The second phase of SIP Automated Driving for Universal Services / Survey and Field test for improving logistics efficiency based on architecture utilizing vehicle information such as probes

Summary Report

Nittsu Research Institute and Consulting, Inc.

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Objectives of the project

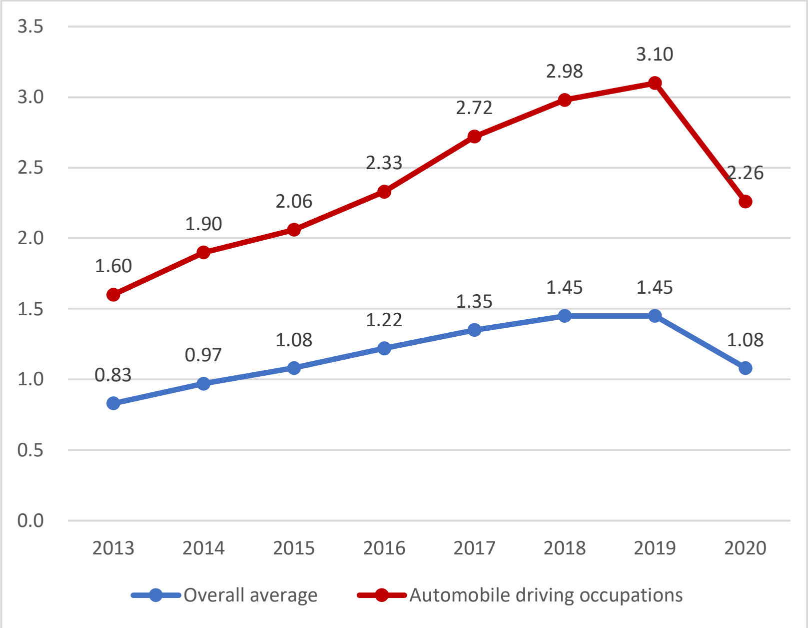
To promote the implementation of automated driving technology in truck transportation in the future, initial stage research and verification is conducted to utilize information and data that can be output from vehicles to solve various problems in logistics and reflect information useful for improving logistics efficiency to the information infrastructure of automated driving.

- In the trucking industry, the shortage of truck drivers is becoming more serious due to the long hours on duty and the heavy workload. For this reason, it becomes difficult to maintain the logistics function to deal with the volume of freight transportation, and there is concern that the economy will be adversely affected.
- As a countermeasure, there are high expectations for the implementation of automated driving technology in truck transportation operations. But it seems meaningless to implement automated driving with the current situation with long working hours, e.g., due to waiting time for cargo (waiting for cargo loading and unloading work) in warehouses and distribution centers. Thus, it is firstly necessary to reduce the time required for operation work.
- Based on this, we examined measures and possibilities to reduce the waiting time for cargo, which is particularly problematic in trucking operations, by utilizing vehicle and probe information. In addition to the waiting time for cargo, we examined the truck operation business process and measures that could lead to time reduction by utilizing vehicles, probes, etc.
- In this project, we will define data items that are useful for shortening the time of truck operation work among vehicle / probe information and verify the possibility of utilizing the data items to shorten the truck operation time. The project was carried out for the purpose of conducting basic research and field tests to organize the architecture design for utilizing those data.

Current situation of truck driver shortage and future outlook for supply-demand gap

While the number of truck drivers peaked in 1995 and has been steadily declining, the ratio of job offers to applicants for automobile driving occupations, including truck drivers, has continued to rise. The ratio of job offers to applicants in 2020, which declined due to the COVID-19 crisis, is also significantly higher than the overall average. It is estimated that there will be a shortage of 214,000 truck drivers in 2030.

Changes in the ratio of job offers to applicants for occupations and automobile driving occupations



Source; The Ministry of Health, Labour and Welfare, Japan

Forecast of supply and demand for commercial truck drivers

(Unit ; thousand)

	FY2020	FY2025	FY2030
Demand	1,053.3	1,157.7	1,184.3
Supply	1,006.7	1,012.1	970.3
Shortage	△46.6	△145.6	△214.0

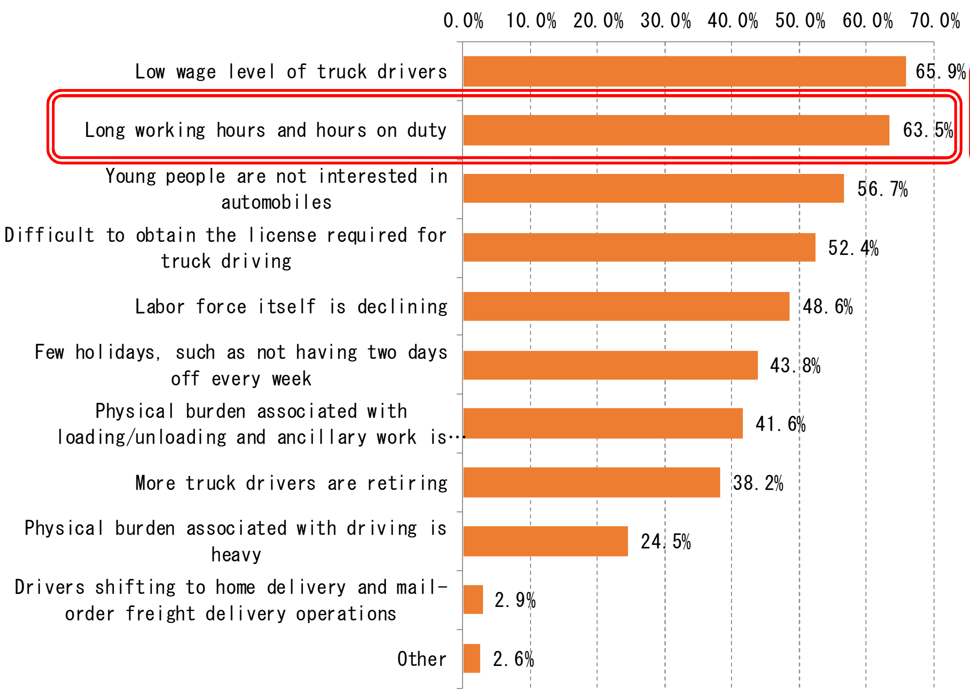
Source ; NRIC

Factors behind the shortage of truck drivers and waiting time for cargo

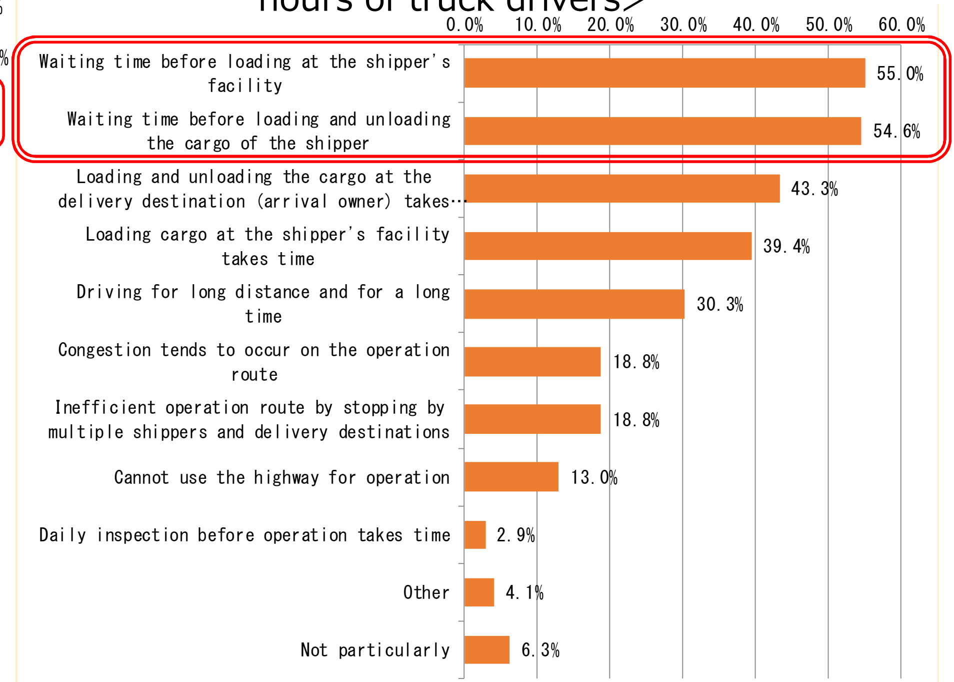
Transport operators recognize "long working hours and hours on duty" as one of the main causes of the shortage of truck drivers. As an operational factor that causes the truck driver to work long hours, "waiting time for loading at the loading site (cargo loading) and unloading site (cargo loading and unloading)" is considered to be the biggest problem.

Questionnaire survey on working hours of truck drivers and utilization of information technology for truck transportation

<Factors behind the shortage of truck drivers>



<Operational bottlenecks that lead to longer working hours of truck drivers>

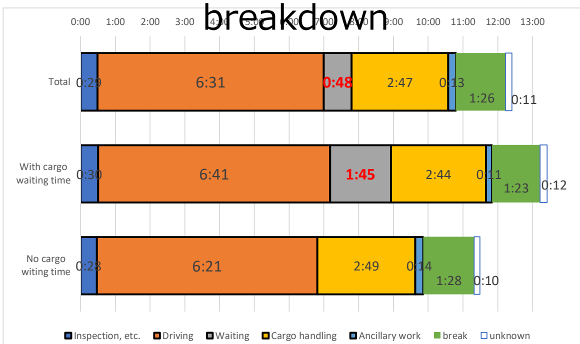


Source ; NRIC, November 2020,（n=416）

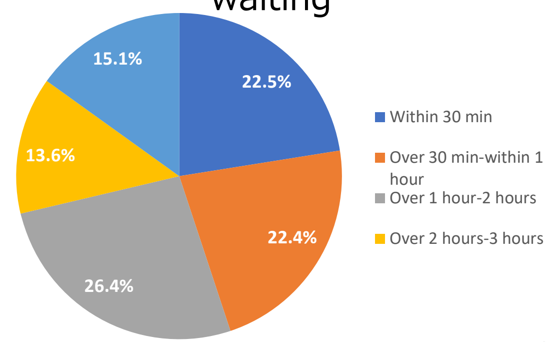
Effect of cargo waiting time on truck drivers' hours on duty

The average cargo waiting time is 48 minutes but 1 hour and 45 minutes with cargo waiting. The average hours on duty with cargo waiting is 1 hour and 53 minutes longer than the average hours on duty without cargo waiting. By type of transported goods, there is a relatively long waiting time for cargo for forest products, metal machinery industry products, light industry products, miscellaneous industry products, etc.

Truck driver hours on duty per operation and its breakdown



Length of the waiting times in operations with cargo waiting



Truck drivers' hours on duty per operation and its breakdown (By transport item, "average for 9 classifications" does not include operation work of unknown transport item)】

	9 classification average	Agriculture and fishery products	Forest products	Mining products	Metal machinery industry products	Chemical industry	Light industrial products	Miscellaneous products	Emissions	Special product
Inspection, etc.	0:30	0:28	0:26	0:34	0:29	0:31	0:30	0:31	0:31	0:31
Driving	6:17	6:39	6:27	6:32	6:10	6:10	6:10	6:20	5:45	6:26
Waiting time for cargo	0:46	0:39	1:00	0:19	0:53	0:37	0:54	0:50	0:36	0:37
Cargo handling	2:46	3:02	2:18	2:02	2:35	2:19	2:59	2:43	1:53	3:06
Ancillary work	0:13	0:13	0:10	0:06	0:15	0:13	0:11	0:11	0:25	0:15
Break / unknown	1:31	1:31	1:23	1:17	1:38	1:24	1:32	1:29	1:25	1:33
Hours on duty	12:04	12:32	11:44	10:50	12:00	11:14	12:16	12:04	10:35	12:28
Waiting time ratio during hours on duty	6.4%	5.2%	8.5%	2.9%	7.4%	5.5%	7.3%	6.9%	5.7%	4.9%
Number of operations for survey	17,377	1,434	432	327	3,870	2,017	4,012	1,779	178	3,328

Source ; Created by NRIC using report of MLIT and MHLW (2015)

Expected information utilization phase for self-driving trucks

It is assumed that the practical application of information utilization for self-driving trucks will be realized through the following steps. There may be information utilization means that have the potential to improve efficiency and shorten time by utilizing information not only in driving operations but also in confirmation operations before driving, and the hurdles for realization are not relatively high.

【Phase 1】 Labor saving and efficiency improvement before and after operation by utilizing vehicle information, probe information, etc.	【Phase 2】 Automated driving operation in closed spaces such as sales offices and shipper facilities(As it is on public roads)	【Phase 3】 Automated driving on public roads(with a driver for an emergency and cargo handling work)	【Phase 4】 Fully automated driving on public roads(Completely unmanned including cargo handling work)
➢ Simplify daily inspections using vehicle info. ➢ Optimization of operation plan utilizing operation info, traffic jam info, weather info, etc. ➢ Improving loading efficiency by utilizing axle load info, loading platform info, etc. ※for operations except driving	➢ Self-driving from the parking to the arrival berth. ➢ Patrol loading at multiple locations on the premises. ➢ Horizontal transport from the material storage area to the line in the factory. ※Driver can get off the truck after parking	➢ The system recognizes traffic conditions and operate driving. ➢ The driver responds in an emergency such as a system malfunction. ➢ The driver carries out incidental work such as cargo handling depending on the transaction conditions with the shipper.	➢ The system recognizes traffic conditions, etc. in the entire process and performs all operations related to driving. ➢ The system also handles emergencies. ➢ The entire process is completely unmanned such as automated opening and closing of loading platform, automated loading and unloading function, etc.

When implementing automated driving in the trucking industry, it is necessary to consider automation based on various laws and regulations that regulate transportation operations in order to achieve both labor saving / unmanned promotion and safety assurance / compliance.

Examination of the possibility of using vehicle / probe data to reduce operating hours①

【Recording and analysis of operation history data for quantitative recognition and sharing of cargo waiting time occurrence status】

In order to reduce the waiting time for cargo, it is necessary for the transport operators and the shipper company to quantitatively share the awareness of the status of the waiting time, and then analyze the factors and consider countermeasures. As the first step, we examined the possibility of utilizing vehicle / probe data for the preparation of quantitative fact-finding data on the status of cargo waiting time.

- ◆ The waiting time for cargo is basically caused by factors on the side of the shipper company. For this reason, in order to eliminate or reduce the cargo waiting time, the transport operators and the shipper company should grasp the actual situation such as the number and time of cargo waiting time at the distribution base of the departure / arrival shipper company and the trend after entering the base. After sharing the information, it is necessary to work on cause analysis and countermeasure examination. For that purpose, it is indispensable to prepare quantitative fact-finding data on the occurrence of waiting time for cargo.
- ◆ However, the departure / arrival shipper company basically does not have a time record of the movement of the truck from entering to leaving the distribution base and the occurrence of cargo waiting time. On the other hand, on the transport operator side, since the load on the truck driver is heavy for the analog time recording for each operation process, there are very few cases where the operation history and time are recorded and maintained for each operation process.
- ◆ Therefore, the truck driver records the history information of the operation process by utilizing the in-vehicle device such as the operation management system. It is hoped that a system for analyzing the situation will be put in place based on the operation history information collected and accumulated by the truck driver to analyze the waiting time for cargo at each distribution. By sharing the analysis information with the shipper company, the shipper company will be encouraged to understand and recognize the actual situation of the cargo waiting time, and will be able to convincingly discuss and formulate measures to eliminate or reduce the cargo waiting time.

Examination of the possibility of using vehicle / probe data to reduce operating hours ②

【Automation and labor saving for daily inspections before truck operation and confirmation of loaded weight】

The cause of the waiting time for cargo is not limited to problems within the distribution base, but early departure / departure may be a cause, keeping in mind the time required for inspections and confirmations required before operation. From this point of view and from the viewpoint of shortening the operation time by improving the efficiency of these inspection / confirmation operations, the possibility of utilizing vehicle / probe data was examined.

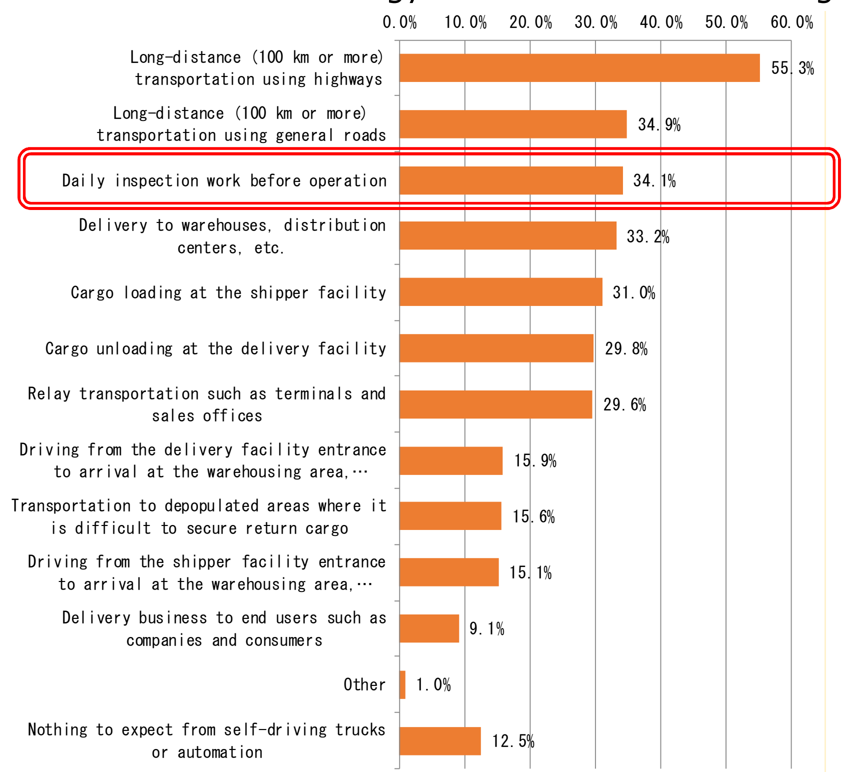
- ◆ Truck drivers always arrive early, fearing that daily pre-operation inspections may take time or cause problems, and as a result, trucks depart and arrive earlier than necessary, resulting in cargo waiting time at the loading or delivery destination. In this way, daily inspections before operation may be a distant cause of waiting time for cargo, so it can be said that improving the efficiency of daily inspections effectively contributes to reducing the waiting time for cargo and suppressing the hours on duty of drivers. In addition, as the opinion of the transport operators, there is a difference in the confirmation / judgment skills of truck drivers in daily inspections, and there is a voice that they want to standardize.
- ◆ If cargo is overloaded at the shipper's destination, the work time will increase because the loaded cargo will be unloaded again, leading to a delay in operation. Therefore, it is very important to know the load weight each time the cargo is loaded in order to prevent from increasing the hours on duty of drivers.
- ◆ For the implementation of self-driving of commercial vehicles such as trucks in the future, it is necessary to pay attention not only to automated driving while driving, but also to automation in operation processes before driving, such as daily inspections and confirmation of whether there is a problem with the load weight. By utilizing the information obtained from the vehicle signal information and the axle load, it is considered that the implementation of these automations has a lower hurdle than the self-driving when driving on the road.

Expectations for automation of daily inspections before truck operation

From a questionnaire survey, it is suitable for long-distance transportation on highways and general roads for "Business that wants to utilize automation technology when it is possible to automate truck driving and operations before and after it without considering restrictions such as investment amount". Next, the answer was "daily inspection work before operation", and it was confirmed that there is a high need for automation of daily inspection work.

【Questionnaire survey on working hours of truck drivers and utilization of information technology for truck transportation】

<Businesses that want to utilize automation technology in truck automatic driving and work before and after it>



Source ; NRIC, November 2020, (n=416)

Field Tests in this project

The following three types of field tests and analyzes were conducted.③ uses data acquired from vehicles, and ①② uses data acquired from in-vehicle devices.

Items	Contents
①Examination for grasping the actual situation of waiting for cargo and sharing information based on operation history data analysis	➢ We will acquire truck operation data, analyze the time required for each operation item in the operation process to understand the actual situation, and conduct studies to shorten working hours and improve efficiency. ➢ In particular, in order to reduce the waiting time for cargo in a closed space, "examination for sharing information on the situation of waiting time for cargo between transport operators, shipper companies, and delivery destinations" and organizing necessary information and data for "implementation of automated operation in a closed space“ are implemented.
②Truck loading weight data acquisition	➢ There is a risk of overloading (overloading of the axle load) at the time of loading, and there is a great need to know whether or not overloading is occurring after cargo handling and before departure. ➢ Based on this, we will conduct a field test to grasp whether the total weight (axle load) of the cargo loaded on the loading platform is within the range stipulated by law with measuring equipment, etc., and to grasp the data in a timely manner.
③Acquisition of vehicle data that contributes to daily inspection item confirmation	➢ Routine inspections are indispensable for accident prevention, etc., but confirmation depends on the driver's personal experience and skill, and if an objective grasp and time-saving measures can be provided, it will reduce the burden of drivers. ➢ In recent years, electronic control of trucks has advanced, and it is possible that data that contributes to the confirmation of daily inspection items can be acquired from the truck, which can lead to confirmation / judgment and reduction of the burden of truck drivers. ➢ Based on this, we will take out the information that contributes to the confirmation of daily inspection items that can be obtained from the vehicle at the present time, and conduct a field test until the data is confirmed.

Acquisition and utilization of operation history data -Overview and significance

Overview	・By analyzing the work record details and other data recorded by the transport operator that has introduced the operation management system using the digital tachograph, the actual situation such as the ratio of cargo waiting time out of hours on duty is grasped. ・Based on the analysis results obtained from this, the possibility that the transport operator can convey the actual situation of the waiting time for cargo to the shipper company and utilize it for discussions for considering countermeasures will be examined.
Significance	・By grasping the actual conditions of "hours on duty", "driving time", "cargo handling time", "loading time", and "others" of truck drivers, it is possible to estimate how much the self-driving trucks will contribute to the reduction of hours on duty. ・In addition, by sharing the situation of the cargo waiting time at the shipper’s premise using the data, it is encouraged to identify the specific location and cause, to contributes to the elimination of the waiting time and improvement of long working hours associated with it. ・As a result, it can be expected to contribute to the optimization of operation plans for the realization of self-driving trucks.

Acquisition and utilization of operation history data -Analysis method

By linking various data acquired from the operation management system using digital tachographs, the restraint time, driving time, cargo handling time, cargo waiting time and others for each driver / working date are totaled. We grasped the ratio of cargo waiting time, etc. during the restraint time of truck drivers. The outline and flow of the data to be analyzed and the analysis method are as follows.

No. of data : 671（Operation record data b/w JUL to NOV 2020）

Work record details

- Cargo handling time
- Loading time

Attendance record, hours on duty management table

- Hours on duty
- Driving time

Vehicle master, etc.

- Vehicle type classification, etc.

By driver, by work date

- **Hours on duty**
- **Driving time**
- **Cargo handling time**
- **Loading time**
- **Others** (time other than above during hours on duty)

Acquisition and utilization of operation history data -Analysis results

Calculated for the total and average as well as the maximum and minimum for hours on duty and driving / cargo handling / waiting time, for a total of 671 operation data.

【Total】

Vehicle type	Hours on duty	Driving	Loading/unloading	Waiting for cargo	Other	No. of data
Small	325:00:00	96:50:00	23:02:00	117:52:00	87:16:00	30
Medium	909:12:00	312:50:00	216:03:00	112:59:00	267:20:00	84
Large	6835:28:00	3300:53:00	1537:57:00	563:05:00	1433:33:00	557
Total	8069:40:00	3710:33:00	1777:02:00	793:56:00	1788:09:00	671

【Average】

Vehicle type	Hours on duty	Driving	Loading/unloading	Waiting for cargo	Other
Small	10:50:00	3:13:40	0:46:04	3:55:44	2:54:32
Medium	10:49:26	3:43:27	2:34:19	1:20:42	3:10:57
Large	12:16:19	5:55:34	2:45:40	1:00:39	2:34:25
Total	12:01:35	5:31:48	2:38:54	1:11:00	2:39:54

【maximum and minimum 】

Vehicle type	Hours on duty		Driving		Loading/unloading		Waiting for cargo	
	Max	Min	Max	Min	Max	Min	Max	Min
Small	14:06:00	7:03:00	6:21:00	1:12:00	3:28:00	0:00:00	11:20:00	0:12:00
Medium	15:37:00	4:50:00	7:32:00	1:06:00	8:14:00	0:00:00	7:12:00	0:01:00
Large	16:00:00	5:30:00	11:33:00	1:25:00	8:05:00	0:00:00	5:14:00	0:01:00

Acquisition and utilization of operation history data - Utilization for discussions between related businesses

In addition to the overall data aggregation analysis results on the previous page, the characteristics and causes of specific cargo waiting locations between the transport operator and the shipper company are targeted for the data of specific vehicles with a large waiting time and the number of times of waiting. We conducted interviews with transport operator, which is the data providers, in order to understand and confirm the possibility of eliminating or reducing the waiting time for cargo.

【Specific examples of interviews based on operation data】

【Case (Vehicle data)】

Vehicle type: Load capacity of 10-ton truck
Main shipper: Transportation machinery and equipment manufacturing industry (exclusive)
Main application: Collection / long-distance transportation / delivery (departure / collection in the evening, delivery before dawn the next day)
Total cargo waiting time (JUL-NOV): 64 hours 43 minutes (76 times)
Average cargo waiting time (JUL-NOV): 51 minutes 6 seconds

【On-site actual conditions (interview results)】

1. Recognition related to the specific example
⇒Aware of the waiting time for cargo, and it is recognized that it is the current situation after discussing with the shipper and making improvements.
2. Possible reason (from the perspective of the transport operator)
⇒Waiting for midnight discount on the highway
(There is a history of discussions to eliminate the waiting time for cargo at the customer's site and the specification of the pickup / delivery time.)
3. Already worked for the improvement?
⇒The need to reduce restraint time is more important than saving on highway tolls. Awareness reform based on data analysis should be promoted.
4. Challenges for improvement
⇒Sharing awareness among stakeholders regarding the merits of shortening hours on duty and the need for further efforts

Effectiveness and issues in implementing operation history data acquisition / analysis

Implementation effectiveness	➢ By utilizing the operation history data, it was possible to specify the vehicles / distribution bases where the waiting time is occurring and the number of hours. ➢ From this result, it is possible to estimate how much the self-driving trucks contributes to shortening the hours on duty of truck drivers. ➢ Since the data provided this time also records the points where the cargo waiting time occurred, it was confirmed that it is possible to roughly identify the specific reason for each cargo waiting time (For 100% identification, a multifaceted survey is required).
Challenges for implementation	➢ Although information on cargo waiting time is useful for discussions to reduce cargo waiting time on an individual company basis, if it is used as shared information for industry and society in general, there is a high possibility that a rejection reaction will occur from both the transport operator and the shipper company. For this reason, it is necessary to find a way to utilize the data with individual company's name remained anonymous to outside the parties concerned. ➢ It is not realistic for small and medium-sized transport operators to perform the calculation of cargo waiting time and the time analysis for each operation process performed in this field test in practice, and software development and maintenance or analysis for calculation analysis would be necessary. ➢ It is necessary to establish a mechanism for information linkage in which the transport operator and the departure / arrival shipper company share the occurrence situation of the cargo waiting time at the shipper's premise by utilizing the data. ➢ By receiving appropriate provision of existing data recorded and managed by each company, it can be expected to contribute to the optimization of operation plans for the realization of self-driving trucks, and it is desirable to establish a system for that purpose.

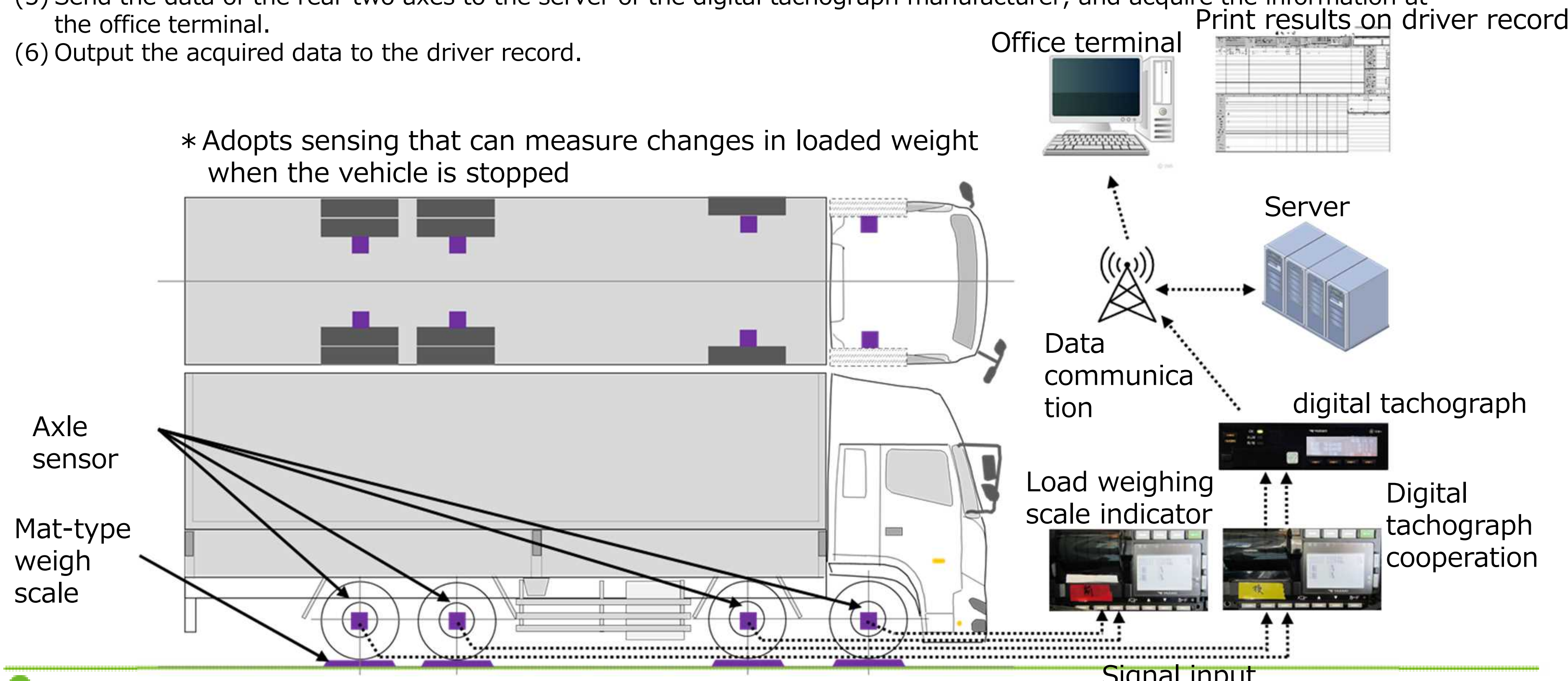
Acquisition and utilization of load weight information -Overview and significance

Overview	・Whether or not the total weight of the cargo loaded on the loading platform is within the maximum load capacity of the vehicle is grasped by the load on the luggage compartment, the axle load, etc., and the loaded weight is grasped in real time at the time of loading.
Significance	・By knowing the exact load capacity of the cargo, it is possible to judge on the spot whether or not it is within the maximum load capacity. ・If the overload situation is found on the observatory after loading, reloading will be required, which will lead to increased waiting time and work time, but **if the loaded weight can be grasped at the time of loading, it will lead to suppression of waiting**. ・Overloading itself is a violation of laws and regulations, and accurate understanding of the status of overloading will lead to stronger legal compliance. ・If the load capacity can be grasped, it will lead to improvement of loading efficiency (improvement of transportation efficiency) by devising operations such as stacked transportation in empty space and joint delivery.

Acquisition and utilization of load weight information -System configuration of field test

The axle load measurement data is acquired from the axle load sensor and the information is transmitted to the terminal via the digital tachograph.

(1) A mat-type weigh scale is installed to check the measurement result of the load weigh scale for loading dummy weights.
(2) Axle load sensors are installed on each axle (4 axes x 2).
(3) Two axle load indicators are installed in parallel in the cab (two axle load indicators are used because the input of the indicator is up to 3 axes).
(4) Send the signal of the rear two-axis display to the digital tachograph (because the digital tachograph has one input system).
(5) Send the data of the rear two axes to the server of the digital tachograph manufacturer, and acquire the information at the office terminal.
(6) Output the acquired data to the driver record.

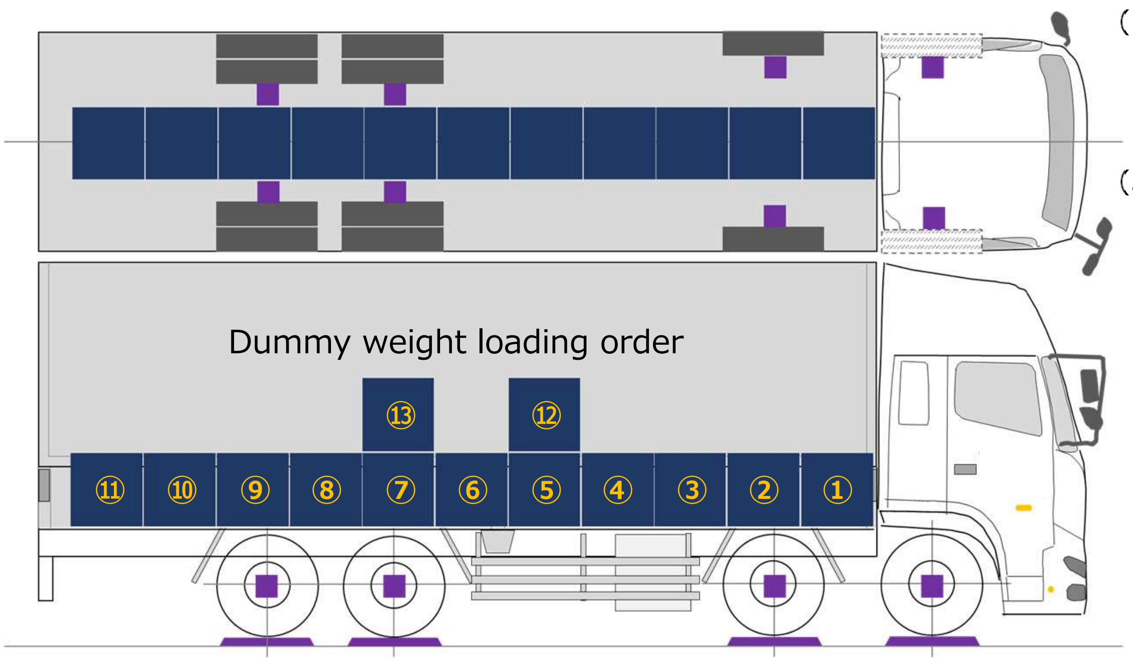


Acquisition and utilization of load weight information -Procedure of field test

(1) From an empty vehicle, 1 ton of dummy weight is loaded in units of one.
(2) Since the maximum load capacity of the test vehicle is 13.9 tons (13,900 kg), dummy weights can be loaded up to 13 tons.
(3) The order of loading dummy weights is basically to load one by one from the cab side (Torii side) toward the rear.
 * Refer to the circled numbers in the figure below for the loading order.
(4) Visually record the results of the mat-type weight scale and the load weight scale display for each dummy weight loading.
(5) When 13 tons of dummy weight is loaded, the total value of the rear two-axis display is acquired and printed on the digital tachograph.
(6) Unload all dummy weights and return them to the empty state.
(7) Repeat steps ① to ⑥ above 5 times.

＊A 1t weight of the 3rd grade standard weight is used for dummy weight

＊Conducted as an experimental environment condition that the road surface environment is flat



field test schedule, etc.
(1) field test schedule
 January 8, 2021 (Friday) (axle sensor installation)
 January 11, 2021 (Monday) (calibration work of loaded weight scale)
 January 13, 2021 (Wednesday) (field test)
(2) Experiment site (specified measuring instrument manufacturer)
 Yazaki Energy System Sagamihara Factory2-14-3 Miyashimo, Chuo-ku, Sagamihara City, Kanagawa Prefecture

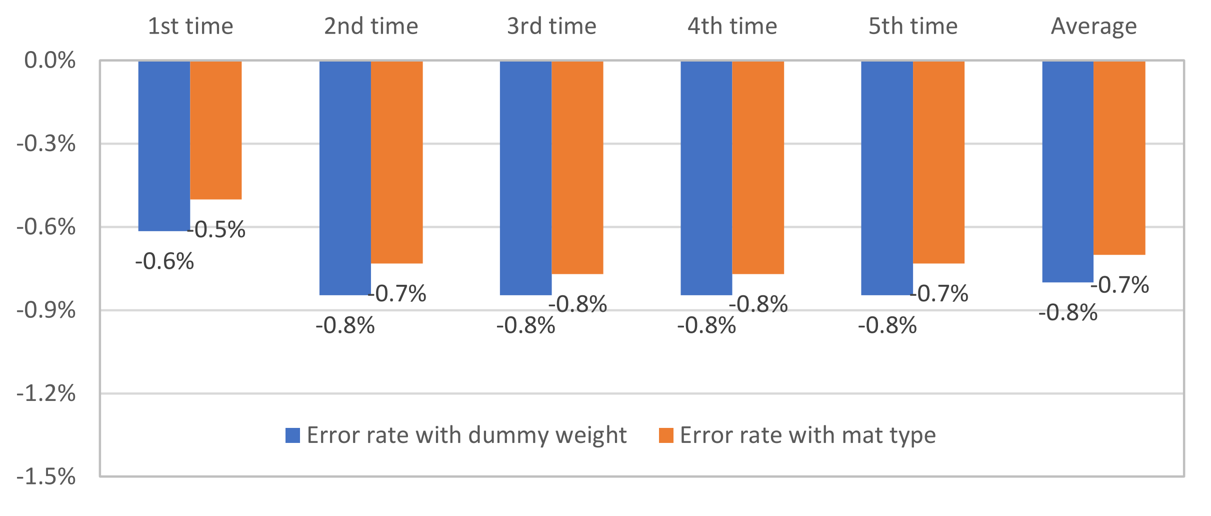

Experiment site


Experimental vehicle

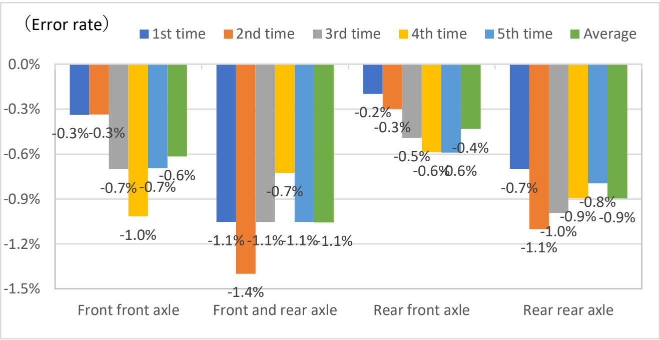
Acquisition and utilization of load weight information -Summary of field test results

- As a result of conducting the loading experiment of the 13t dummy weight 5 times, the error rate between the loaded weight and the weight measured by the axle load sensor was about ▲1% in all 5 times, and the error rate was ▲0.8%. on average of 5 times.
- The error rate comparing the measurement result of the mat-type weight scale and the axle load sensor measured at the same time was about ▲1% in all 5 times, and it was ▲0.7% on average of 5 times.
- Looking at the error rate of each axis when loading a 13t dummy weight (comparison between the loading weight scale and the mat-type), all the axes are within about 1% on average.

（Error rate when loading 13 tons）



(Reference) Error rate with the mat-type for each axis when loading a 13t dummy weight



Acquisition and utilization of load weight information -Summary of field test results

運　転　日　報

P01
出力日 21/01/18

日報番号	21011315561600020952	乗務員	99999999 テスト	出庫 メータ	179,459.29	出庫 日時	2021/01/13 15:56	走行時間	0:00		
運行日	2021/01/13(水)	車両	00020952 SIP実証実験	入庫 メータ	179,459.29	入庫 日時	2021/01/13 16:07	ｱｲﾄﾞﾘﾝｸﾞ時間	0:11		
天候		車種	DTG7バックカメラ連動	走行距離	0.00	稼働時間	0:11	停止時間	0:00		
				実車 / 空車 距離	0.00 / 0.00	一般 / 高速 / 専用道 距離	0.00 / 0.00 / 0.00				

安全	経済	総合	燃費	CO2
-	-	-	-	-

No	作業	住所	着日時	発日時	作業時間	走行時間	ｱｲﾄﾞﾘﾝｸﾞ時間	所要時間	走行距離	品名	数量	積載状況	重量
1	出庫	相模原市中央区宮下二丁目		13/15:56		00:00	00:00	00:00					
2	代替作業	相模原市中央区宮下二丁目	13/15:56	13/16:07	00:10	00:00	00:10	00:00	0.00				10.050 t
3	入庫	相模原市中央区宮下二丁目	13/16:07			00:00	00:00	00:00	0.00				

始業日時	13/15:56
終業日時	13/16:07
就業時間	0:11
残業時間	0:00
深夜時間	0:00
代替作業時間	0:10
荷積時間	0:00
修理対応時間	0:00
納品時間	0:00
休憩時間	0:00
その他時間	0:00
重量計	10.050t
出庫前ALC	
入庫後ALC	
連続走行時間	0:00
最高速 一般	0km/h
最高速 高速	0km/h
最高速 専用道	0km/h
速度OV回数	0
回転OV回数	0

Lv	1	2	3	4-
急発進・加速	0	0	0	0
急減速	0	0	0	0

Weight is displayed in the red frame

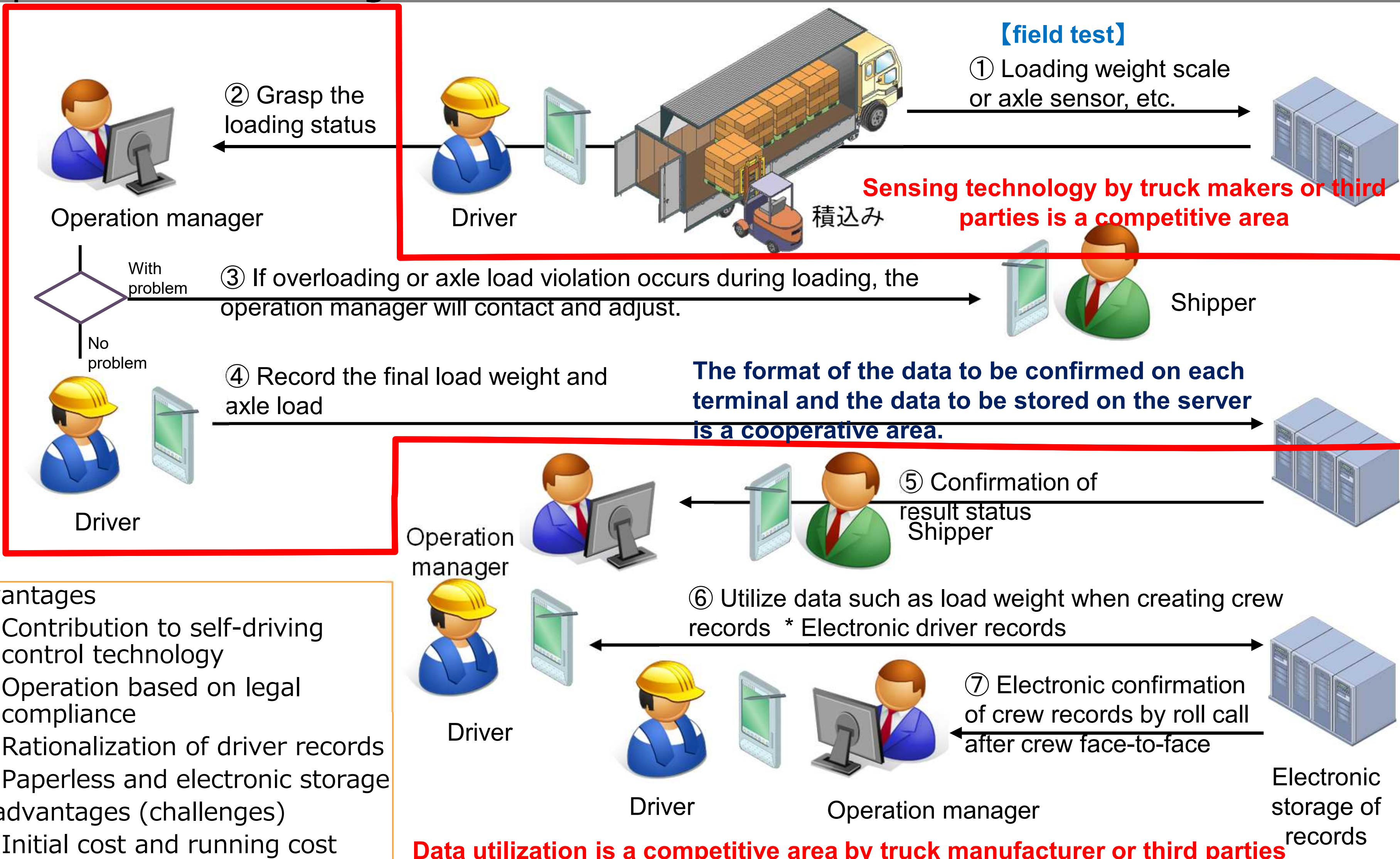
給油量		通行料		
ガソリン	0.00L	ETC	0	0回
軽油	0.00L	現金	0	0回
(距離)				
合 計	0.00L	合 計	0	0回

入口IC	出口IC	金額	精算日時

Effectiveness and challenges of load weight grasping

Effectiveness	➢ Overload operation is an act prohibited by law, and if the cargo is overloaded at the shipper's destination, the loaded cargo will be unloaded again, which will increase the work time and lead to delays in operation. Therefore, it is important not only for the driver but also for the transport operator and **the shipper** to grasp the load weight. ➢ We were able to confirm the accuracy of the loading scale used in this field test with an error rate of about 1%. In addition to being able to check the loaded weight on the display installed on the truck, it was also confirmed that the results will be recorded in the driver record in cooperation with the digital tachograph. ➢ From the above, it was clarified that a load weighing scale that grasps the load weight from the axle of a truck is an effective means of suppressing overload operation.
Challenges	➢ In the future, it will be necessary not only to manage the results as driver records, but also to be able to check the load weight on a tablet terminal that has a data transmission function to the office so that the load weight can be appropriately grasped even at a place away from the truck. ➢ In consideration of data confirmation by multiple parties, it is important that the data transmitted to the tablet terminal etc. is in a unified format encrypted so that it can be linked with each device. ➢ It is not necessary to indicate the axle load if it is a driver record (daily driving report) in normal operation, but it is also required to record each axle load in consideration of the correspondence to the shipper and the administration. ➢ In addition to the **initial cost** of mounting the axle load sensor, there is a concern that the **running cost** of maintenance will increase the burden on transport operators.

Acquisition and utilization of daily inspection item information- Implementation image



Advantages
- Contribution to self-driving control technology
- Operation based on legal compliance
- Rationalization of driver records
- Paperless and electronic storage

Disadvantages (challenges)
- Initial cost and running cost

Expected cooperation area

Acquisition and utilization of daily inspection item information-Overview

Purpose and method	・Instead of the inspection instruction terminal that is supposed to be used at the time of implementation, a vehicle equipped with vehicle-to-vehicle communication technology for platooning experiments is used as a "pseudo terminal", and among the inspection items for daily inspection, the vehicle status in vehicle-to-vehicle communication by acquiring and utilizing vehicle information using information terminals, etc., for information that can be grasped on the monitor, the load and time required for inspection work can be reduced, leading to a reduction in cargo waiting time and overall restraint time.
Expected effect	・By reducing the time required for daily inspections, which must be carried out before operation, the entire hours on duty is suppressed. ・Assuming a case where a problem is found in the inspection, there is a tendency to come to the office early as a truck driver's mind, so reducing the psychological burden of this part will lead to suppression of early departure. ・Early arrival → early departure → early arrival chain may lead to early arrival at the pickup destination and delivery destination, and the occurrence of waiting time for cargo, which can be suppressed.

Acquisition and utilization of daily inspection item information-System configuration of field test

At the time of implementation, the image is that "reservation instructions and inspections for daily inspections are performed by operating the terminal", but this time, experiment was carried out using the inter-vehicle communication technology of truck platooning, so the operation of the instruction vehicle is "reservation for daily inspections using a pseudo terminal.

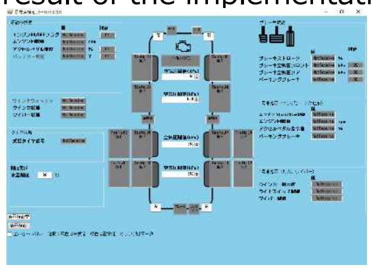
(1) Place an instruction vehicle that instructs the implementation of daily inspection items (inspection items).
(2) Place a vehicle (implementation vehicle) that will carry out the inspection items in response to instructions.
(3) The instruction vehicle (pseudo terminal) is manned to instruct the vehicle to carry out the inspection items scheduled for the experiment.
(4) Send the instruction contents to the implementing vehicle by data communication.
(5) The vehicle will automatically carry out the inspection items instructed.(A personnel is assigned to the driver's seat to check the implementation status and to ensure safety)
(6) Send the status of the instruction vehicle (pseudo terminal) and the implementation vehicle to the office terminal at any time, and check the implementation status on the monitor screen.

field test schedule, etc.
① field test schedule
Friday, March 5, 2021
System operation check
Monday, March 8, 2021
System adjustment, preliminary experiment
Wednesday, March 9, 2021 field te

②Experiment location (not disclosed)

Experimental vehicle

Monitor screen of the condition of the instruction vehicle and the result of the implementation vehicle

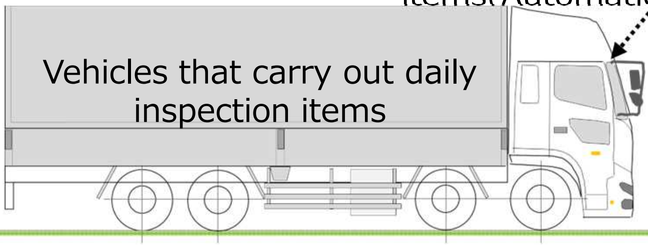


Office terminal

Data communication

2． Implementation of daily inspection items(Automatic operation)

1． Daily inspection item instructions(Manned operation)



Acquisition and utilization of daily inspection item information -Procedure of field test

(1)Conducted inspection items for which signal acquisition is possible (see the table on the right).
(2)The implementation procedure is as follows (the left winker is shown as an example).
A. By manned, the instructing vehicle performs “left winker ON”.
B. By this action, the implementation vehicle is instructed to the “left winker ON ".
C. The personnel on driver's seat visually confirm that the "left winker ON" of the implementation vehicle has been made.
D. Receive the operation instruction signal at the office terminal, and check the status of "left winker ON" of the instruction vehicle and the implementation vehicle on the monitor screen of the personal computer.
E. By checking the situation visually and on the monitor screen, the success or failure of the substitute confirmation of daily inspection items is judged.

* The operation of the instruction vehicle was regarded as "daily inspection reservation / implementation using a pseudo terminal".

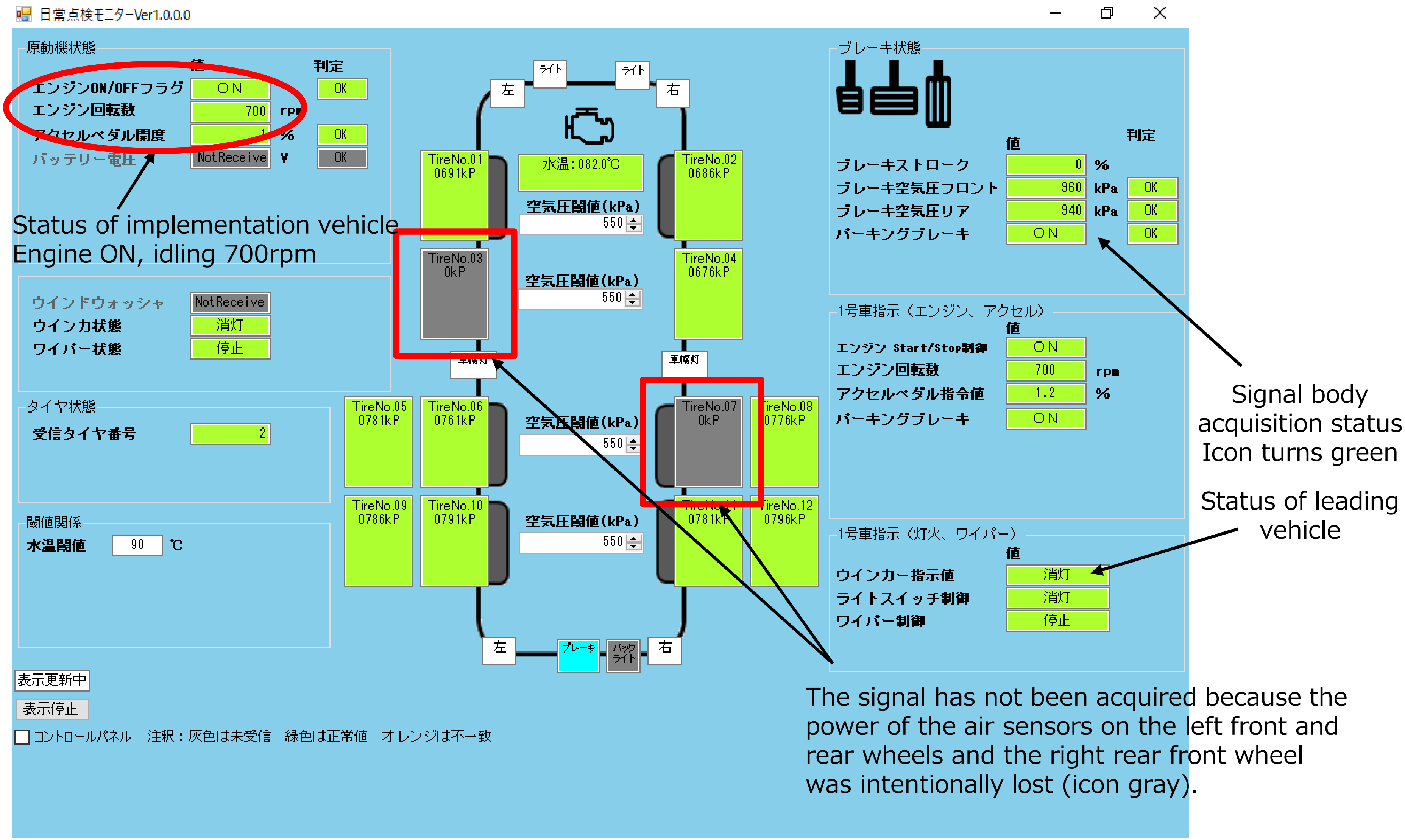
	Inspection point	Inspection items	How to carry out the inspection	Implemented※	
Abnormal part during operation		Abnormality of the relevant part	Abnormality during the previous day or the previous operation	×	
Driver's seat	Break pedal	Step, brake	Gap with the floor board and treading	×	
	Parking brake lever	Pull step	Lever fixing, air exhaust sound	○	
	Motor (engine)	* How motor is applied, abnormal noise	Smooth engine rotation, abnormal noise when starting the engine and idling	○	
		* Low speed and acceleration	Rotation when idling	○	
			Accelerator pedal catching, smooth rotation	○	
	Wind washer	* Injection condition	Direction and height of spray of wind washer fluid	×	
	Wiper	* Wiping condition	Low speed and high speed operation, clean wiping	○	Intermittent
					Slow
					High speed
	Air manometer	How air pressure rises	How the air pressure rises, the display range of the air pressure gauge	○	Front
					Rear
	Brake valve	Exhaust noise	Brake valve exhaust sound	○ (note)	
Engine room	Wind washer tank	※Liquid volume	Wind washer fluid volume	×	
	Brake reservoir tank	Liquid volume	Liquid volume in reservoir tank (MAX-MIN, etc.)	−	
	Battery	※Liquid volume	Liquid volume in each battery tank (UPPER-LOWER, etc.)	△	
	Cooling device such as radiator	※Amount of water	Amount of cooling water in the reservoir tank (MAX to MIN, etc.)		
	Lubrication device	※Amount of engine oil	Within the range indicated by the oil level gauge		
	Fan belt	※Tension and damage	Belt deflection, damage	−	
Around the car	Lighting device, direction indicator	Lighting / blinking, dirt, damage	How the lighting devices such as headlights and brake lights are lit and how the direction indicators are blinking	○	Car side light
					Low beam
					High beam
					Indicator left
					Indicator right
					hazard
					brake
					Backlight
				△	number (fog)
			Dirt, discoloration, or damage to lenses and reflectors	×	
	Tire	Air pressure	Insufficient air pressure	○	
		Installation condition	Disc wheel mounting condition	×	
		Cracks, damage	Cracks, damage, foreign matter sticking, biting		
		Abnormal wear	Abnormal wear		
		* Groove depth	Insufficient groove depth		
	Air tank	Water coagulation in the tank	Air tank coagulation	×	
	Break pedal	* Step, brake	Brake chamber and rod stroke, drum and lining gap	−	

「※」 Items to be implemented at an appropriate time based on the mileage, operating conditions, etc.
「○」 Carried out in the demonstration experiment 「△」 Things that can be implemented by signal acquisition, harness branching,
「×」 Items that may require visual inspection and are not suitable for automation 「−」 Excluded
「note」 Exhaust noise from the brake valve is confirmed by lowering the air pressure by operating the brake.

Daily inspection items whose status was confirmed using vehicle data

- Start / stop the engine
- Air brake pressure value (real-time value)
  - The pressure value of the air tank was targeted, and the pressure value when the brake was stepped on was excluded.
  - Omitted for processing the increase in air pressure
- Parking brake signal (because of the air brake, only the parking brake is turned on / off)
- Number of revolutions when idling (real-time value)
- Waveform when the engine speed is operated 3 times from idling to the lower limit of the green zone (real-time value)
- Low speed / high speed movement of wiper (wiping condition is omitted)
- Lights (headlights low beam, side lights, turn signals, brake lights)
  - The operation of the headlight high beam was excluded because it is unknown at this time whether data acquisition and communication are possible.
- Items related to tire pressure (using TPMS)

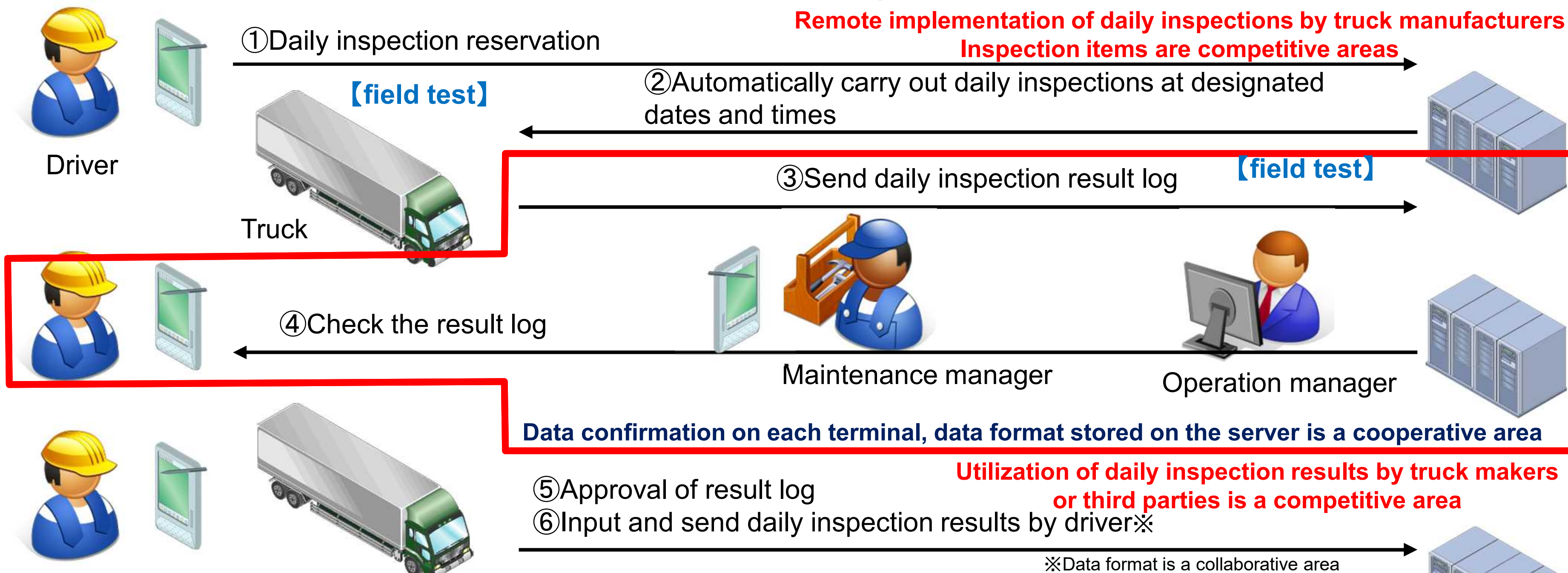
Acquisition and utilization of daily inspection item information -field test results



Effectiveness and challenges in implementing automatic confirmation of daily inspection items

Effectiveness	➢ Commercial trucks are obliged to carry out daily inspections before the start of operation, and are currently mainly carried out visually. Vehicle control signals can be used for many of the daily inspection items, and if these can be used, inspection efficiency can be expected. ➢ In this field test, by utilizing the inter-vehicle communication of platooning vehicles, it is possible to instruct daily inspections from a pseudo remote location and carry out many daily inspection items unattended without the driver's operation. At the same time, we have found a direction in which vehicle-to-vehicle communication technology can grasp inspection results at remote locations and save the results as logs. ➢ From the above, it was clarified that using the vehicle control signal of the truck to automatically carry out daily inspections and transmitting and utilizing the results to information terminals etc. will lead to **reduction of the driver's work time and burden**.
Challenges	➢ In the future, it will be necessary to consider how to deal with non-lights cases such as broken lights of brakes and headlights. In addition, it is necessary to consider whether it is possible to obtain signals from the vehicle so that the vehicle signals can be used as a substitute for the inspection contents regarding the amount of liquid such as batteries and cooling water, which are items for daily inspection. ➢ On the other hand, there are items that are difficult to check without visual inspection, such as the depth of the tire groove and dirt on the lighting device, so there remains a challenge in completely unmanning all daily inspections. ➢ Since the current system requires the recording of daily inspections and the confirmation and storage of maintenance managers, even if the daily inspection items are automatically confirmed, **the results must be recorded and stored in a paper record book**. It does not lead to reduction of office work.

Acquisition and utilization of daily inspection item information-Implementation image

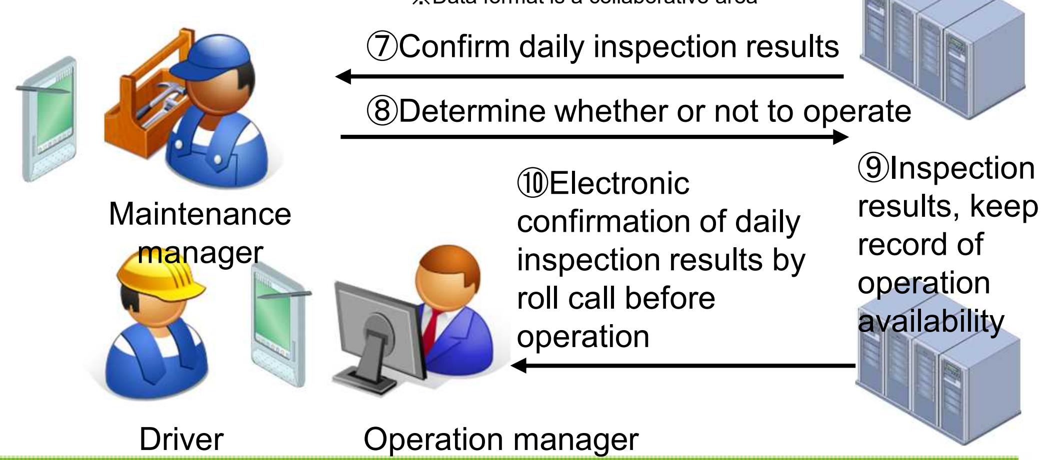


Advantages

- Efficiency and labor saving by automated check
- Drivers, maintenance managers, and operation managers can grasp the results even in remote areas
- Paperless and electronic storage

Disadvantages (challenges)

- Difficult to automate all inspection items
- Coordination with relevant government agencies is required for automatic implementation and electronic storage on the vehicle side.



Expected cooperation area

Summary

It was verified that the following data items are effective in controlling truck operation time through field tests based on use cases such as "understanding the actual situation of loading waiting time", "real-time grasping of loading weight during loading", and "efficiency of daily inspection items".

	Data item	Acquisition device	Confirmation process of effectiveness / possibility of data utilization			
			Office	Operation	Loading/unloading place	Management
Operation history Data analysis	**Hours on duty** **Driving hours** **Loading waiting time** **Loading/unloading time**	On-board unit data, etc. Individual company system	–	**General**	**General**	・Vehicle allocation and fuel economy management ・Creating managing records ・Restraint time management ・Traffic accident prevention
Grasp the load weight	**Actual load weight (axle load)**	Individual company system	**Loading and unloading**	–	**Loading and unloading**	・Vehicle allocation and regular inspection ・Create operation records ・Restraint time management ・Traffic accident prevention
Daily inspection items	**Parking brake/lever(step)** **Motor (engine)** **(Condition, abnormal noise)** **(Low speed, acceleration status)** **Wiper (operating status)** **Air pressure gauge(How the air pressure rises)** **Brake valve (exhaust noise)** **Lighting device, turn signal(Lighting / blinking condition)** **Tire (pneumatic pressure)**	Vehicle data, etc.	**Daily inspection** ↓ ・Receive the entire daily inspection results and use them to decide whether or not to operate ↓ ・Utilize the decision on whether or not to operate for roll calls	–	–	・Create daily inspection records ・Periodic inspection ・Traffic accident prevention ・Cargo accident prevention

Architecture for utilization of operation history data to improve distribution efficiency

Purpose (Strategy/ Policy)	➢ Responding to a shortage of truck drivers → Controlling truck operating hours → Suppression / reduction of cargo waiting time
Regulations	➢ Standards for improving the working hours of automobile drivers (Notification of improvement standards) ➢ Trucking Business Act (Transport Safety Regulations)
Organization (Related parties)	➢ Logistics and supply chain operators related to shipping, transportation, and warehousing (Transport operator, shipper company (shipper), shipper company (delivery destination)) ➢ Data output equipment related manufacturers (in-vehicle equipment manufacturers / truck manufacturers) ➢ Software development vendor ➢ Related administrative agencies (Ministry of Land, Infrastructure, Transport and Tourism, Ministry of Health, Labor and Welfare, etc. or external agencies)
Service (Business)	➢ Visualization of the occurrence of cargo waiting time and improvement of a shared environment between directly related parties ➢ Comprehensive operating hours analysis including cargo waiting time ➢ Documentation of cargo waiting time occurrence status as macro data ➢ In the future, control of entry into the base according to the congestion status of the berths entering and exiting the distribution base

⇕

Function	➢ History recording function for each business process of the truck operation process ➢ Working time analysis function for each business process of truck drivers focusing on cargo waiting time ➢ Truck operation data linkage sharing function between related businesses ➢ Security management / data encryption function ➢ real-time dynamic management and traffic control functions for vehicles scheduled to enter the base (In the future)
Data	➢ Historical record data of truck operation process ➢ Office data such as transport operator and warehousing / delivery destination bases of departure / arrival shipper companies ➢ External data (map / location information, road traffic information, other data necessary for interpreting operation data and dynamic management data)
Asset (Data resource)	➢ Truck vehicles and in-vehicle equipment equipped with trucks ➢ Loading scale

Architecture for utilizing data on load weight and daily inspection items

Purpose (Strategy/ Policy)	➢ Responding to a shortage of truck drivers → Controlling truck operating hours → Efficient inspection / confirmation work before operation / Prevention of waiting for cargo due to early departure / departure more than necessary → Elimination of reloading by checking the weight at the time of loading / Prevention of waiting for cargo due to unnecessary work ➢ Promotion of truck safety and legal compliance → In the future, it is desirable to centrally aggregate and manage data related to truck safety and legally compliant operation, including data that contributes to daily inspection item confirmation and data such as the confirmation status of proper loading weight.
Regulations	➢ Road Trucking Vehicle Act, Road Traffic Act, Trucking Business Act (Transport Safety Regulations)
Organization (Related parties)	➢ Transport operator, shipper company ➢ in-vehicle equipment manufacturers / truck manufacturers ➢ Ministry of Land, Infrastructure, Transport and Tourism, National Police Agency, other related administrative agencies
Service (Business)	➢ For transport operators ⇒ Reduction of hours on duty by improving efficiency of daily inspection and load weight measurement ➢ For transport operators and shipper companies ⇒ Prevention of overloading ➢ For truck manufactures ⇒ Check for defects in self-developed vehicles ➢ For government agencies ⇒ Preparation of truck vehicle maintenance status, accident information, and other statistical data to promote safe and legal operation of trucks

⇕

Function	➢ Display function that allows drivers to visually judge the confirmation results of daily inspection items based on vehicle signals ➢ Daily inspection item confirmation result / load weight data transmission function to the operation manager's terminal ➢ Security management / data encryption function
Data	➢ Vehicle signal data that contributes to daily inspection item confirmation ➢ Load weight data ➢ External data (map information, data related to ensuring vehicle / safe operation)
Asset (Data resource)	➢ Truck vehicles (signal transmission that contributes to daily inspection item confirmation) ➢ Loading scale

Future tasks

Continuing exploration of useful vehicle data items, formulating a unified data format, and linking with vehicle / probe data and peripheral-related data, etc. is necessary.

◆Regarding vehicle data, there is a possibility that there are more data items that are useful for reducing cargo waiting time and confirming daily inspection items, and it is meaningful to continue exploration.
In doing so, we recognize that it is important to consider the "secondary data" that is processed and generated from CAN data acquired as primary data from trucks.

◆Regarding the "secondary data" generated by processing CAN data, it is necessary to formulate a unified data format so that truck manufacturers can record and provide the data items as data belonging to the "cooperative area".

◆On the other hand, since there are data items that cannot be covered by vehicle data alone, it is also important to examine the possibility of expanding effectiveness and implementation feasibility by linking vehicle data and in-vehicle device data.

* As a prerequisite for consideration, it is important to continue to check trends in information utilization by truck manufacturers and the needs of the trucking industry.

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This report documents the results of Cross-ministerial Strategic Innovation Promotion Program (SIP) 2nd Phase, Automated Driving for Universal Services (SIP-adus, NEDO management number: JPNP18012) that was implemented by the Cabinet Office and was served by the New Energy and Industrial Technology Development Organization (NEDO) as a secretariat.