candidates, and calculates the operation cost by totaling the influence degree on the shunting plan, the influence degree on the crew plan, and the influence degree on the work plan.
4. The vehicle allocation support system according to claim 3, wherein the influence determination unit specifies a change generated in each of the shunting plan, the crew plan, and the work plan when a vehicle as the extracted candidate is allocated to the train, and calculates cost required for the specified change as the operation cost.
5. The vehicle allocation support system according to

claim 1, wherein

the display unit ranks the plurality of extracted candidates based on a degree of satisfying the facility condition and the operation cost, and arranges and displays the extracted candidates in order of the ranking.

6. The vehicle allocation support system according to claim 1, wherein
for the extracted candidates, the display unit displays in a graph format a train diagram when the candidates are applied and an index that needs to be improved concerning the train diagram when the candidates are applied.

7. The vehicle allocation support system according to claim 6, wherein
when a change in time is designated in the display of the train diagram, the display unit displays the index at the designated time.

8. The vehicle allocation support system according to claim 6, wherein
the display unit performs display so as to enable a condition of an item included in the facility condition to be designated and changed, and, when the condition of the item is specified or changed, causes the vehicle candidate extraction unit to extract a candidate under a new facility condition, and displays a train diagram when the candidate is applied and an index when the candidate is applied for the candidate.

9. A computer-executable vehicle allocation support method for supporting work of allocating a vehicle to a train of a railroad, the method comprising:

a constraint management process of managing a constraint condition indicating an item that needs to be satisfied when allocating a vehicle at a vehicle yard to a train, the constraint condition being determined for each vehicle yard, and a facility condition indicating a facility that needs to be included in a vehicle to be allocated to a train, the facility condition being determined for each time and/or route;
a vehicle candidate extraction process of extracting a candidate of a vehicle to be allocated to the train on a train diagram, the candidate being extracted by searching for a vehicle that is allocable to the train on the train diagram so as to satisfy the constraint condition and the facility condition and to be capable of transporting a number of passengers with demand, when information on the number of passengers with demand, which is a number of passengers that needs to be transportable by the train, is given together with an allocation implementation re-

quest to implement allocation of a vehicle to a train on the train diagram;

an influence determination process of calculating, for the extracted candidate, an operation cost based on influence degrees, which are degrees of influence on a shunting plan which is a plan concerning circulation of vehicles, a crew plan which is a plan concerning an allocation of crews to a train, and a work plan which is a plan concerning work including a vehicle inspection; and

a display process of displaying the operation cost relating to the candidate of the extracted candidate.

10. A program configured to cause a computer to execute:

a constraint management procedure of managing a constraint condition indicating an item that needs to be satisfied when allocating a vehicle at a vehicle yard to a train, the constraint condition being determined for each vehicle yard, and a facility condition indicating a facility that needs to be included in a vehicle to be allocated to a train, the facility condition being determined for each time and/or route;

a vehicle candidate extraction procedure of extracting a candidate of a vehicle to be allocated to the train on a train diagram, the candidate being extracted by searching for a vehicle that is allocable to the train on the train diagram so as to satisfy the constraint condition and the facility condition and to be capable of transporting a number of passengers with demand, when information on the number of passengers with demand, which is a number of passengers that needs to be transportable by the train, is given together with an allocation implementation request to implement allocation of a vehicle to a train on the train diagram;

an influence determination procedure of calculating, for the extracted candidate, an operation cost based on influence degrees, which are degrees of influence on a shunting plan which is a plan concerning circulation of vehicles, a crew plan which is a plan concerning an allocation of crews to a train, and a work plan which is a plan concerning work including a vehicle inspection; and

a display procedure of displaying the operation cost relating to the candidate of the extracted candidate.

Amended claims in accordance with Rule 137(2) EPC.

1. A vehicle allocation support system that supports work of allocating a vehicle to a train of a railroad, the system comprising:

a constraint management unit configured to manage a constraint condition indicating an item to be satisfied when allocating a vehicle at a vehicle yard to a train, the constraint condition being determined for each vehicle yard, and a facility condition indicating a facility to be included in a vehicle to be allocated to a train, the facility condition being determined for each time and/or route;

a vehicle candidate extraction unit configured to extract a candidate of a vehicle to be allocated to the train on a train diagram, the candidate being extracted by searching for a vehicle that is allocable to the train on the train diagram so as to satisfy the constraint condition and the facility condition and to be capable of transporting a number of passengers with demand, when information on the number of passengers with demand, which is a number of passengers that needs to be transportable by the train, is given together with an allocation implementation request to implement allocation of a vehicle to a train on the train diagram; and

an influence determination unit configured to calculate an operation cost, for the extracted candidate, based on influence degrees, the system being configured to display the operation cost relating to the candidate of the extracted candidate unit on a display device (60), **characterized in that**

the influence determination unit is configured to calculate said operation cost based on influence degrees including influence on a shunting plan which is a plan concerning circulation of vehicles, a crew plan which is a plan concerning an allocation of crews to a train, and a work plan which is a plan concerning work including a vehicle inspection.

2. The vehicle allocation support system according to claim 1, wherein the vehicle candidate extraction unit acquires inspection history indicating history of inspections performed on all vehicles managed in the vehicle yard, and an inspection plan indicating a plan of inspections to be implemented for all the vehicles, extracts vehicles allocable to the train from among vehicles whose inspections have been completed in a time zone in which an allocation of a vehicle to a train is requested by the allocation implementation request, and extracts, from among the extracted vehicles, a vehicle

which satisfies the constraint condition and the facility condition and allows the number of passengers with demand to be transported.

3. The vehicle allocation support system according to claim 1, wherein the influence determination unit further calculates each of the degrees of influence on the shunting plan which is the plan concerning circulation of vehicles, the crew plan which is the plan concerning the allocation of crews to the train, and the work plan which is the plan concerning the work including the vehicle inspection, for the extracted candidates, and calculates the operation cost by totaling the influence degree on the shunting plan, the influence degree on the crew plan, and the influence degree on the work plan.

4. The vehicle allocation support system according to claim 3, wherein the influence determination unit specifies a change generated in each of the shunting plan, the crew plan, and the work plan when a vehicle as the extracted candidate is allocated to the train, and calculates cost required for the specified change as the operation cost.

5. The vehicle allocation support system according to claim 1, wherein the display unit ranks the plurality of extracted candidates based on a degree of satisfying the facility condition and the operation cost, and arranges and displays the extracted candidates in order of the ranking.

6. The vehicle allocation support system according to claim 1, wherein for the extracted candidates, the display unit displays in a graph format a train diagram when the candidates are applied and an index that needs to be improved concerning the train diagram when the candidates are applied.

7. The vehicle allocation support system according to claim 6, wherein when a change in time is designated in the display of the train diagram, the display unit displays the index at the designated time.

8. The vehicle allocation support system according to claim 6, wherein the display unit performs display so as to enable a condition of an item included in the facility condition to be designated and changed, and, when the condition of the item is specified or changed, causes the vehicle candidate extraction unit to extract a candidate under a new facility condition, and displays a train diagram when the candidate is applied and an

index when the candidate is applied for the candidate.

9. A computer-executable vehicle allocation support method for supporting work of allocating a vehicle to a train of a railroad, the method comprising:

a constraint management process of managing a constraint condition indicating an item that needs to be satisfied when allocating a vehicle at a vehicle yard to a train, the constraint condition being determined for each vehicle yard, and a facility condition indicating a facility that needs to be included in a vehicle to be allocated to a train, the facility condition being determined for each time and/or route;

a vehicle candidate extraction process of extracting a candidate of a vehicle to be allocated to the train on a train diagram, the candidate being extracted by searching for a vehicle that is allocable to the train on the train diagram so as to satisfy the constraint condition and the facility condition and to be capable of transporting a number of passengers with demand, when information on the number of passengers with demand, which is a number of passengers that needs to be transportable by the train, is given together with an allocation implementation request to implement allocation of a vehicle to a train on the train diagram;

an influence determination process of calculating, for the extracted candidate, an operation cost based on influence degrees, and

a display process of displaying the operation cost relating to the candidate of the extracted candidate,

characterized in that

influence degrees considered for operation cost determination are degrees of influence on a shunting plan which is a plan concerning circulation of vehicles, a crew plan which is a plan concerning an allocation of crews to a train, and a work plan which is a plan concerning work including a vehicle inspection.

10. A program configured to cause a computer to execute:

a constraint management procedure of managing a constraint condition indicating an item that needs to be satisfied when allocating a vehicle at a vehicle yard to a train, the constraint condition being determined for each vehicle yard, and a facility condition indicating a facility that needs to be included in a vehicle to be allocated to a train, the facility condition being determined for each time and/or route;

a vehicle candidate extraction procedure of ex-

tracting a candidate of a vehicle to be allocated to the train on a train diagram, the candidate being extracted by searching for a vehicle that is allocable to the train on the train diagram so as to satisfy the constraint condition and the facility condition and to be capable of transporting a number of passengers with demand, when information on the number of passengers with demand, which is a number of passengers that needs to be transportable by the train, is given together with an allocation implementation request to implement allocation of a vehicle to a train on the train diagram;

an influence determination procedure of calculating, for the extracted candidate, an operation cost based on influence degrees, and

a display procedure of displaying the operation cost relating to the candidate of the extracted candidate,

characterized in that

influence degrees considered for operation cost determination are degrees of influence on a shunting plan which is a plan concerning circulation of vehicles, a crew plan which is a plan concerning an allocation of crews to a train, and a work plan which is a plan concerning work including a vehicle inspection.

FIG. 1

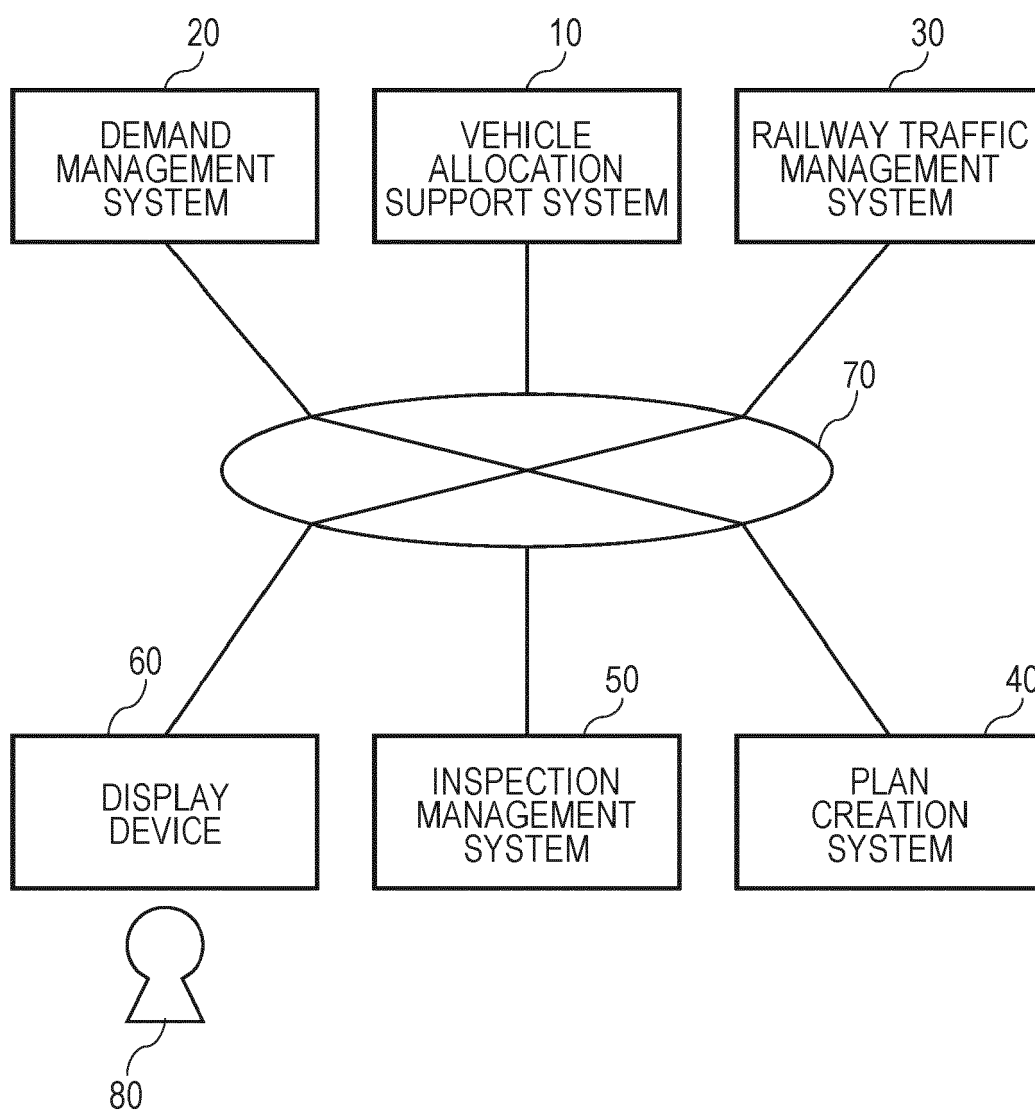


FIG. 2

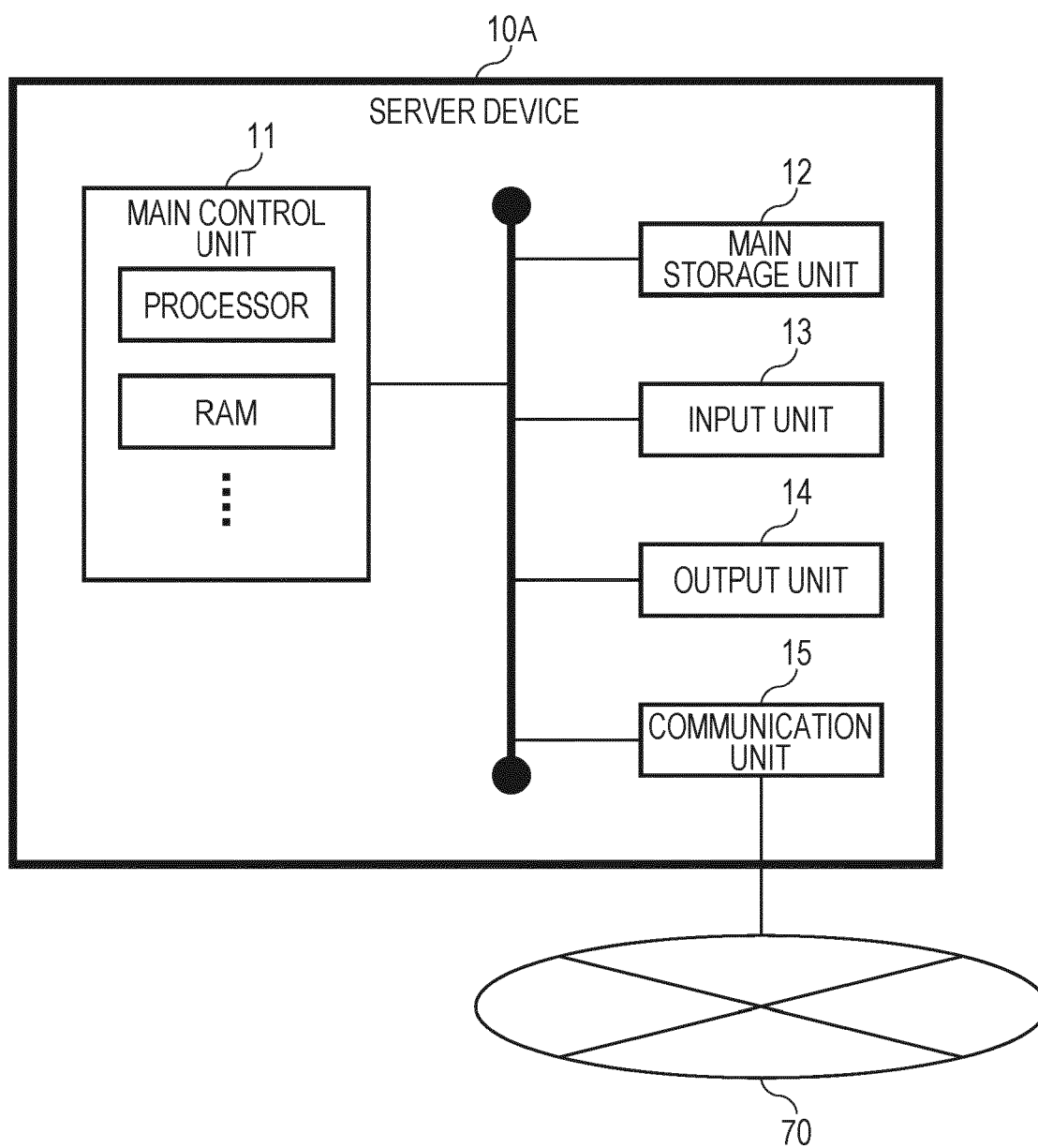


FIG. 3

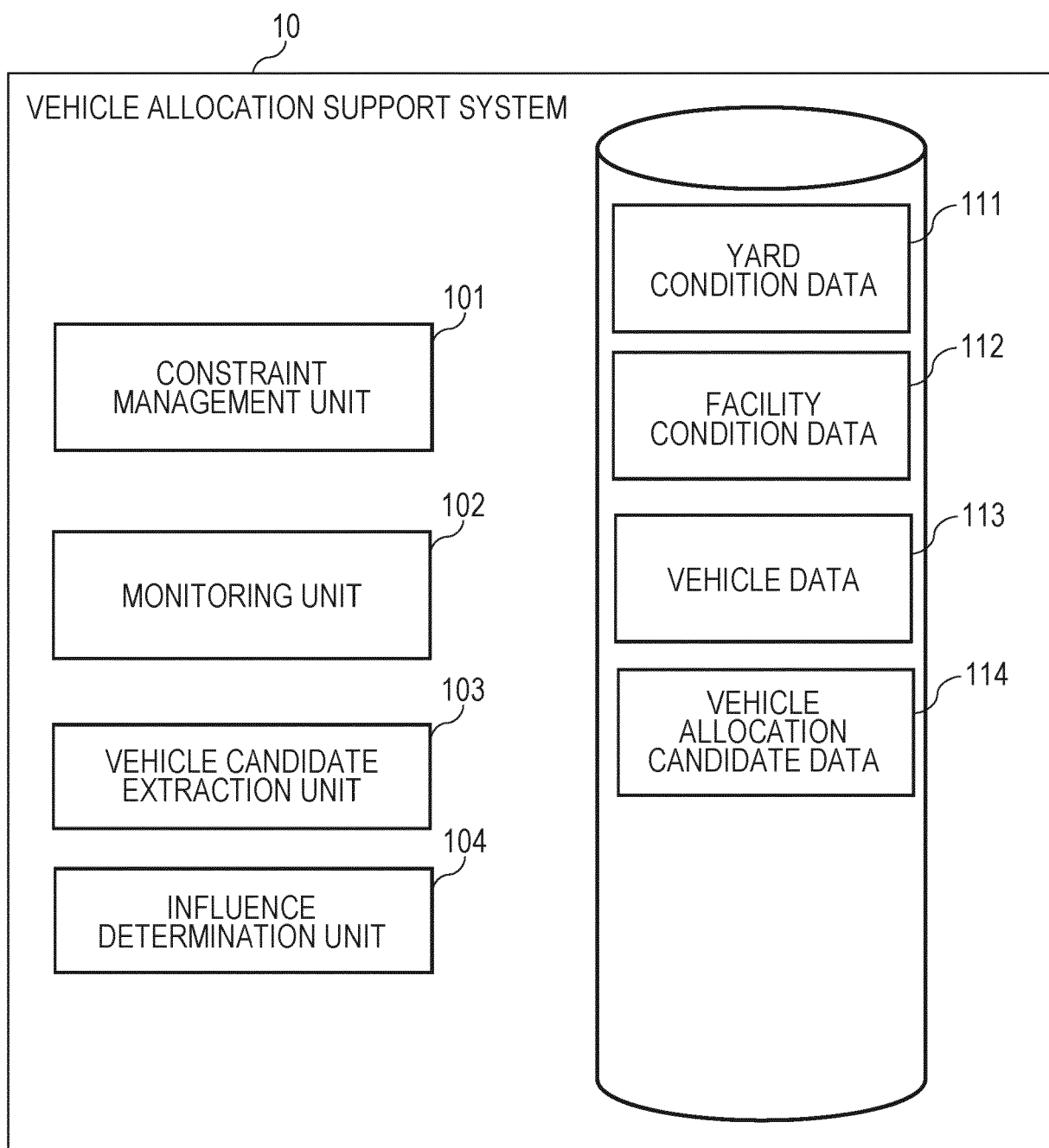


FIG. 4

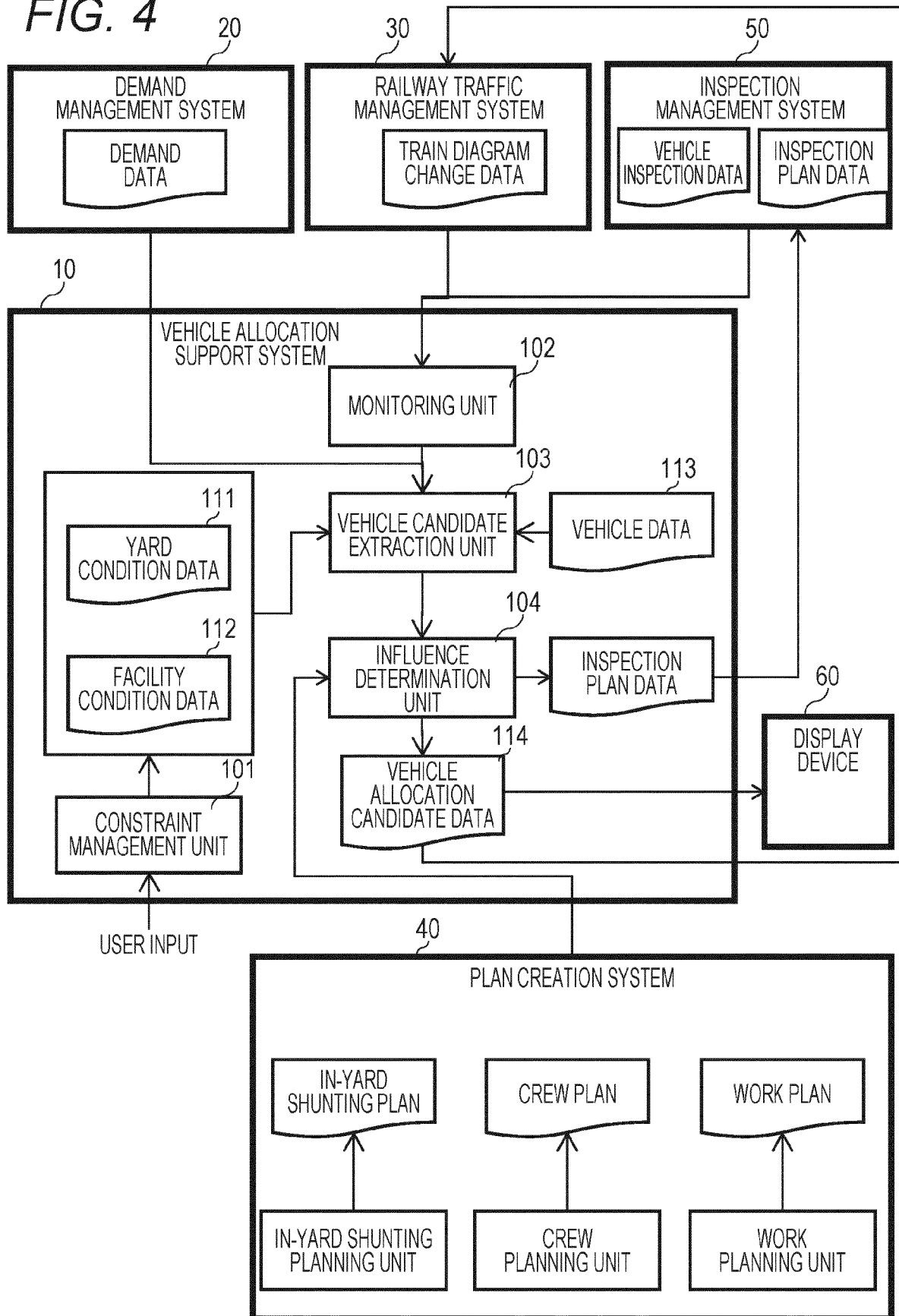


FIG. 5

501	502	503	504	505
YARD ID	ROUTE ID	CONSTRAINT	EVALUATION VALUE	PRIORITY
X	T	VEHICLE ALLOCATION IN CHANGE OF VEHICLE ORGANIZATION	PRESENT	1 (MUST)
X	-	MAXIMUM NUMBER OF USES OF SPARE VEHICLES PER DAY	3	2
X	TT	VEHICLE ALLOCATION IN MIDDLE OF INSPECTION	PRESENT	3
X	T	UPPER LIMIT OF OPERATION COST	+2000	1 (MUST)
...	...	...	...	...

FIG. 6

ROUTE ID	TIME ZONE	603					NUMBER OF CARS	...
		Wifi	BICYCLE SPACE	WHEELCHAIR	CATERING			
T	WEEKDAYS 6-8	-	-	-	-	-	-	-
T	8-10	⊙	-	○	⊙	8 OR MORE	-	-
T	10-17	○	○	○	-	-	-	-
T	17-23	○	-	○	-	6 OR MORE	-	-
T	SUNDAY 6-8	-	○	-	-	-	-	-
S	8-10	⊙	○	-	-	-	-	-
...	...	...	...	...	...	...	...	...

FIG. 7

ATTRIBUTE INFORMATION OF VEHICLE			INSPECTION INFORMATION			
701 VEHICLE ID	702 TYPE	703 ORGANIZATION ID	704 SUPPLY NUMBER	705 CUMULATIVE TRAVEL DISTANCE	706 LATEST INSPECTION COMPLETION DATE AND TIME	707 STATE
A11	ABC201	H81	150	3000	20180711	1111
A12	ABC202	H82	100	2500	20180713	1112
A13	ABC203	H41	200	3500	20180710	1113
A14	ABC204	H43	200	3000	20180710	1114
A15	ABC205	H42	150	2500	20180712	YARD 1
AA11	ACC103	H85	100	3000	20180713	YARD 3
...	...	...	...	...	...	...

FIG. 8

801 VEHICLE ID	802 CONSTRAINT SATISFYING NUMBER	803 FACILITY SATISFYING NUMBER	804 EXCESS BOARDING NUMBER	805 MINIMUM PREPARATION TIME	806 DAY INSPECTION STATUS	807 SHUNTING PLAN INFLUENCE DEGREE	808 CREW PLAN INFLUENCE DEGREE	809 WORK PLAN INFLUENCE DEGREE	810 OPERATION COST
A11	5	3	64	1h	INSPECTED	+3	+5	0	2500
A13	3	5	64	2h	MIDDLE OF INSPECTION	+8	+5	0	3000
AA11	4	5	-50	4h	-	+15	0	+15	4500
...	...	...	...	...	...	...	...	...	...

FIG. 9

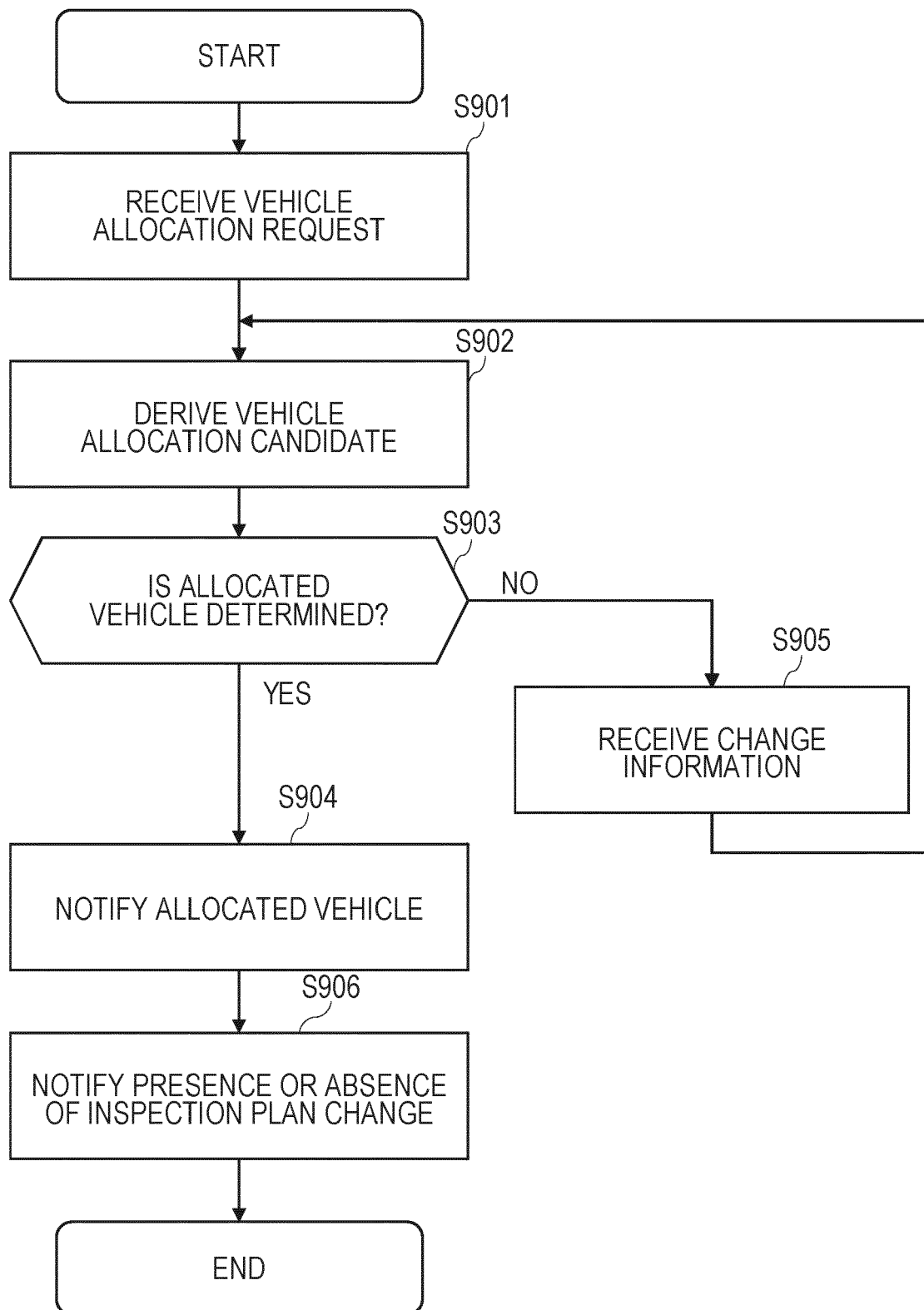


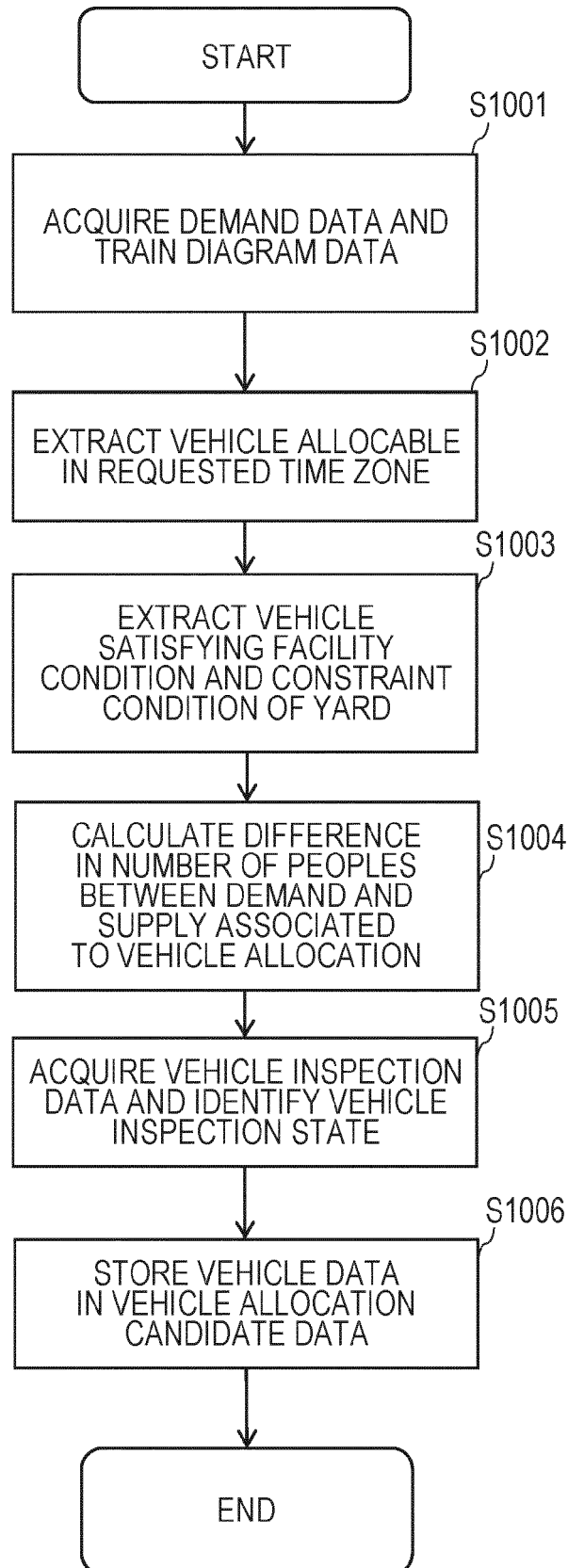
FIG. 10

FIG. 11

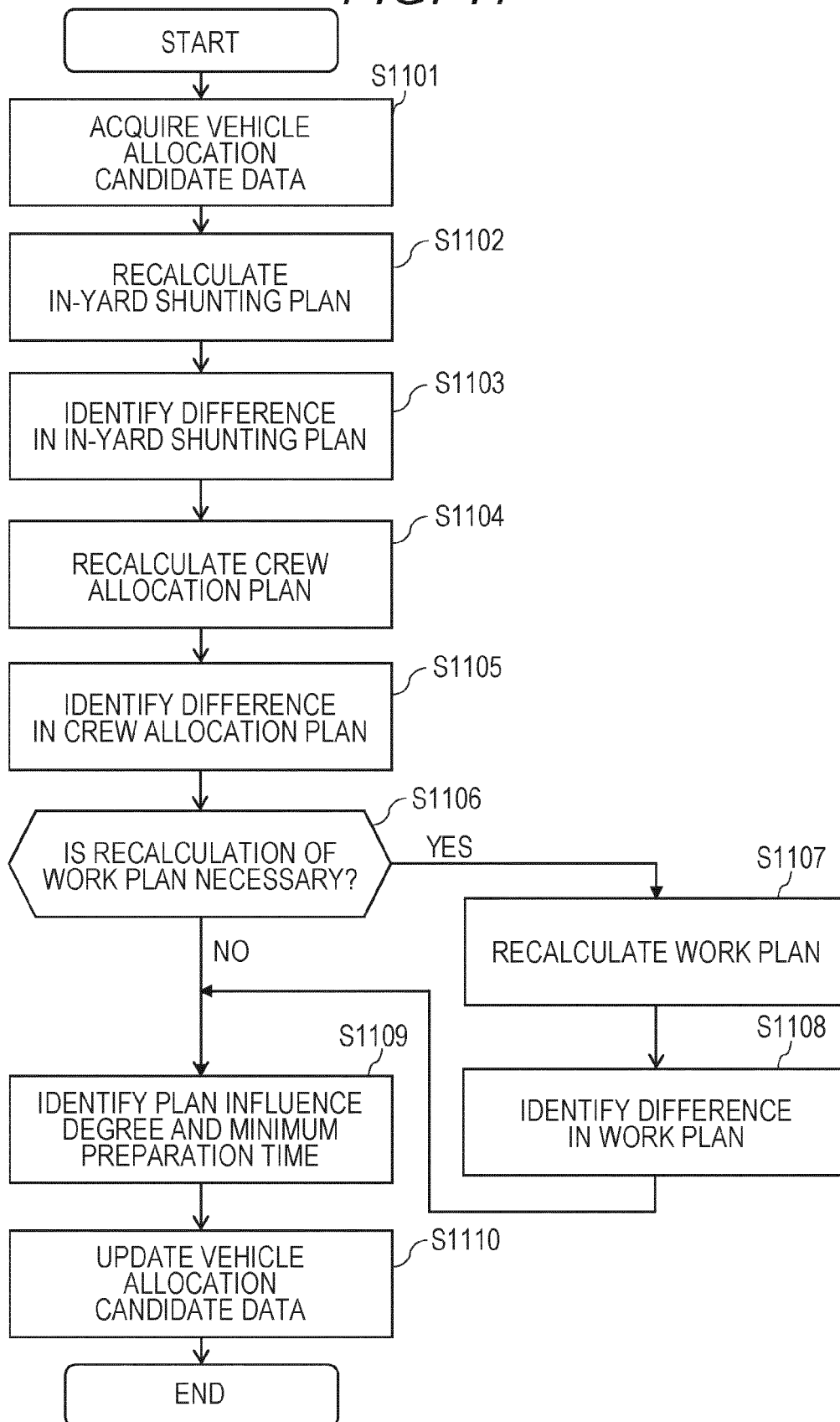


FIG. 12

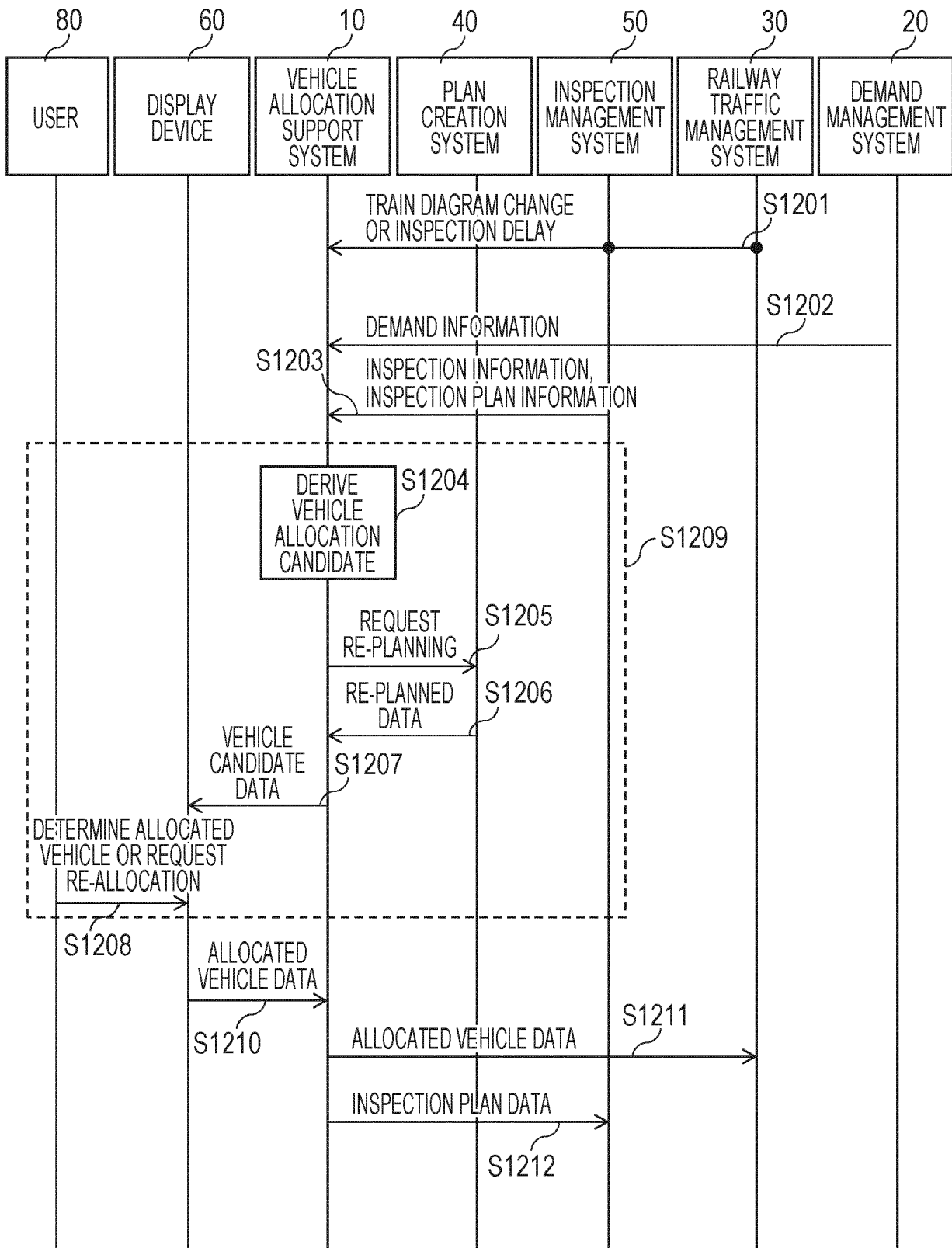


FIG. 13

1301

1302

1303

1309

1311

1312

1304

1305

1306

1307

1308

1310

1313

1314

VEHICLE ALLOCATION SCREEN

TRAIN NAME 100A

ALLOCATED VEHICLE A11

VEHICLE REQUIREMENTS

TOILET

WHEELCHAIR

BICYCLE

EXCESS BOARDING NUMBER +64

SENDING TIME FROM YARD (CERTAINTY OF BEING PUT INTO OPERATION)

SEEM TO BE IMMEDIATELY DISPATCHED

VEHICLE A11

YARD X

VEHICLE B12

YARD Y

SEEM TO REQUIRE HALF-DAY

SEEM TO BE IMMEDIATELY SENT

CONFIRM MAINTENANCE INFLUENCE

MIDDLE OF ALLOCATION

CONFIRM MAINTENANCE INFLUENCE

ALLOCATION

ALLOCATION CHANGE

Close

TRAIN NAME 200A

VEHICLE REQUIREMENTS

TOILET

WHEELCHAIR

BICYCLE

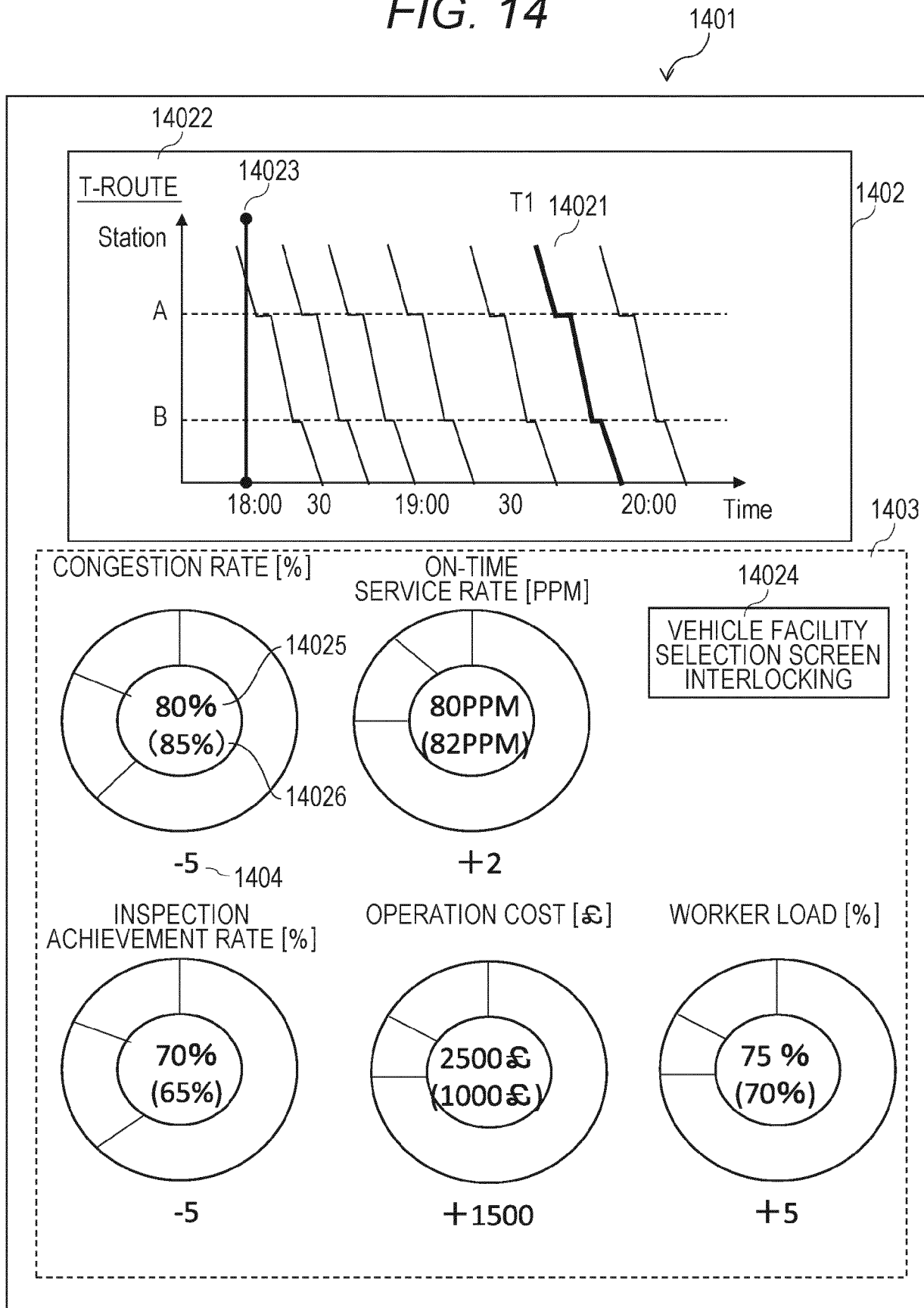
EXCESS BOARDING NUMBER

SENDING TIME FROM YARD

INFLUENCE ON YARD OPERATION:
INSPECTION CHANGE: PRESENT
ENTRY SECTION NUMBER: 2 → 3
DEADHEADING: PRESENT
INSPECTION DATE CHANGE: NO
NEXT INSPECTION DATE: THREE DAYS LATER
ADDITIONALLY REQUIRED TIME: 5h
OPERATION COST: +1500 £

CANCEL

FIG. 14





EUROPEAN SEARCH REPORT

 Application Number
 EP 19 15 9979

5

10

15

20

25

30

35

40

45

50

55

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y	US 2007/005200 A1 (WILLS MITCHELL S [US] ET AL) 4 January 2007 (2007-01-04) * paragraph [0010] - paragraph [0054]; figures 1,2 * * claims 9,10 *	1-10	INV. B61L17/00 B61L27/00
Y	US 2016/292627 A1 (YAMADA TAKEAKI [JP]) 6 October 2016 (2016-10-06) * paragraphs [0029] - [0030]; figure 1 *	1-10	
Y	EP 3 086 268 A1 (HITACHI LTD [JP]) 26 October 2016 (2016-10-26) * paragraph [0085] - paragraph [0102] *	6-8	
			TECHNICAL FIELDS SEARCHED (IPC)
			B61L
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 25 September 2019	Examiner Mäki-Mantila, M
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			

 1
 EPO FORM 1503 03.82 (P04C01)

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

EP 19 15 9979

5 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.

25-09-2019

10

15

20

25

30

35

40

45

50

55

ORM P0459

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2007005200 A1	04-01-2007	BR PI0608008 A2	03-11-2009
		CA 2599780 A1	21-09-2006
		CN 101535942 A	16-09-2009
		EP 1861302 A2	05-12-2007
		US 2007005200 A1	04-01-2007
		WO 2006099387 A2	21-09-2006
		ZA 200708324 B	31-12-2008

US 2016292627 A1	06-10-2016	CN 105814600 A	27-07-2016
		JP 2015138395 A	30-07-2015
		SG 11201604141T A	30-08-2016
		US 2016292627 A1	06-10-2016
		WO 2015111342 A1	30-07-2015

EP 3086268 A1	26-10-2016	EP 3086268 A1	26-10-2016
		JP 6571376 B2	04-09-2019
		JP 2016203873 A	08-12-2016

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2014151849 A [0004] [0005] [0006]