MINISTRY OF PUBLIC WORKS AND TRANSPORT

General Directorate of Techniques
Road Infrastructure Department

Guidelines for Operation of Dynamic Response Intelligent Monitoring System (DRIMS)

February 2018

Main Text: Guideline for Operation of Dynamic Response Intelligent Monitoring System (DRIMS)

Appendix: Configuration and Operation of Road Monitoring Device

Main Text:
Guideline for Operation of Dynamic Response Intelligent Monitoring System (DRIMS)

CHAPTER 1 Introduction

1.1 Introduction

Dynamic Response Intelligent Monitoring System (DRIMS), which has been invented by “Bridge and Structures Laboratory at University of Tokyo in Japan”, is one of the systems to measure road roughness and estimate International Roughness Index (IRI). DRIMS estimates IRI values of inspected roads by converting acquired vibration data of vehicles (in acceleration) into IRI values. DRIMS consists of two types of software, 1) measurement software and 2) analysis software. This guideline describes detailed procedures of DRIMS operation step by step.

1.2 Outline of DRIMS

Figure-1 illustrates brief explanation on IRI measurement mechanism of DRIMS and installation image of DRIMS equipment into ordinary cars. As shown in the left figure, vibration data obtained by an accelerometer above one of the rear tires is converted into IRI values. Also, as shown in the right figure, DRIMS is very compact and can be easily installed into ordinary cars without any modification of car shapes.

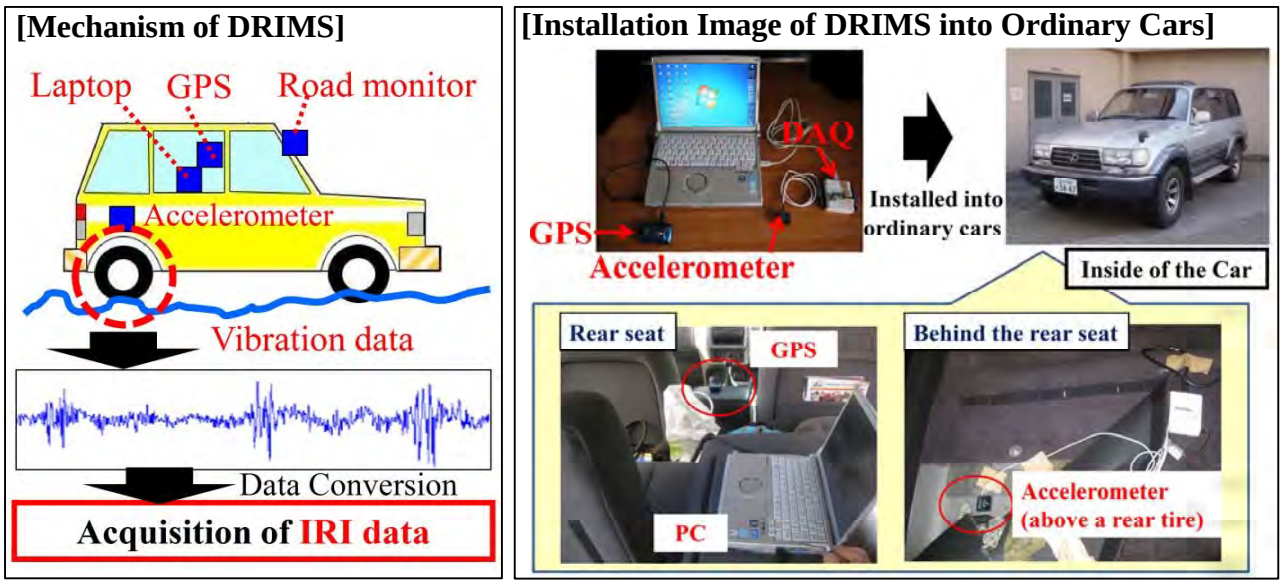


Figure-1 Mechanism and Installation Image of DRIMS

1.3 Basic Composition of DRIMS

One set of DRIMS is composed of the following 6 items shown in Table-1. Basically, items No.1-No.5 are always installed into inspection cars as shown in Figure-1. Item No.6, Humps, is used only during hump calibration activity. Additionally as an option, road monitoring device (recorder) can be utilized with DRIMS for more visual output. Also, battery connected to cigar socket of vehicles is very useful for long-distance inspection in order to continuously operate PC.

Table-1 Basic Composition of DRIMS

No.	Items	Photo	Description
1	Laptop PC		Acquisition of vibration data & conversion of the vibration data into IRI values
2	GPS		Recording of locations during measurement
3	Accelerometer		Measurement of vehicles' vibration data
4	DAQ (Data Acquisition Module)		For transferring the data from accelerometer to computer
5	Tape		One-sided tape: fixing of Accelerometer Two-sided tape: fixing of DAQ
6	Humps		Applied to hump calibration
7	Color cone		Applied to hump calibration (to be installed at start point)
Additional Device (Option)			
*A	Road monitoring device (Road condition recorder)	 	Recording of road conditions (The data is to be saved in SD-Card.)
*B	DC-AC Inverter		Power source for the laptop PC connected to a cigarette lighter socket of the vehicle

1.4 Outline of IRI Measurement Using DRIMS

Figure-2 summarizes the procedure of IRI measurement using DRIMS. In inspection stage, "IRI measurement with DRIMS" and "road monitoring with recording device" are carried out simultaneously. In addition, before or after the inspection, hump calibration shall be conducted prior to analysis stage in

which IRI values of inspected roads are calculated with assumptive vehicle properties based on hump calibration result. As the result of the analysis, IRI map (Google Earth format) and IRI data sheet (CSV format) are to be given. Also, movie with GPS information is separately obtained as an output of the recording device. Table-2 summarizes software needed for DRIMS application, namely 1) measurement software of DRIMS, 2) analysis software of DRIMS, 3) Google Earth (for presentation of DRIMS output), and 4) Registrator Viewer (option). Actual displays of "Measurement Software" and "Analysis Software" are also shown in Figure-2 for reference.

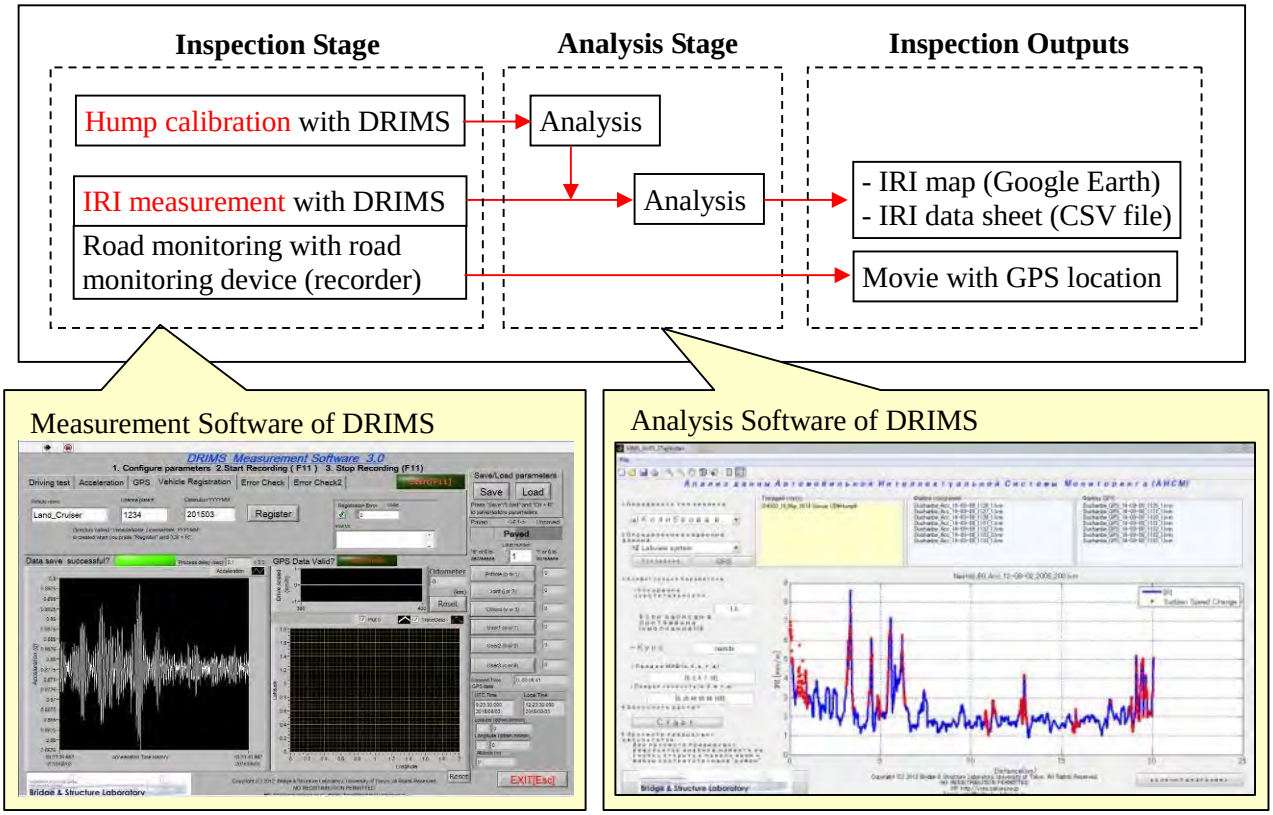


Figure-2 Outline of IRI Measurement Using DRIMS

Table-2 List of Software Related to DRIMS Application

No.	Name	Icon	Description
1	Measurement Software		For measurement of GPS data and acceleration data
2	Analysis Software		For analysis of acceleration data and calculating IRI
3	Google Earth		For visual checking of IRI on satellite map. Note: Internet connection is required.
4	Registrator Viewer (option)		For reviewing of recorded movies with GPS information

1.5 Technical Terms Used in DRIMS Software

Table-3 shows a list of basic technical terms used in DRIMS software. Users shall get familiar with these technical terms for smooth operation of DRIMS.

Table-3 Technical Terms Used in DRIMS Software

Technical Terms	Description
Driving test	Specifically, hump calibration and IRI estimation
Acceleration	Vertical acceleration (vibration) of inspection cars
GPS	Global Positioning System to tell locations of inspections
Vehicle registration	Registration of inspection course, vehicle type, and number of passengers
Error check	Error check of DRIMS configuration set-up
Hump calibration	Calibration to determine conditions of IRI measurement
IRI estimation	Acquisition of vibration data through inspections to be converted into IRI by analysis (in other word, IRI measurement)
Outputs	Outputs of hump calibration or IRI estimation
Google Earth	Name of satellite map software
Distance	Distance from start points of inspections to certain inspection points
Latitude & Longitude	Latitude & longitude of inspection vehicles

1.6 Outline of the Guideline

A series of DRIMS operation procedure is explained in this guideline according to the flowchart shown in Figure-3. In order to enable operators to efficiently master the entire DRIMS operation procedure, a checklist is introduced in Chapter 9.

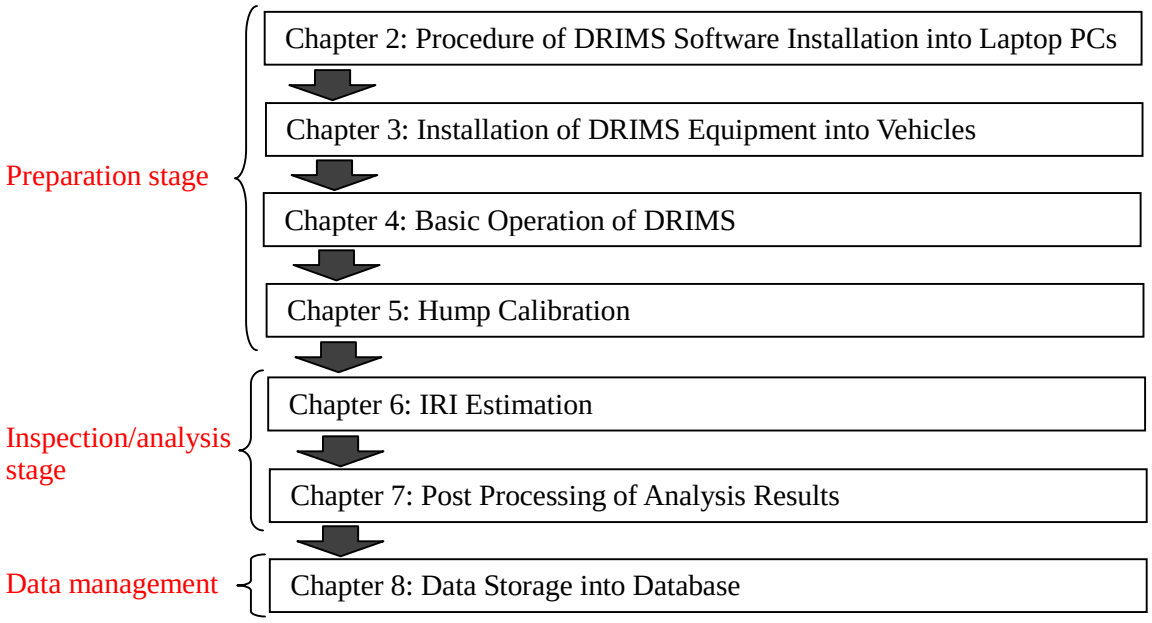


Figure-3 Outline of DRIMS Operation Procedure

CHAPTER 2 Procedure of DRIMS Software Installation into Laptop PCs

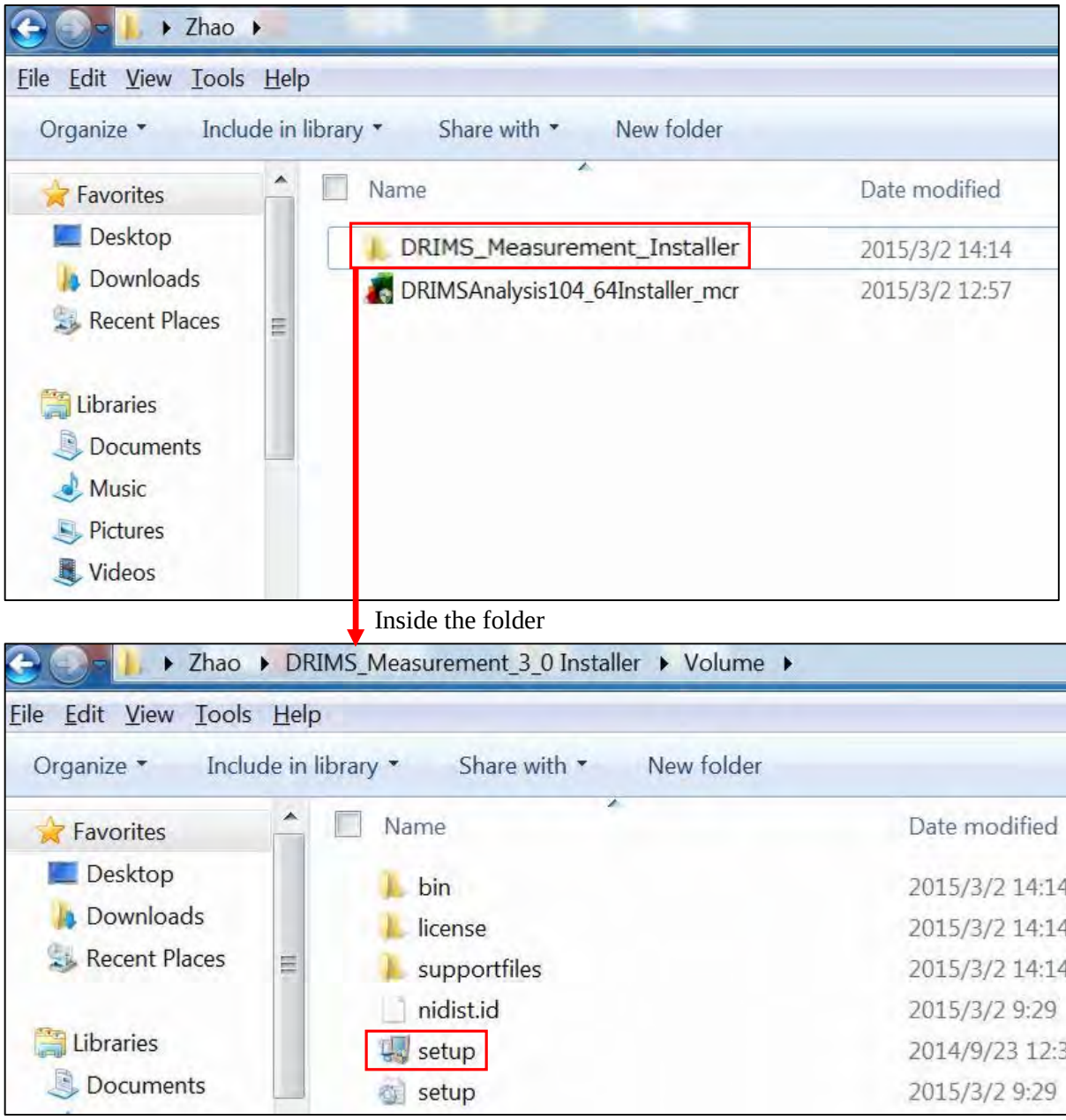
2.1 Outline

This section describes procedure of DRIMS software installation into PC. For application of DRIMS, both Measurement Software and Analysis Software shall be properly installed in operators' PC.

2.2 Installation Procedure of Measurement Software

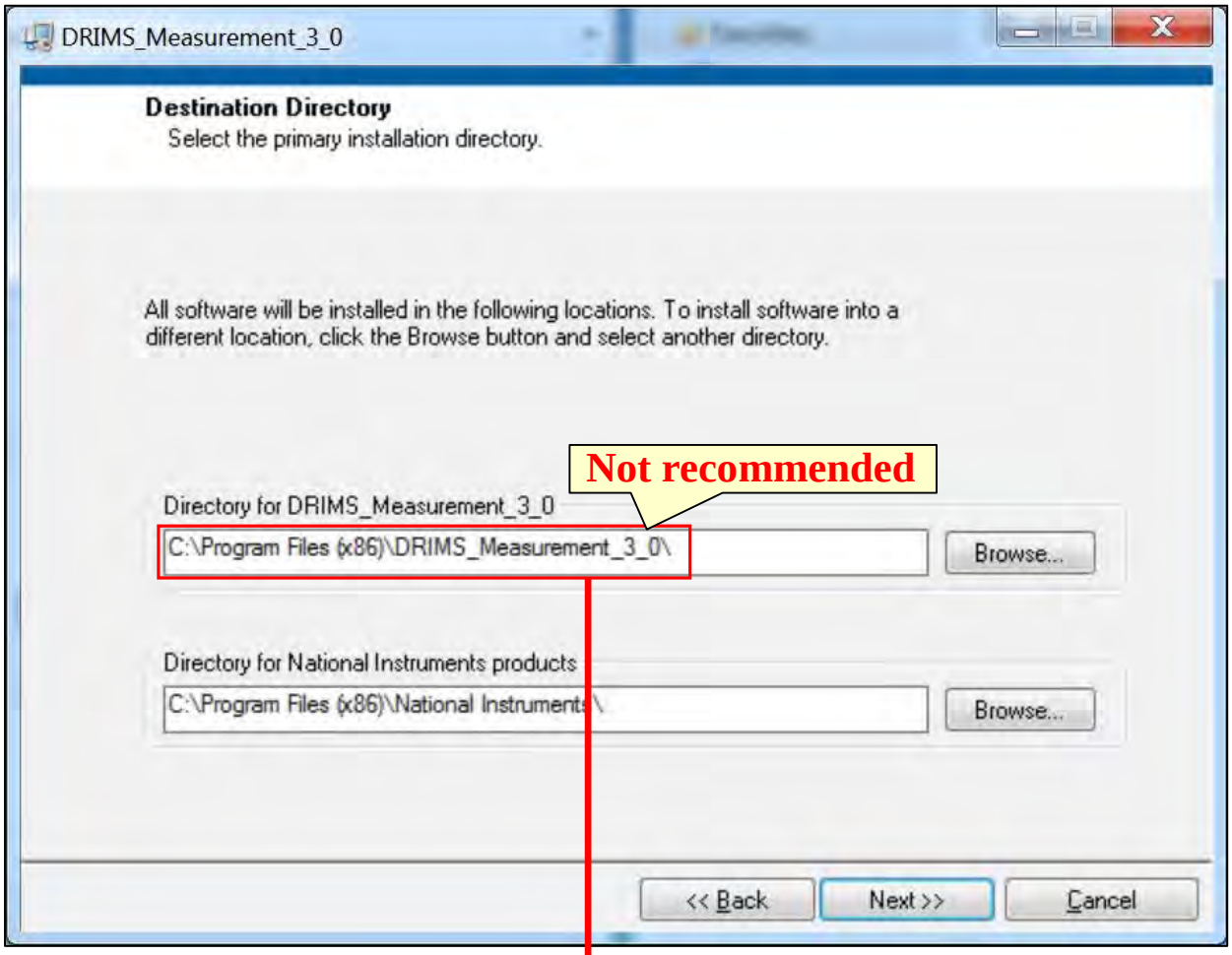
DRIMS Measurement Software can be installed into PC with the following 6 steps.

Step-1: Click a file named "setup (installation file)" in a folder named "DRIMS_Measurements_ Installer".

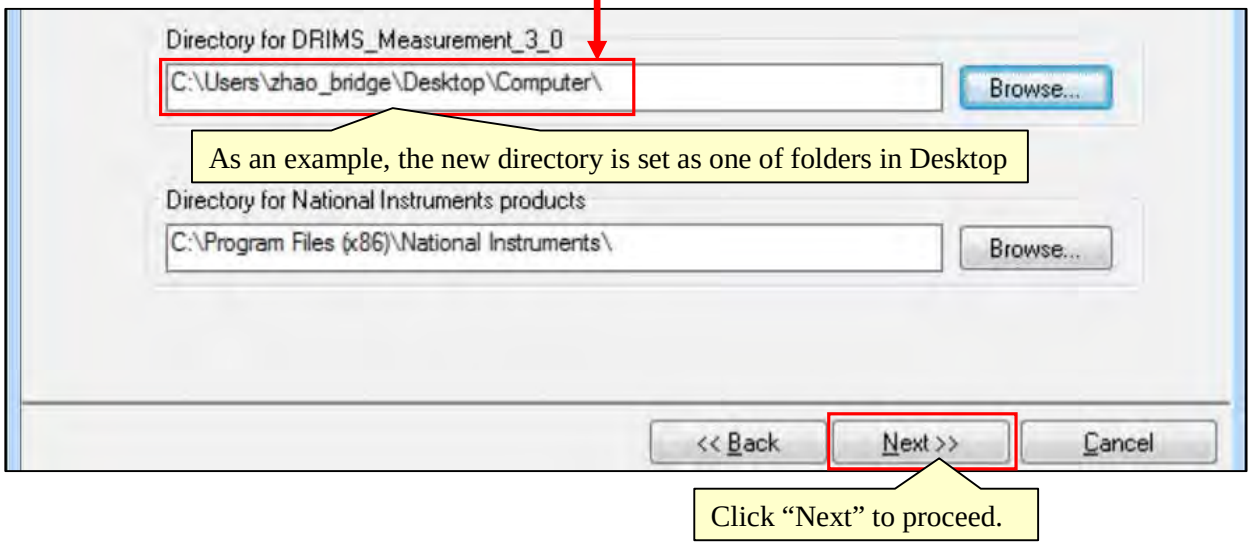


Step-2: Change the install directory (location for installation of the file) of “DRIMS Measurement Software” to any other directory outside the “Windows program directory (Ex. Program Files (x86)”. If the file is installed into the Windows directory, the program might not be able to create files without permissions of PC administrators. Click “Next” to process the installation.

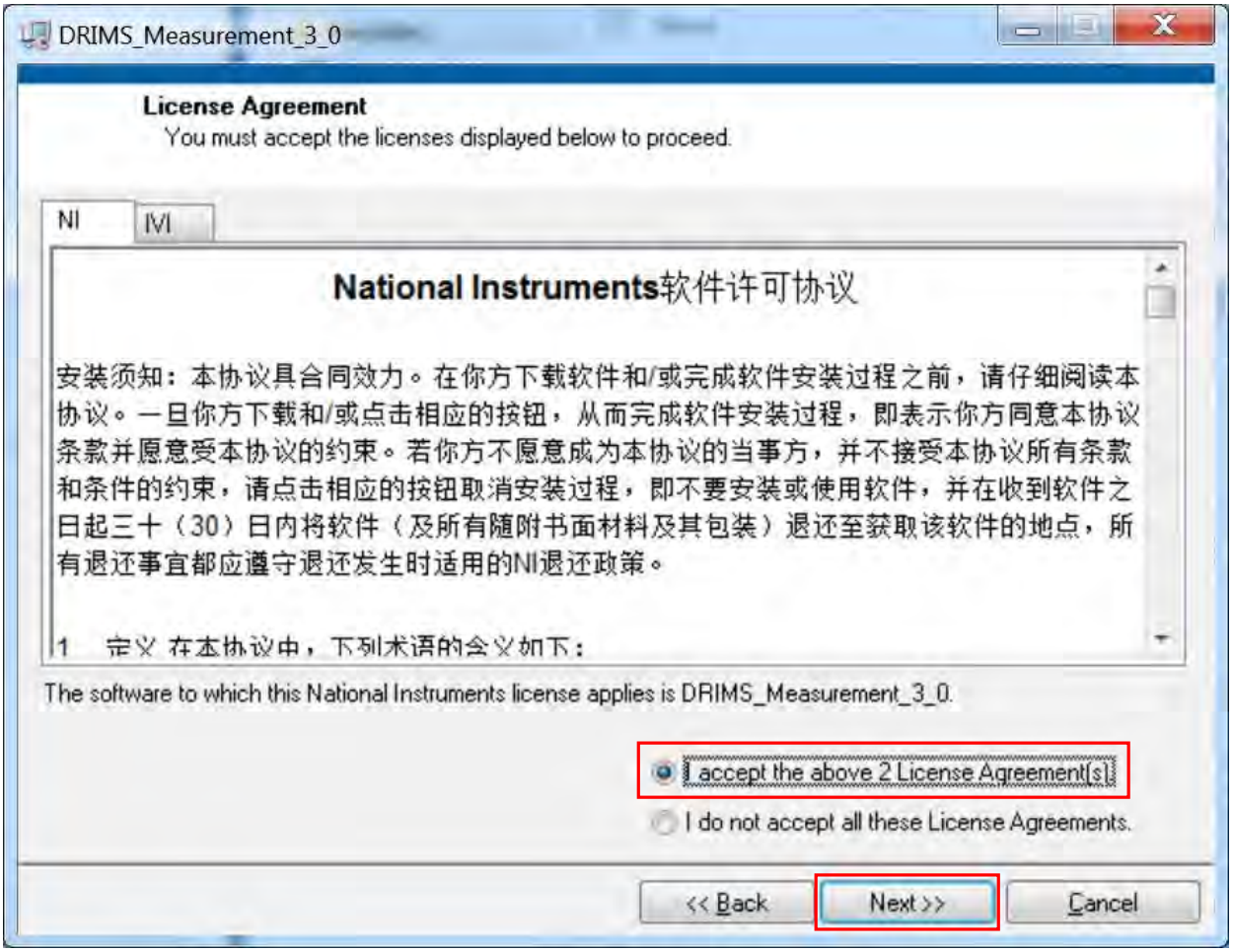
[Default Stetting]



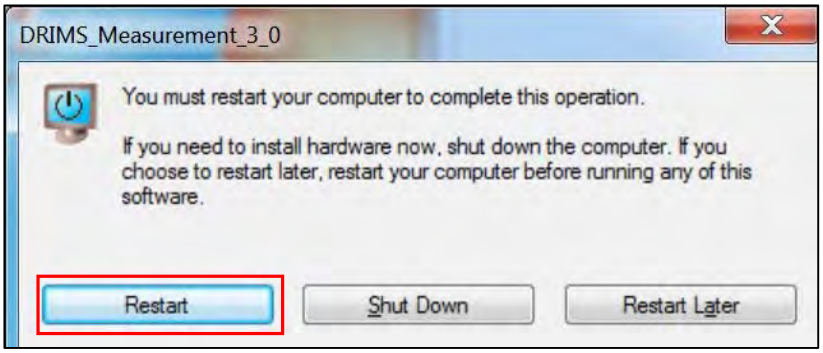
[After Changing of Directory for Installation]



Step-3: Accept license agreement and click “Next” to process the installation.

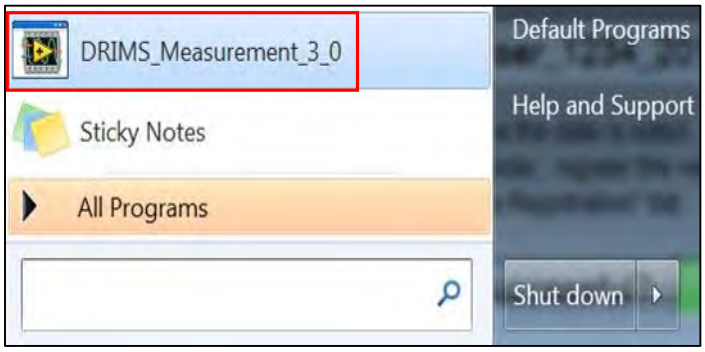


Step-4: After completion of the installation, restart PC.

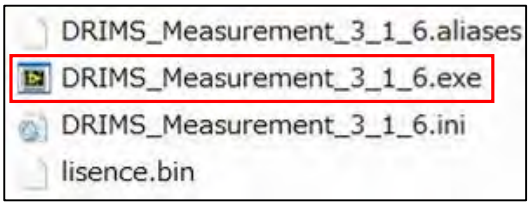


Step-5: Star the installed “Measurement Software” from either the following 2 locations.

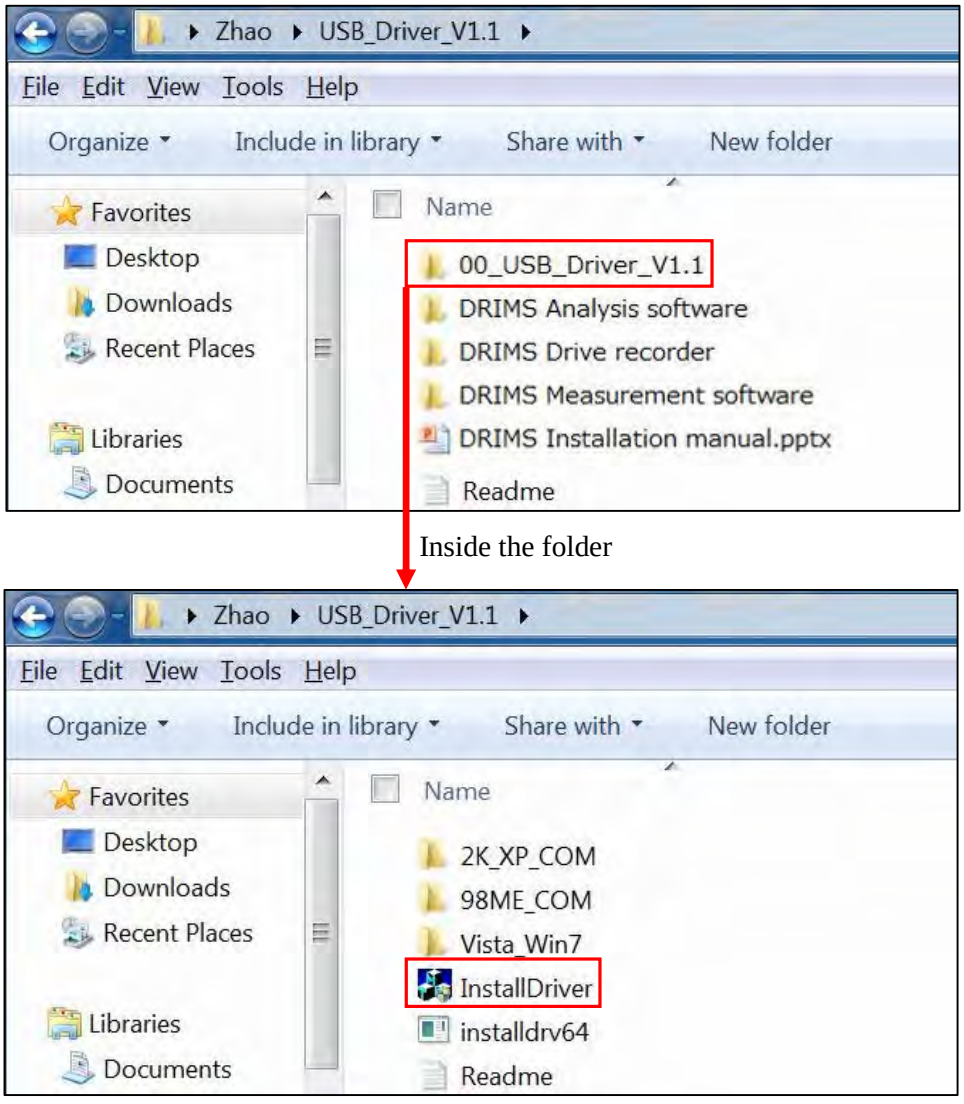
[PC Start Menu]



[Designated Directory for Installation]



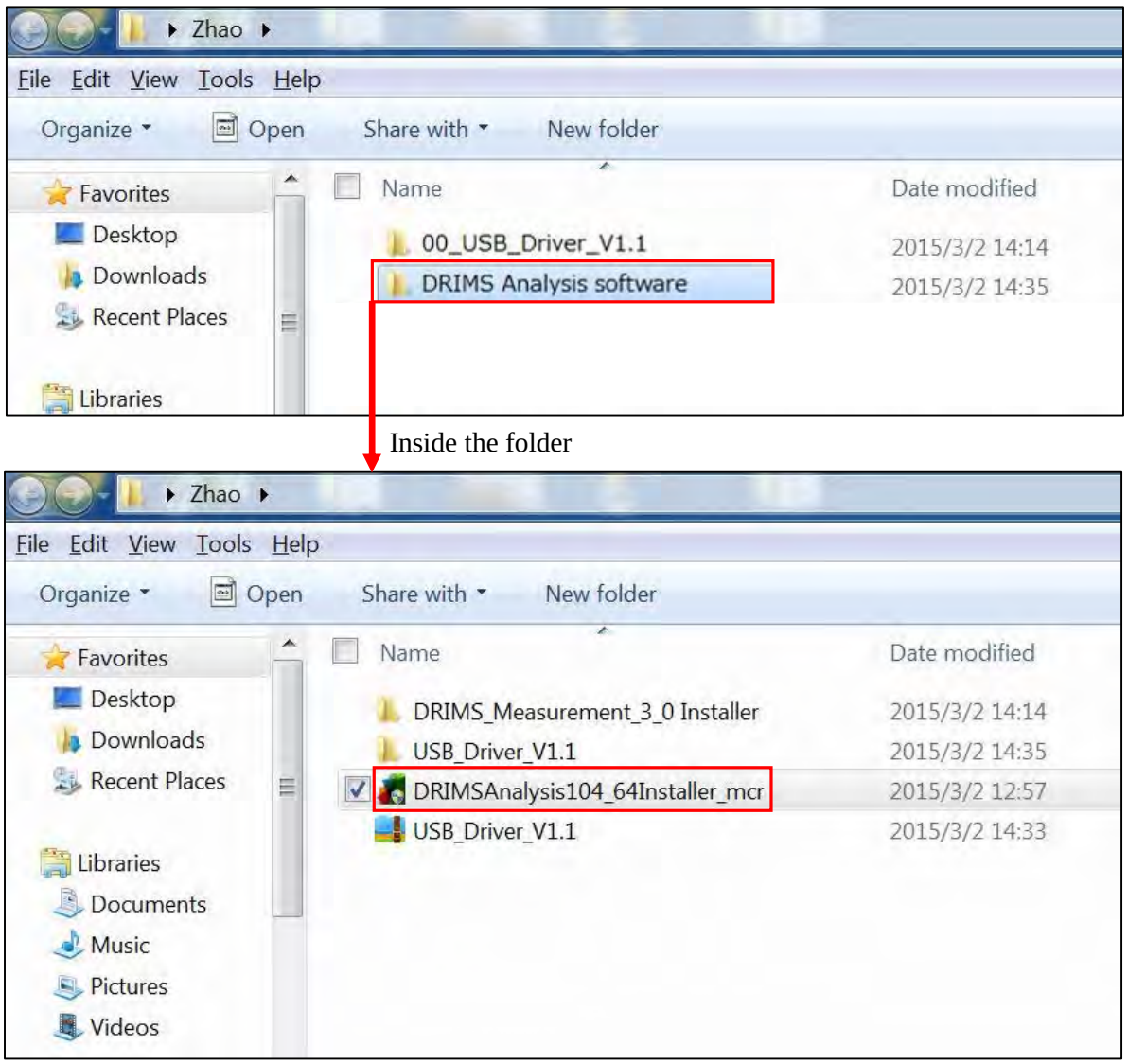
Step-6: Click a file named “InstallDriver” in a folder named “00_USB_Driver_V1.1” and install GPS driver.



2.3 Installation Procedure of Analysis Software

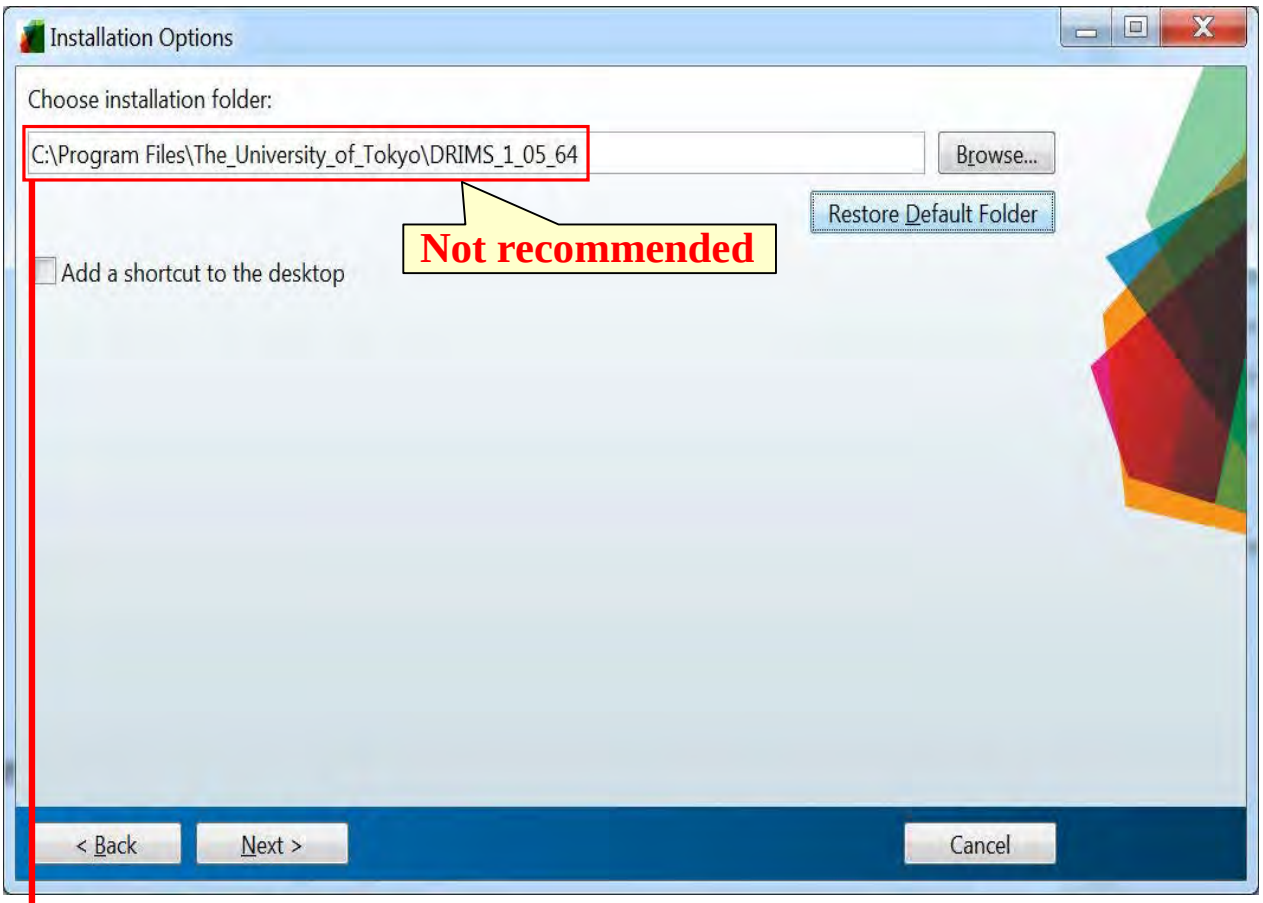
DRIMS Analysis Software can be installed into PC with the following 7 steps.

Step-1: Click a file named “DRIMSAnalysisInstaller_mcr (installation file)” in a folder named “DRIMS Analysis Software”. If the system warns you for installation permission, run the file as PC administrator.

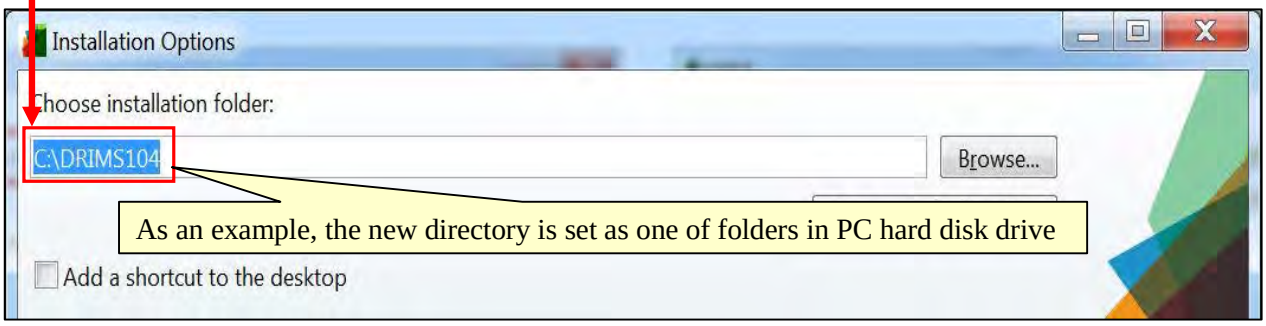


Step-2: Change the install directory (location for installation of the file) of “DRIMS Analysis Software” to any other directory outside the “Windows program directory (Ex. Program Files (x86)”. If the file is installed into the Windows directory, the program might not be able to create files without permissions of PC administrators. Click “Next” to process the installation.

[Default Stetting]



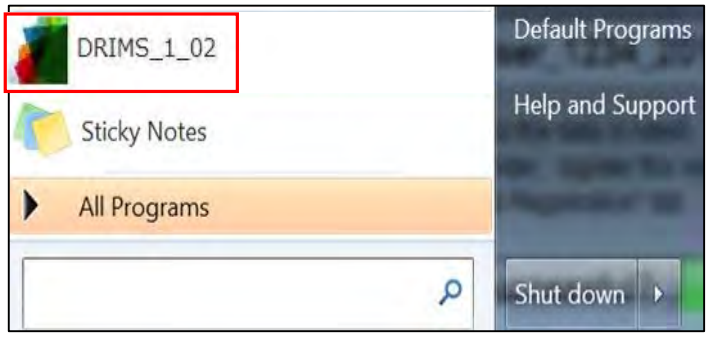
[After Changing of Directory for Installation]



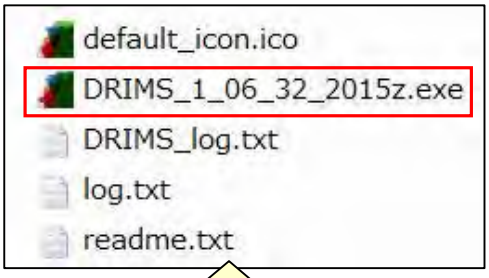
Step-3: For installation of “Matlab Complier Runtime”, no need to change the directory. Click “Next” to process the installation.

Step-4: Star the installed “Analysis Software” from either the following 2 locations.

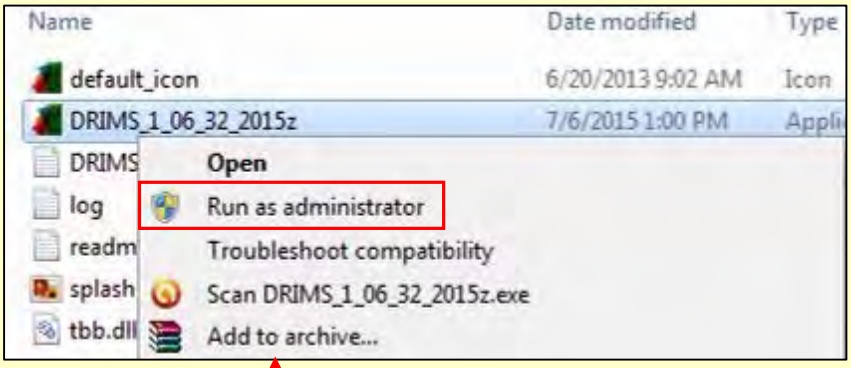
[PC Start Menu]



[Designated Directory for Installation]



In case that your PC asks permission, run the software as administrator.



This window appears by right click of PC mouse.

CHAPTER 3　Installation of DRIMS Equipment into Vehicles

3.1　Outline

Typical installation image of DRIMS equipment into vehicles is shown in Figure-4. USB cable to connect DRIMS (Specifically, DAQ (Data Acquisition)) and PC can be inserted into any USB ports of the PC.

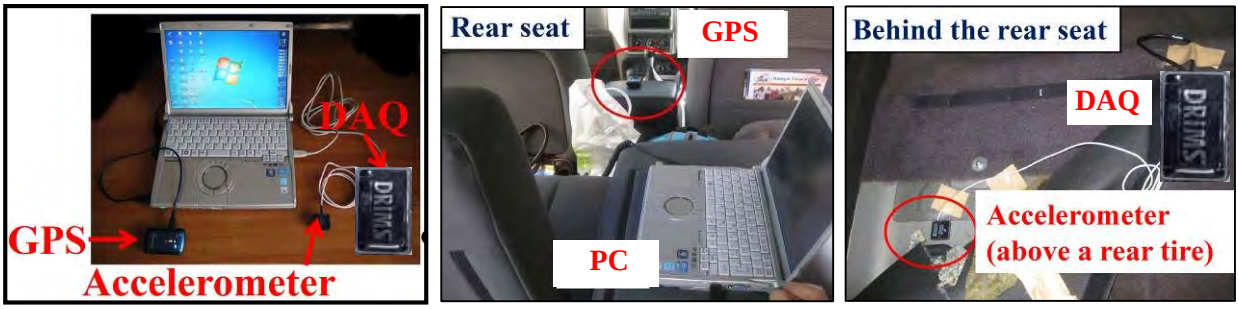
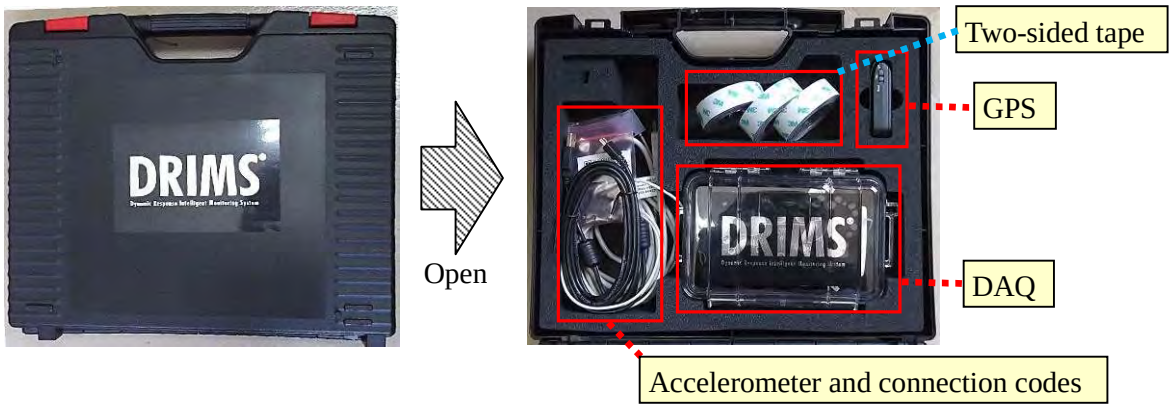


Figure-4　Typical Installation of DRIMS Equipment into Vehicles

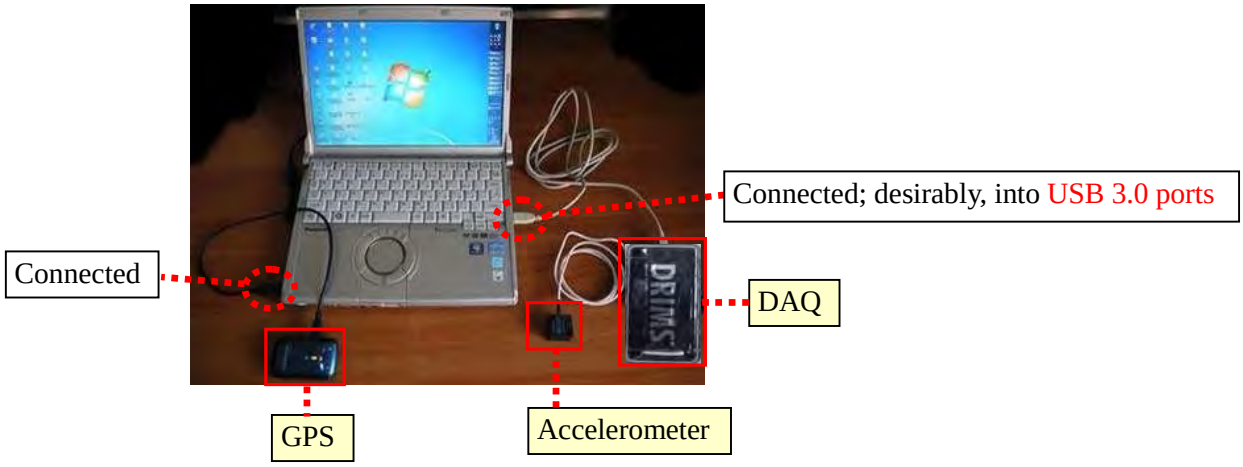
3.2　Equipment Installation Procedure

DRIMS equipment shall be installed into vehicles according to the following procedure.

Step-1: Open DRIMS equipment box and takeout the equipment.



Step-2: Connect GPS and DAQ to the laptop PC.

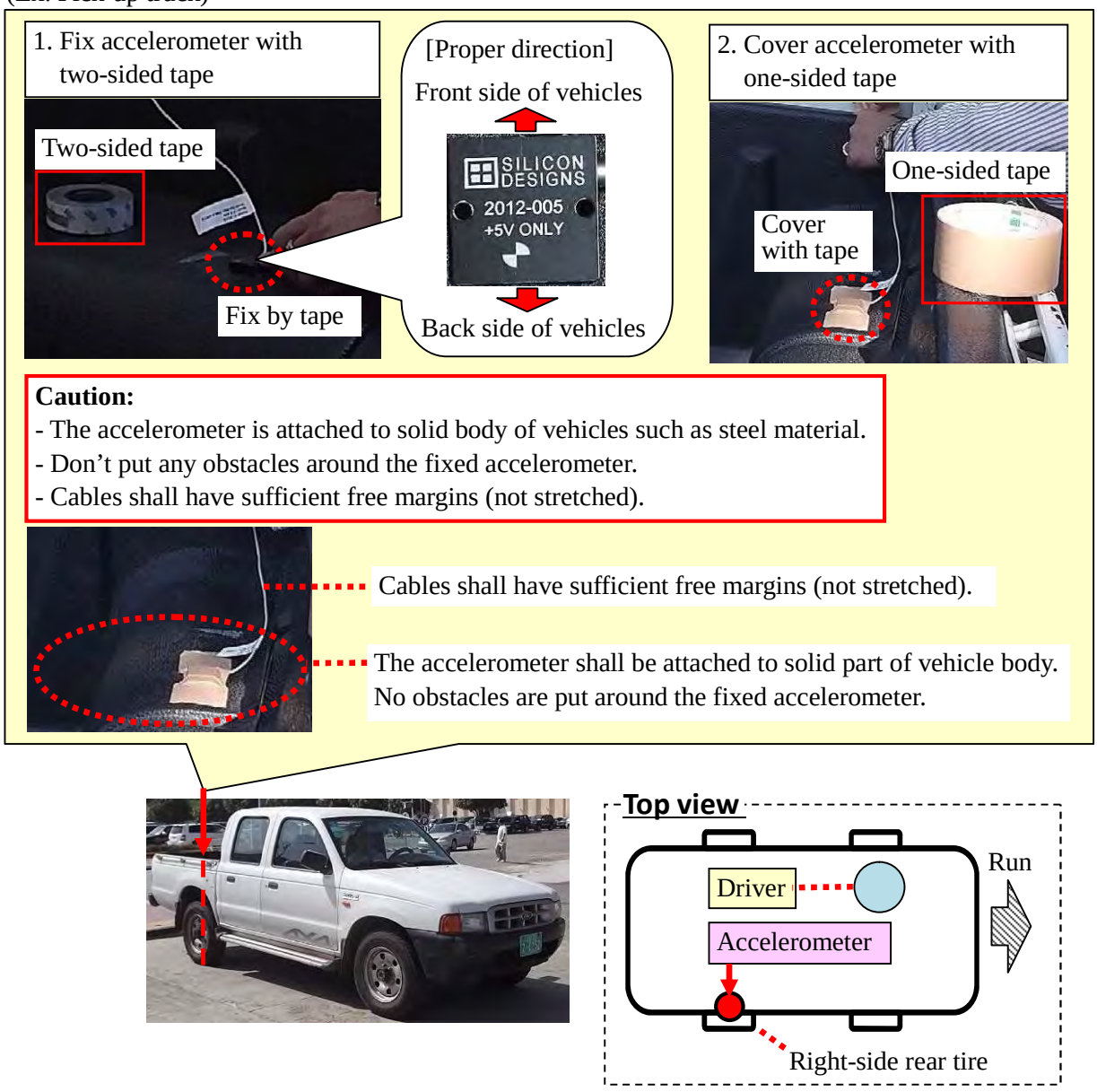


[Recommendation for connection of DAQ into USB 3.0 Ports]

It is recommended that USB cables of DAQ should be connected to USB 3.0 ports. Recently, computers have 2 types of USB ports, USB 2.0 and USB 3.0. The difference is that data transmission speed of USB 3.0 (5120Mbps) is ten times as fast as that of USB 2.0 (480Mbps). That means USB 3.0 ports enables DAQ to transmit acquired data into laptop PCs more quickly and without fail. USB 3.0 ports can be easily identified by either “color of ports (blue) or “SS (Super Speed) USB logo”.

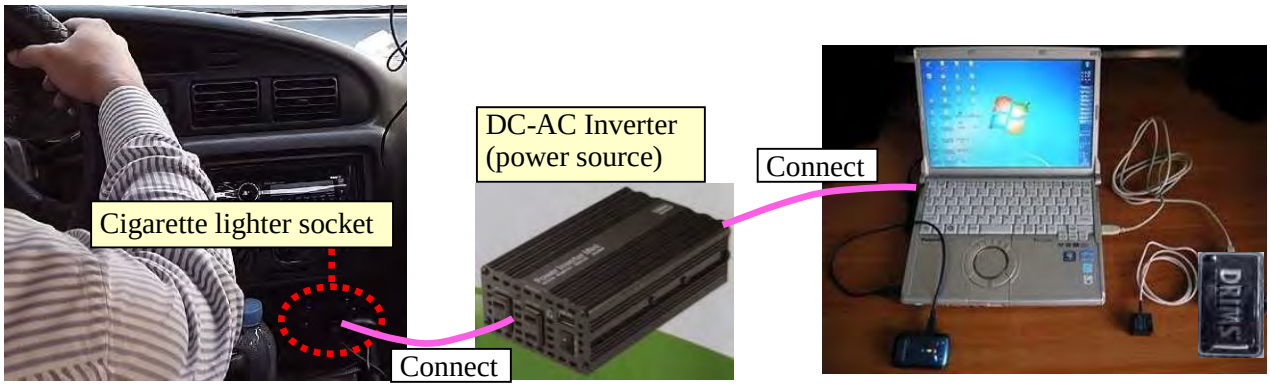
Step-3: Fix the accelerometer above one of rear tires on opposite side of driver seats; in case of left hand drive vehicles, the accelerometer is to be installed above the right-side rear tire.

(Ex. Pick-up truck)



Step-4: Fix DAQ with one-sided tape in rear seats.

Step-5: Connect “DC-AC Inverter” with a laptop PC and a cigarette lighter socket of the vehicle.



Step-6: Adjust the time of the laptop PC.

Step-7: Install the recorder near the rear view mirror and synchronize the time with that of laptop PC.

Step-8: Set the GPS near side window.

Set the GPS near side window.
(to capture a satellite signal)

CHAPTER 4 Basic Operation of DRIMS

4.1 Operation of DRIMS Measurement Software

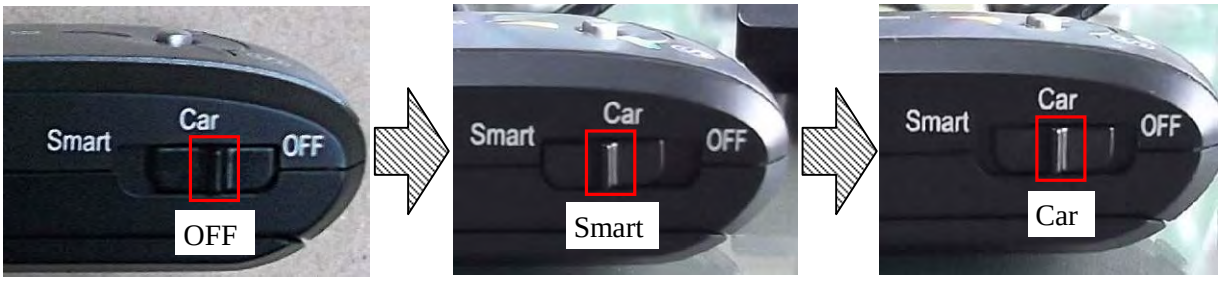
4.1.1 Configuration and Operation Check of DRIMS Measurement Software

After setting up DRIMS equipment, configuration and operation check shall be done as follows.

Step-1: Preparation of GPS

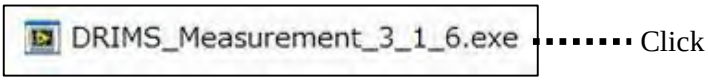
1) Connect USB cable to computer.
2) Turn on GPS by moving the switch from “OFF” to “Smart”.
3) Move the switch from “Smart” to “Car”.
4) Wait for about 30 seconds.
5) Confirm twice peep sound and blinking the center light. (It means connecting to satellite.)

[Initially, power is off.] [Move the switch to “Smart”] [Move the switch to “Car”]



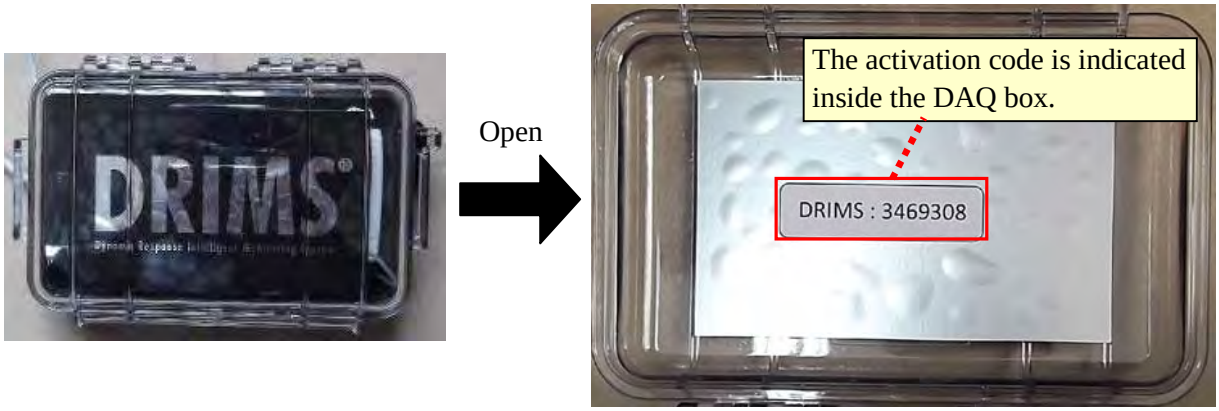
Step-2: Start DRIMS Measurement Software

1) Click and turn on DRIMS measurement software.

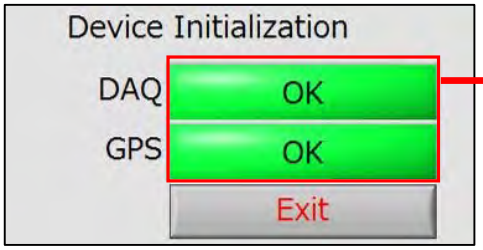


2) Enter a DRIMS activation code (registration for license) if requested

A DRIMS activation code is to be requested if computers are not licensed. The activation codes are indicated inside the DAQ box.

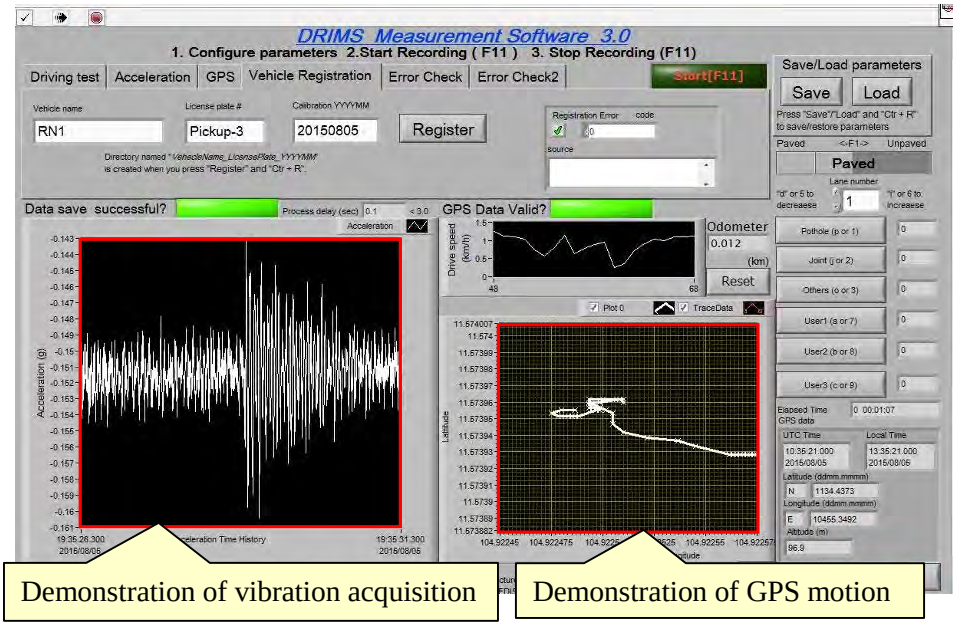


If there’s no problem with initial preparation explained so far, the following window is to be displayed and software gets activated.



These 2 items shall be checked as “OK”.
If not, close the software and restart it after checking if all the equipment is set properly.

The following figure is an example of properly functioning image of the software.

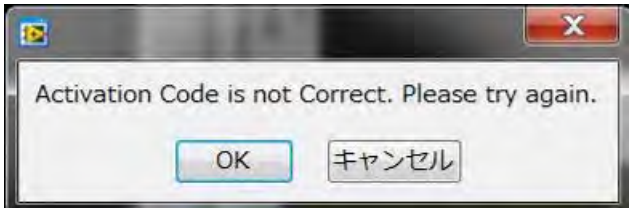


[Trouble Shooting (Activation of DRIMS Measurement Software)]

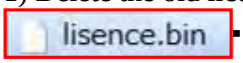
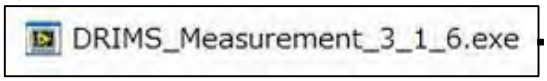
Trouble	Measures to be Taken
“OK” is not shown for DAQ.	Change the USB port for DAQ.
	Remove USB cable and restart software.
“OK” is not shown for GPS.	1) Remove USB and close the software window. 2) Restart GPS before connecting to PC, and confirm beep sound. 3) After that, connect to PC and start the software
	Change the USB port for GPS.

[Trouble Shooting (licensing of computers for activation of unregistered DRIMS equipment)]

If unregistered DRIMS is connected to computers, and DRIMS Measurement Software is turned on, the following error occurs.

Trouble
DRIMS measurement software doesn’t get activated with the following error massage. 

In order to license the computers for activation of unregistered DRIMS equipment, the old licenses registered in the computers have to be invalidated and new activation codes have to be registered in the computers. The detailed procedure is explained below.

Measures to be Taken
1) Delete the old license file named “license.bin” in the DRIMS measurement folder.    Select and delete 2) Click and turn on DRIMS Measurement Software.    Click 3) Enter a new activation code (registration for license). DRIMS measurement software gets activated after the new activation code is entered. Once computers are licensed to the unregistered DRIMS equipment, the license file, “license.bin”, is to be generated in the DRIMS measurement folder again.

Step-3: Data Entry for “Vehicle Registration”

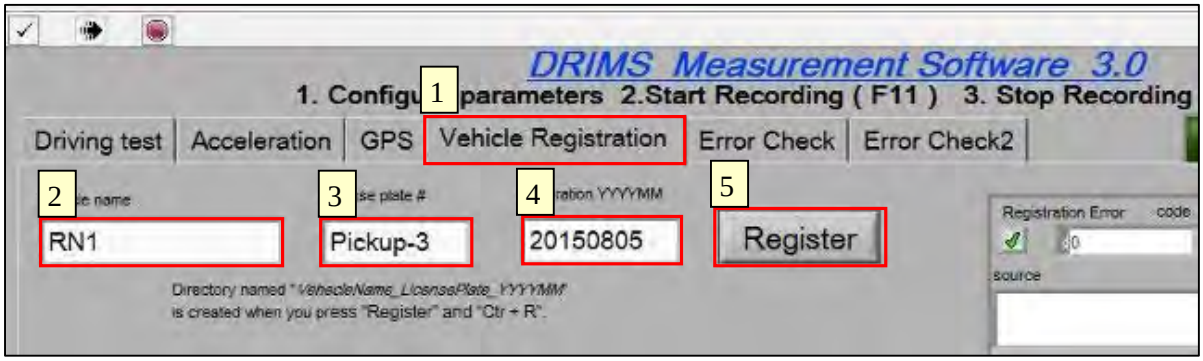
1) Select “Vehicle Registration”.

2) Enter road name (Ex. RN1).

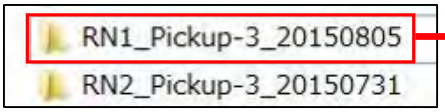
3) Enter 1) a type of inspection vehicles and 2) number of passengers (Ex. Pickup-3).

4) Inspection date.

5) Click “Register”.



6) Check a folder for outputs generated in the folder where Measurement Software is saved.



The generated folder (Outputs of inspections are to be saved in here.)

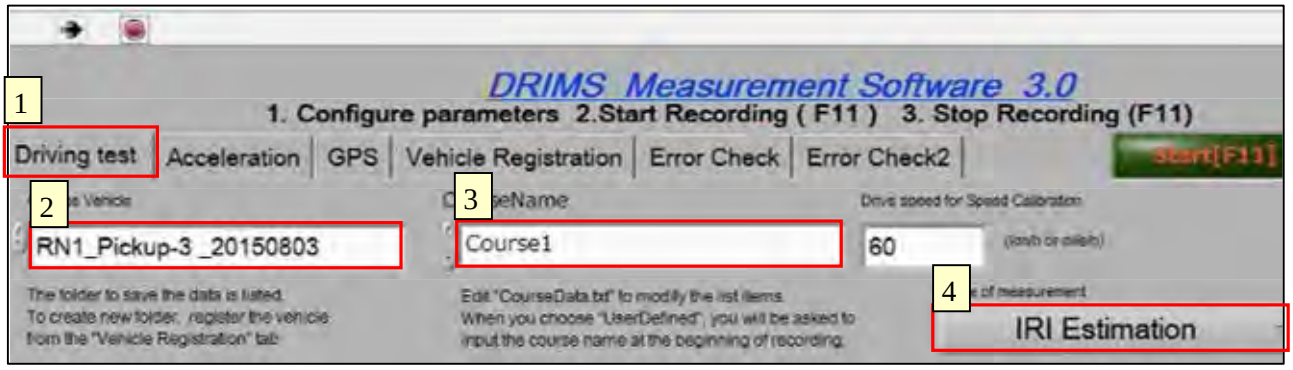
Step-4: Data Entry for “Driving test”

1) Select “Driving test”.

2) Check if the folder generated in Step-3 is selected.

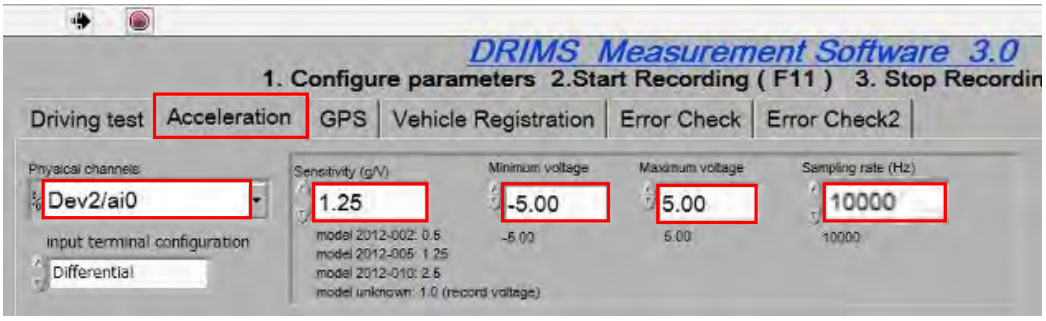
3) Define course name. (Ex. Couse1, Course2, Course3 etc.)

4) Chose either “IRI Estimation” or “Hump Calibration”.



Step-5: Data Check of “Acceleration”

Select “Acceleration” and check if necessary data entry is the same as the example shown below.

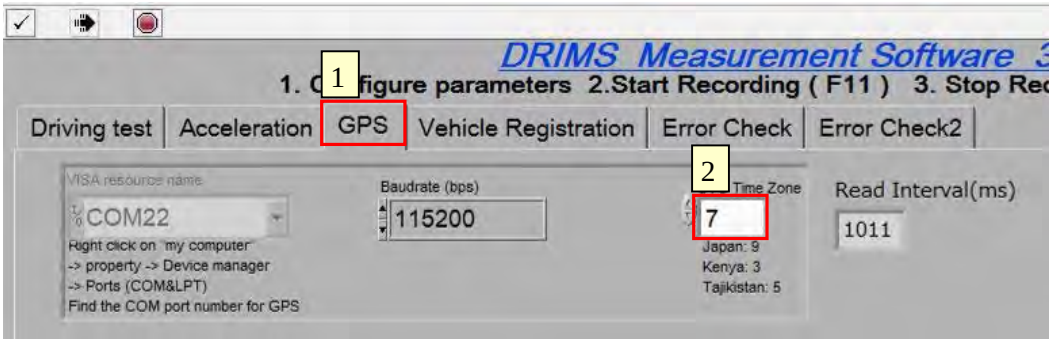


Step-6: Data Entry for “GPS”

1) Select “GPS”.

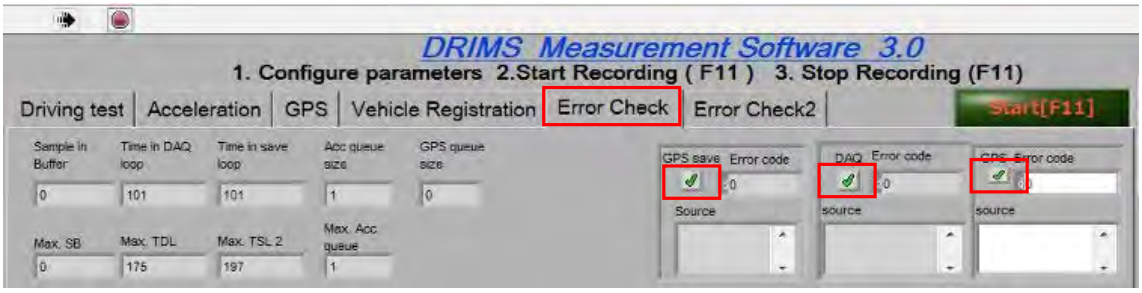
2) Enter “7” in UTC Time Zone.

Note: Universal Time, Coordinated (UTC) in Cambodia is “+7”.

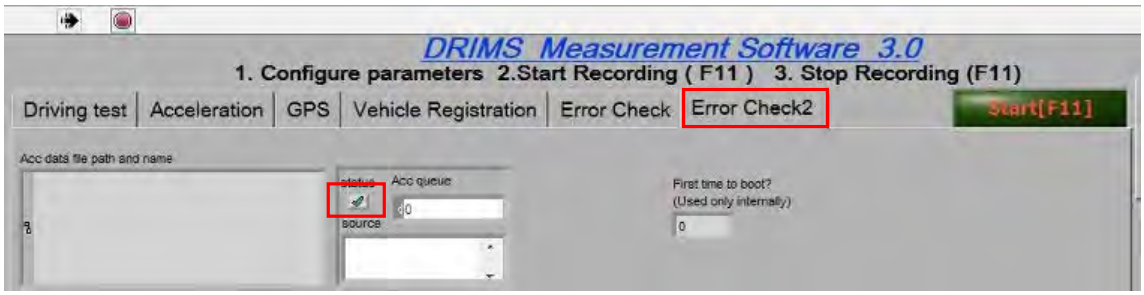


Step-7: Error Check

1) Select “Error Check” and check if necessary data entry is the same as the example shown below.



2) Select “Error Check2” and check if necessary data entry is the same as the example shown below.

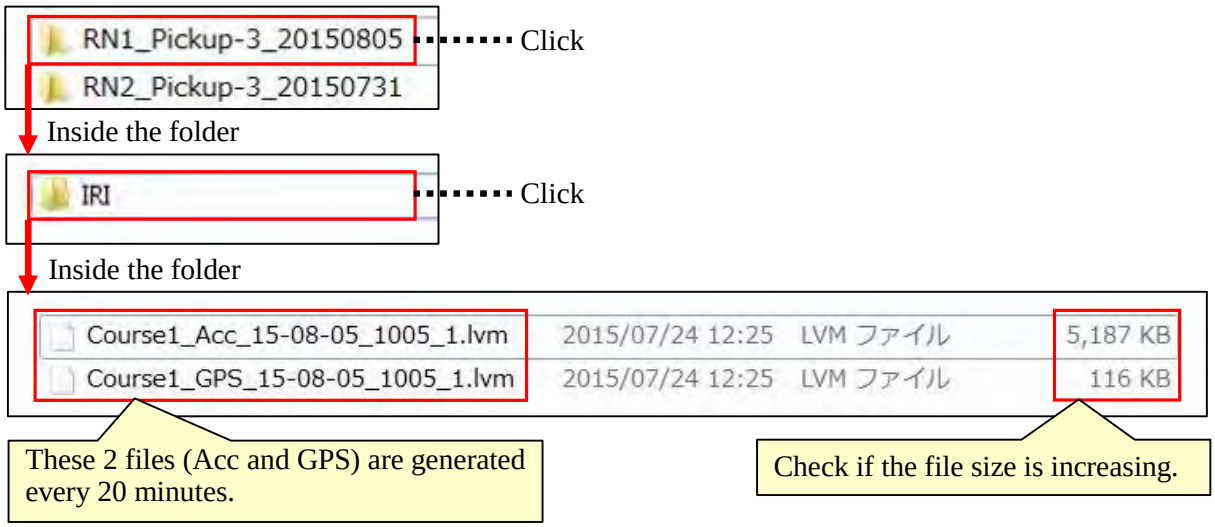


Step-8: Run the Measurement Software (actual measurement)

1) Select “Driving test”.

2) Click “Start[F11]” to run the software. (The icon turns into “Logging[F11]”.)

Step-9: Check if output files are generated in the folder explained in Step-3.

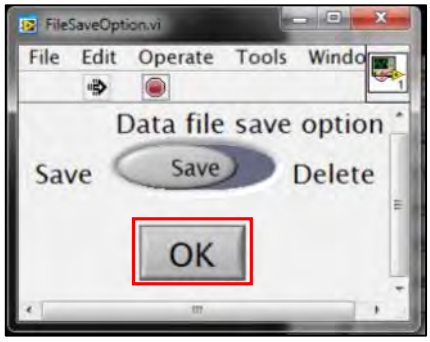


Step-10: Stop the software

1) Click “Logging[F11]” to stop the software.

Click

2) Choose “OK” to save the generated data files.



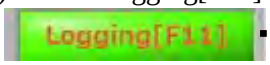
[Recommendation for Operation Test before Actual Inspections]

Process of Step-8 through Step-10 should be carried out as operation test before actual inspections.

1) Click “Start[F11]” to run the software.

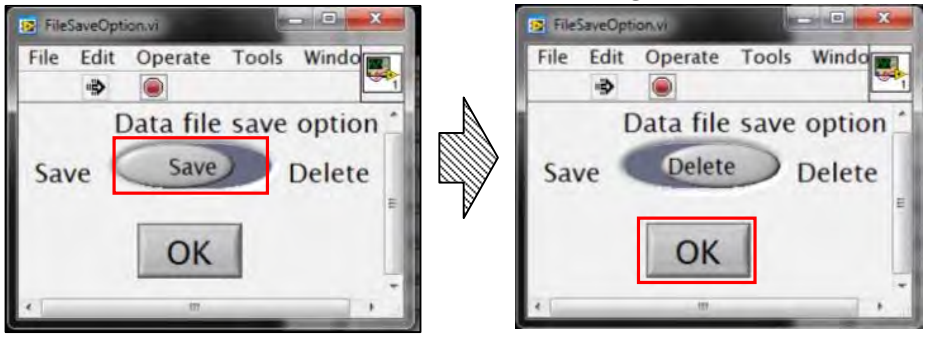
Click

2) Click “Logging[F11]” to stop the software.

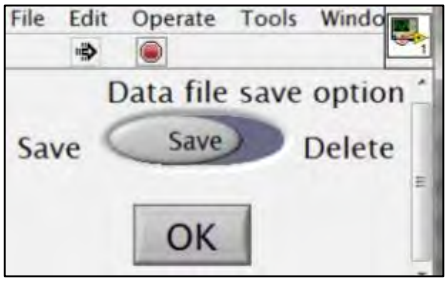


Click

3) Click “Save” first. Then, click “OK” after confirming that “Save” has turned into “Delete”.



[Trouble Shooting]

Trouble	Measure
The window shown below doesn’t appear when “Logging[F11]” is clicked to stop the software. 	1) Remove all the connected cables. 2) Close the software. 3) Start the procedure all over again from Step-1.

Step-11: Check the generated data files in the folder as explained in Step-9.

4.1.2 Screen Structure of DRIMS Measurement Software

Figure-5 illustrates basic screen structure of DRIMS measurement software.

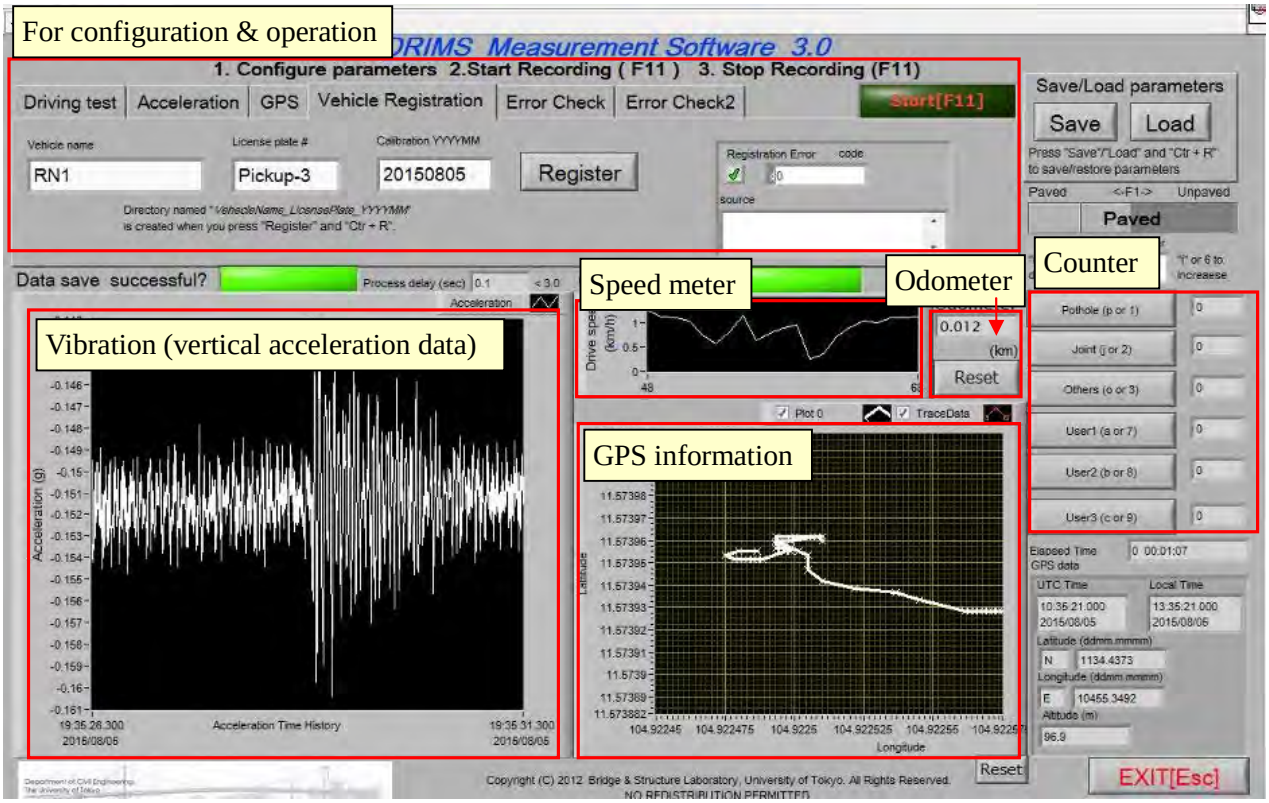


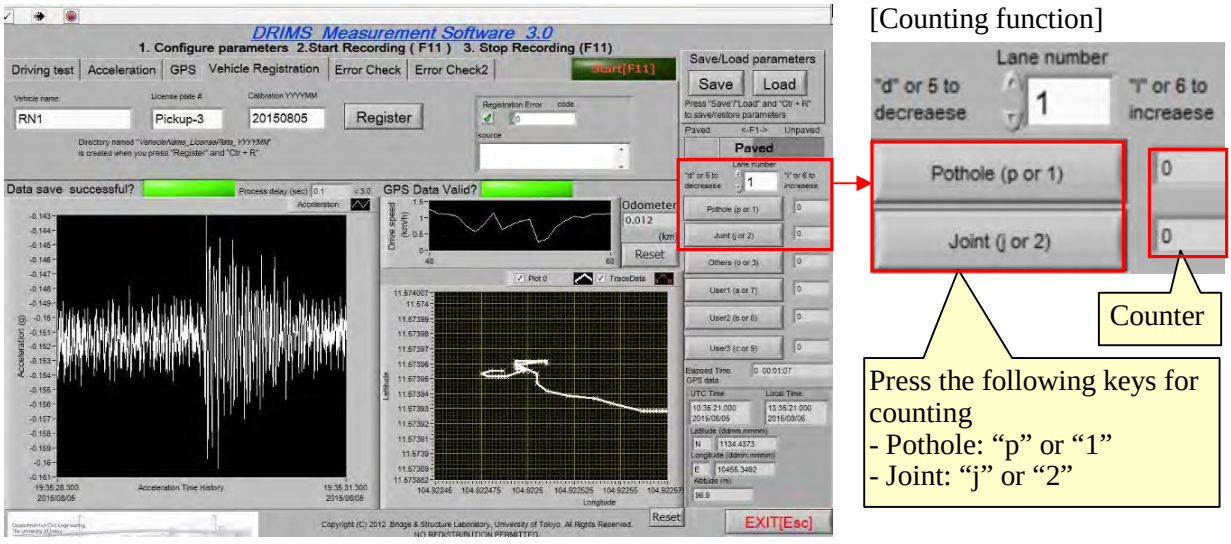
Figure-5 Screen Structure of DRIMS Measurement Software

[Additional function to IRI measurement]

In addition to IRI measurement, the software has counting function for the following items.

1) Number and locations of potholes

2) Number and locations of bridge expansion joints



4.1.3 Basic Rules for Operation of DRIMS Measurement Software

Basic rules of DRIMS application are as follows.

1) Do not start IRI measurement without “Operation Check” described in Section 4.1.1.
2) During IRI measurement, constantly check if generated data files are properly stored in certain folders.
3) Once IRI measurement is completed, save the obtained data files in properly-named folders of designated file server, PC etc.. For example, dates and locations of inspections shall be included in the folders’ names.

4.2 Folder Structure of DRIMS Measurement Software

Basic folder structure of DRIMS Measurement Software is shown in Figure-6. Folders of each inspection course have 2 folders, “Hump” and “IRI”. Acc files and GPS files are generated in these folders after inspections/calibrations. Then, “output” folders are to be added after analyses based on the Acc files and GPS files.

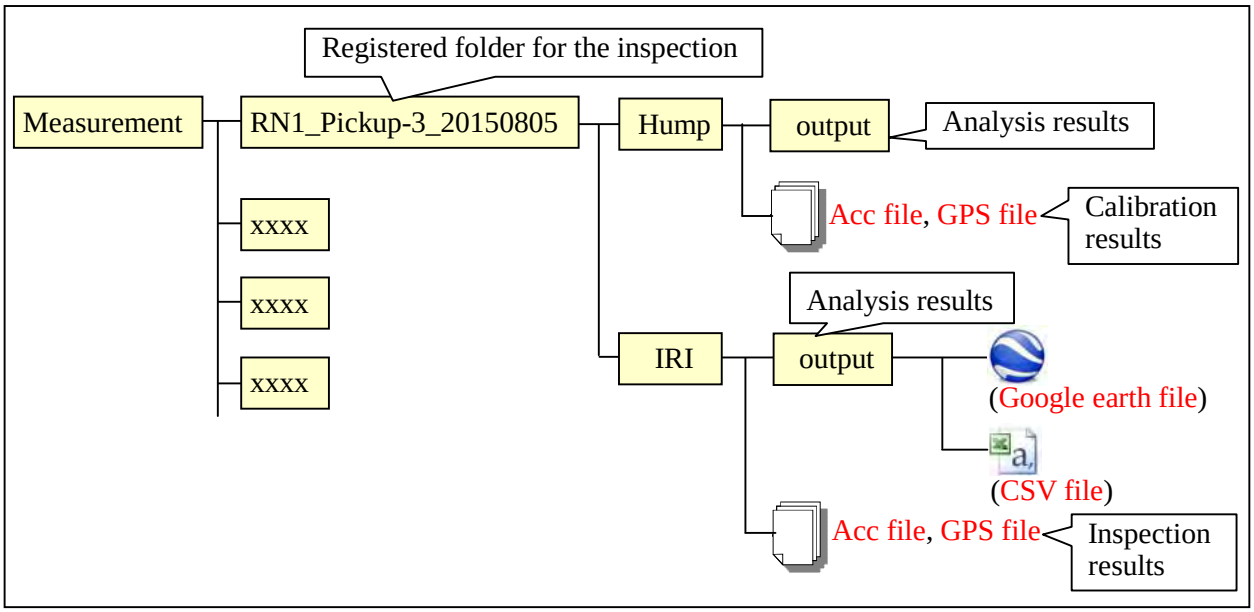


Figure-6 Folder Structure of DRIMS Measurement Software

CHAPTER 5 Hump Calibration

5.1 Objective of Hump Calibration

5.1.1 Objective of Hump Calibration

Hump calibration shall be conducted in order to adjust different vibration characteristics of inspection vehicles. As shown in Figure-7, vehicle response (vibration) is quite different, depending on vehicle types. This means, IRI values could be a lot different due to vehicle types. Therefore, vehicle models in IRI-analysis software shall be standardized by hump calibrations in order to maintain consistency of IRI.

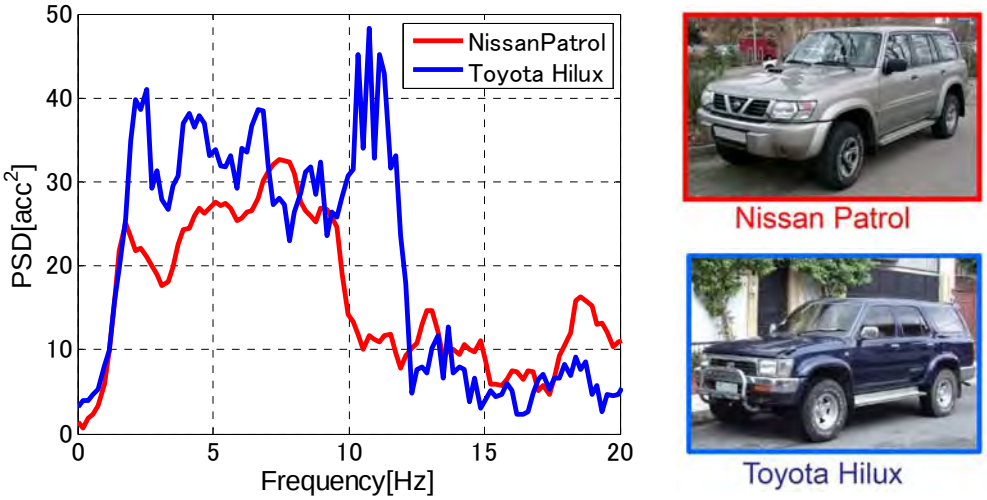


Figure-7 Comparison of Vehicle Response Difference

5.1.2 Effect of Hump Calibration

Figure-8 shows effect of hump calibration on IRI value calculation; IRI values of 2 different type vehicles are similar (adjusted by hump calibration).

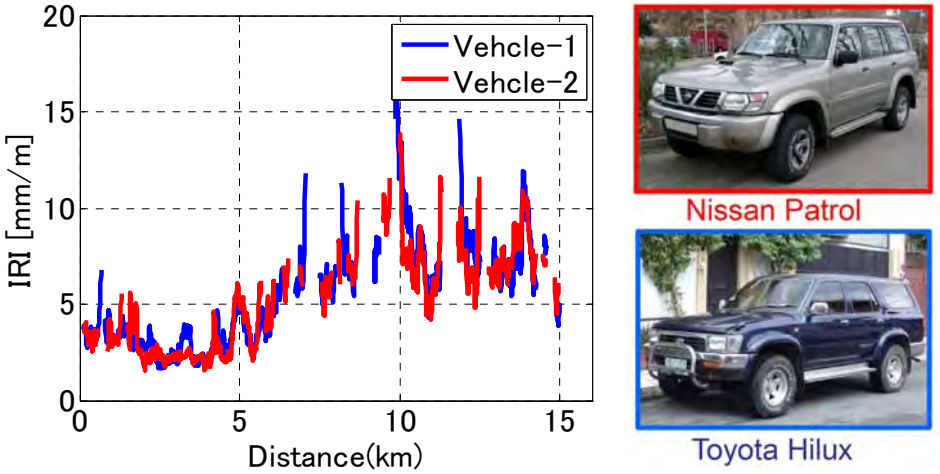


Figure-8 Comparison of IRI Values after Hump Calibration

5.2 Outline of Hump Calibration

Figure-9 outlines standard hump calibration procedure. Hump calibration requires about 100m flat driving course. Vehicles speed up in the first 20m of the course and maintain constant speed of 20km/h before they get on humps. After passing the humps, the vehicles still maintain 20km/h for 5 seconds and begin to speed down. This process, hump calibration, shall be conducted at least 5 times repeatedly. It should be noted that the distance indicated in Figure-9 is a reference, but not a specific rule. Small difference of the distance does not affect the calibration results so much as long as the constant driving speed of 20km/h is maintained about 5 seconds before and after vehicles get on the humps. It also should be noted that the number of passengers shall be the same as that for IRI measurement.

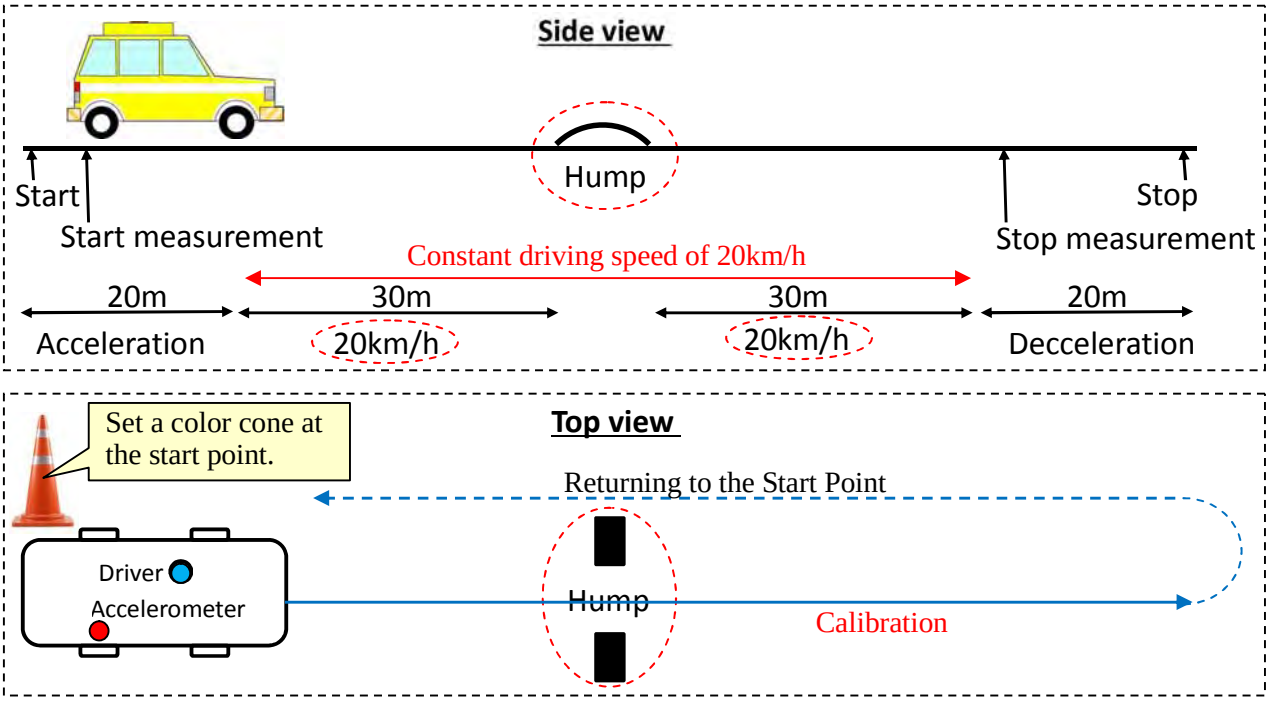
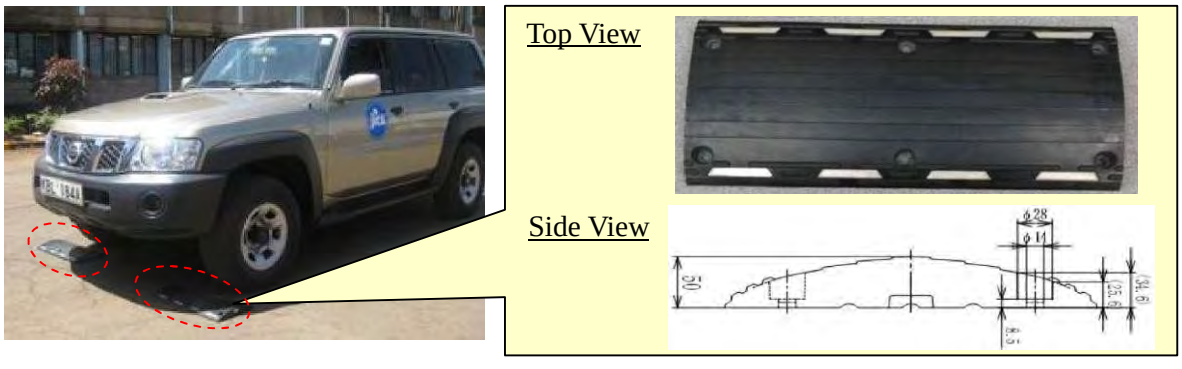


Figure-9 Outline of Standard Hump Calibration

5.3 Hump Calibration Procedure

Hump calibration shall be carried out in accordance with the following procedure.

Step-1: Install humps in the calibration course and a color cone at the start point.

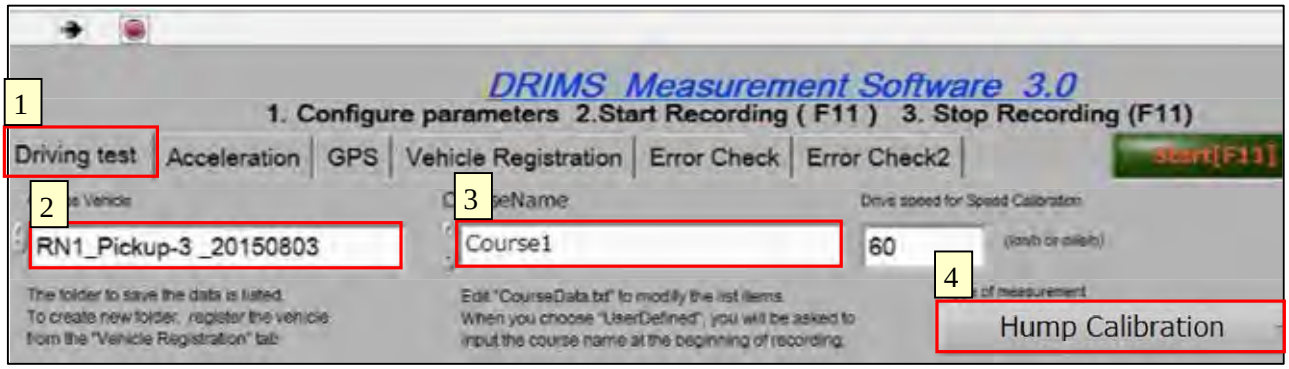


Step-2: Open DRIMS Measurement Software.

DRIMS_Measurement_3_1_6.exe ..... Click

Step-3: Data Entry for “Driving test”

1) Select “Driving test”.
2) Select the folder for Inspection
3) Define course name. (Ex. Course1)
4) Chose “Hump Calibration”.

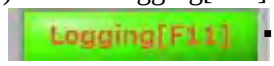


Step-4: Start calibration

1) Set the vehicle at the start point.
2) Click “Start[F11]” to run the software.

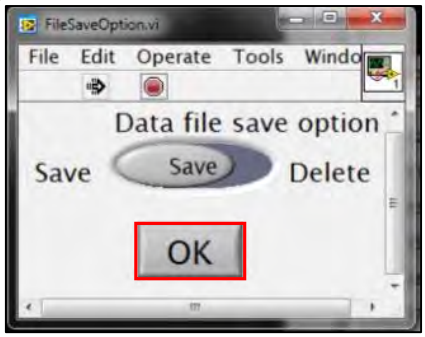
..... Click

3) Speed up and maintain 20km/h.
4) After getting on humps, keep driving at 20km/h for 5 seconds.
5) Click “Logging[F11]” to stop the software.



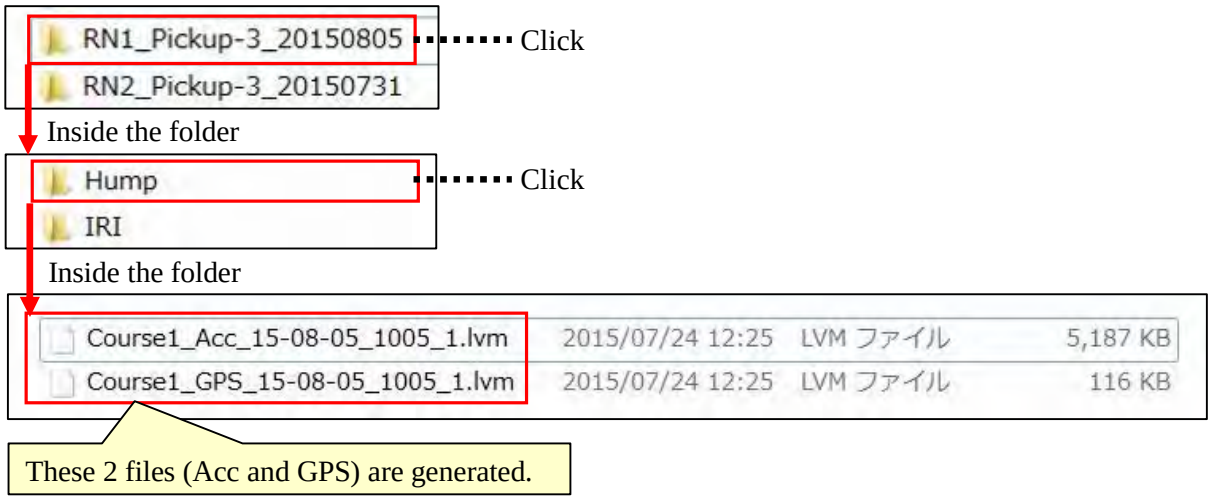
..... Click

6) Click “OK” and save the data.



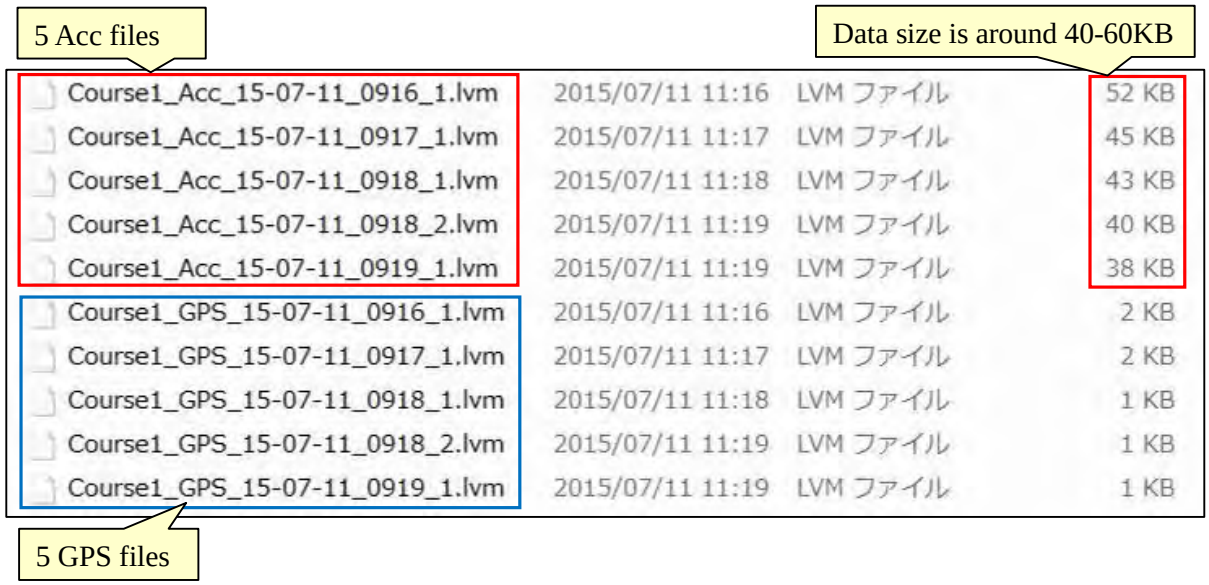
Note: If you fail to drive at constant speed of 20km/h, don’t save the data and carry out the calibration again.

Step-5: Check if the obtained data is properly saved in the following folder.



Step-6: Repeat the above process (hump calibration) 5 times.

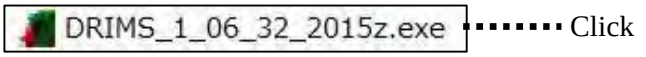
Step-7: Check the generated ACC files and GPS files (totally 5 sets).



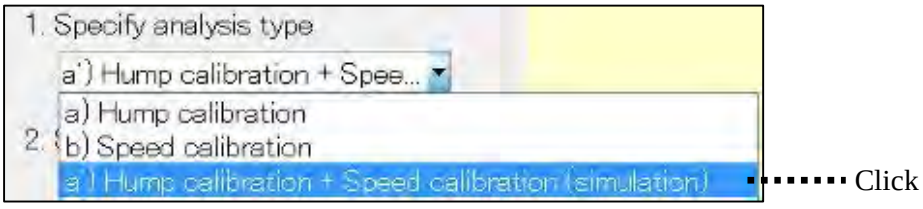
5.4 Analysis for Hump Calibration

Hump calibration result shall be finalized by analysis in accordance with the following procedure.

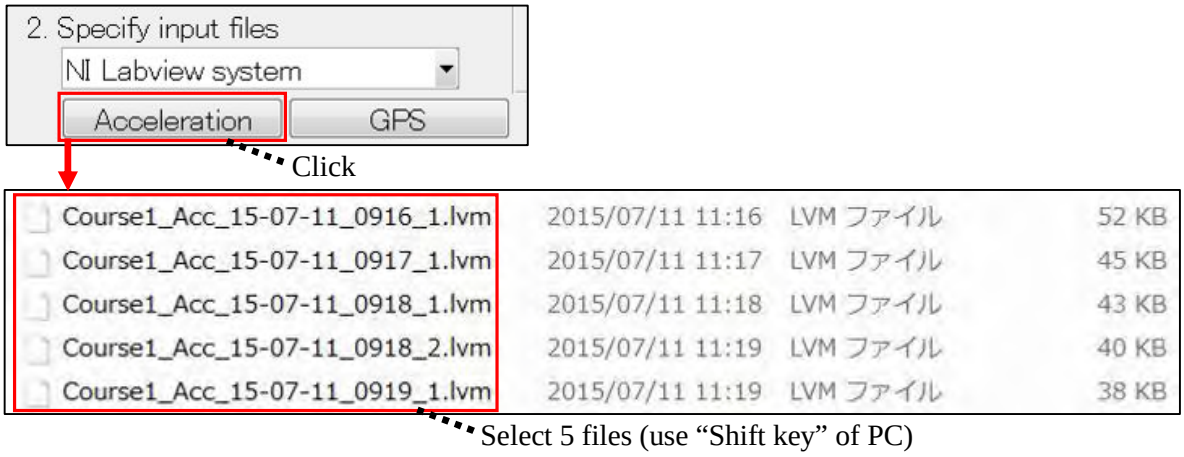
Step-1: Turn on DRIMS Analysis Software



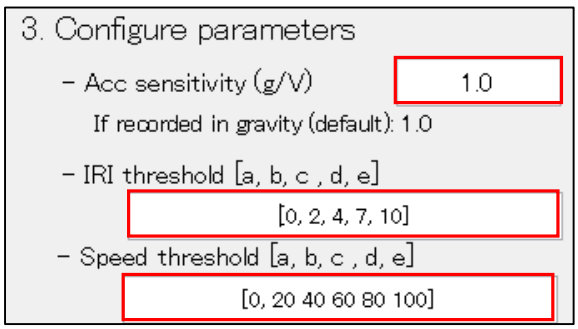
Step-2: Select “Hump calibration +Speed calibration (simulation)” in “1. Specify analysis type”.



Step-3: Click “Acceleration” in “2. Specify input files” and select 5 Acc files obtained from hump calibration. (You can select more than one file by pressing “Shift key” of PC.)



Step-4: Check if configuration of “3. Configure parameters” is set as follows.

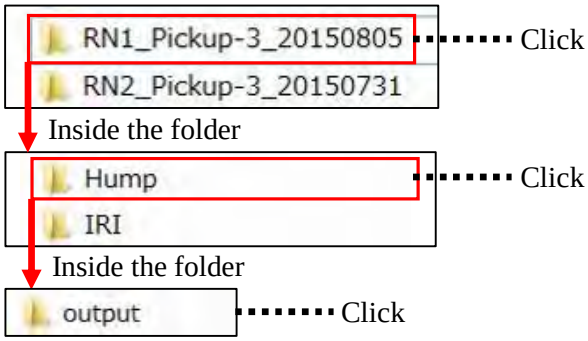


Step-5: Run the calculation.

Note: 1) New window pops up when the calculation starts.

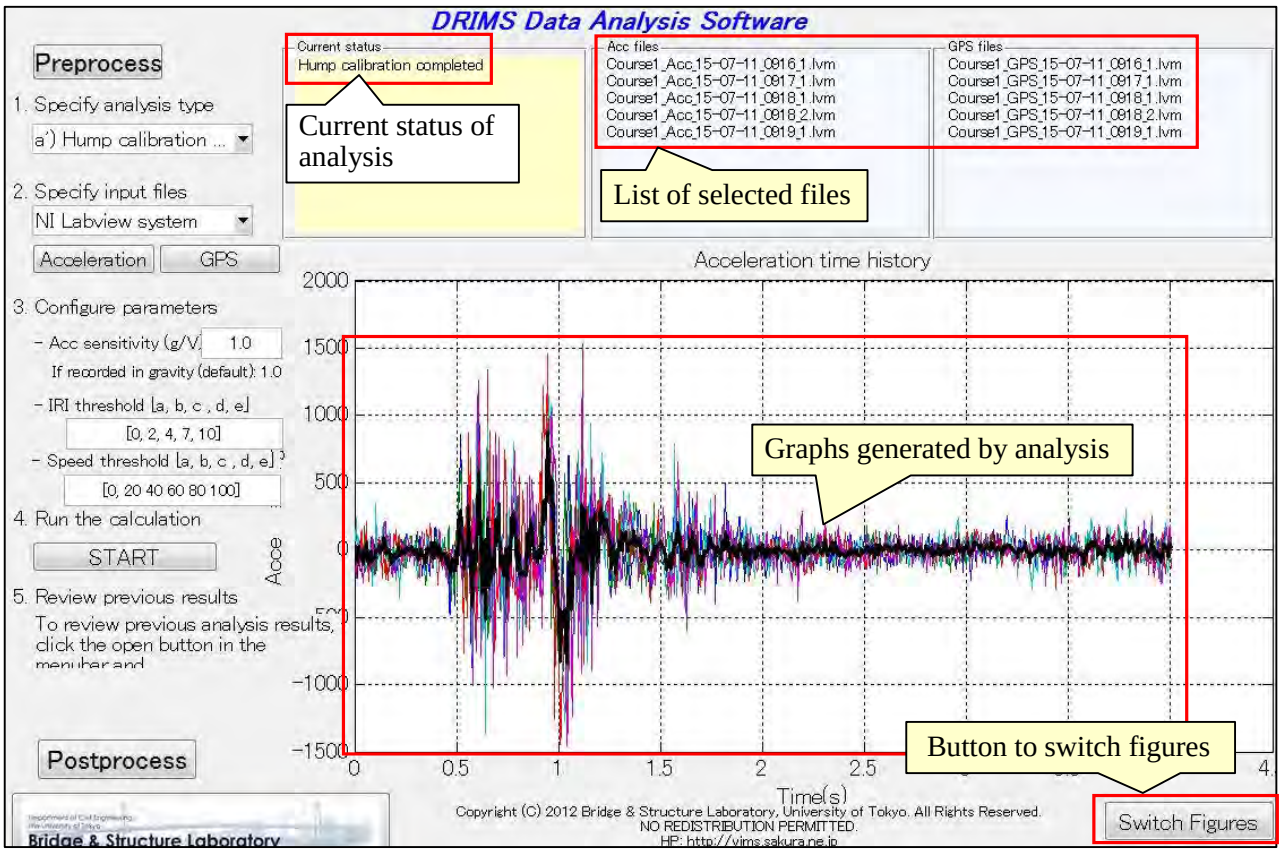
2) The calculation is to be finished in 5-10 minutes.

Step-6: Check if analysis result is properly saved in the following folder.



Note: The generated data files are to be used in analysis for IRI estimation.

[Reference (Screen Structure of DRIMS Analysis Software)]



Step-7: Check the analysis result.

Lines of “Model” and “Measurement” shown in Figure-10 shall be close to each other in the frequency range of 0 to 5 HZ (up to the first peak of the curve); acceptable difference of the 2 curves is 10% at most. If not, hump calibration shall be redone all over again.

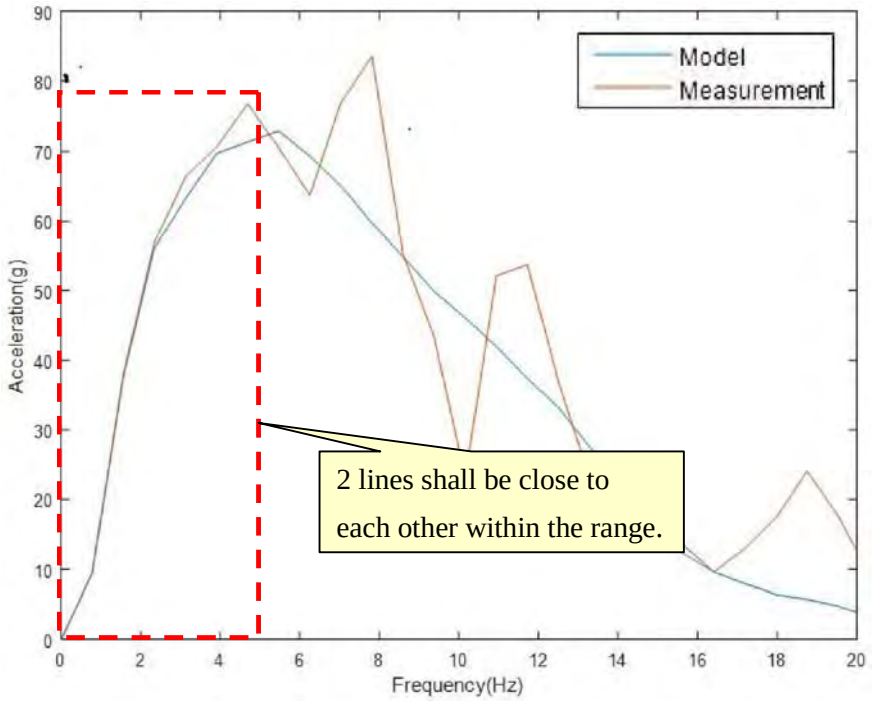


Figure-10 Criteria for Checking of Analysis Results

[Trouble Shooting]

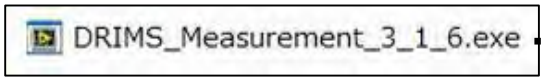
Trouble	Measures to be Taken
Calculation stop during its process	This error occurs due to inadequacy of some of the selected 5 Acc files. To solve this problem, follow the procedure below. 1) Conduct the analysis again file by file in order to identify which file is defective. 2) Delete the defective files. 3) Carry out hump calibration again in order to obtain Acc files that replace the defective files. Note: Refer to “Section 5.3” and check the procedure closely before redoing the hump calibration.

CHAPTER 6 IRI Estimation

6.1 IRI Measurement Procedure

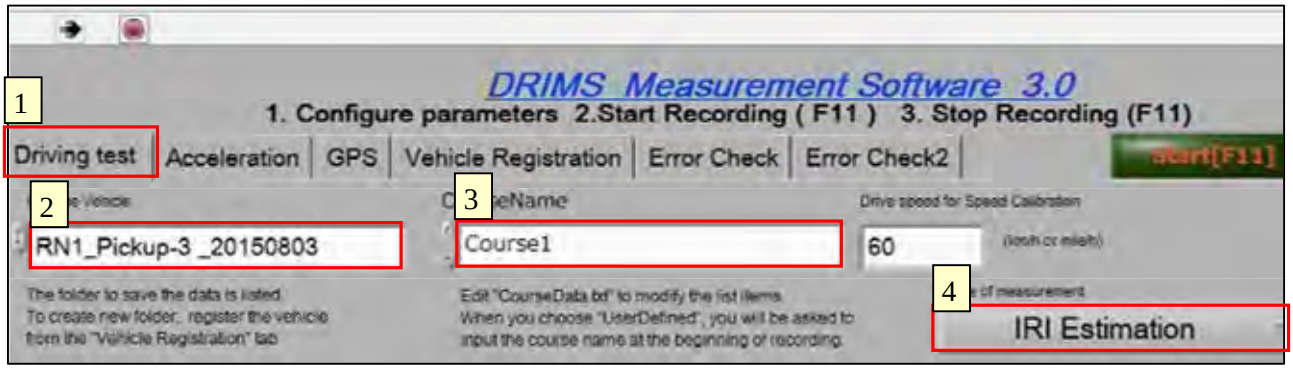
IRI Measurement shall be carried out in accordance with the following procedure.

Step-1: Open DRIMS Measurement Software.



Step-2: Configure the software, following Step-1 to Step-7 explained in “Section 4.1.1”.

Note: Select “IRI Estimation” in data entry of “Driving test”.



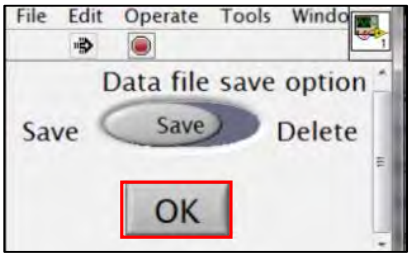
Step-3: IRI Measurement

1) Determine “start point” and “end point” of inspection courses and set vehicles at the start point.

2) Click “Start[F11]” at the inspection start point.

3) Click “Logging[F11]” at inspection rest points /inspection end point.

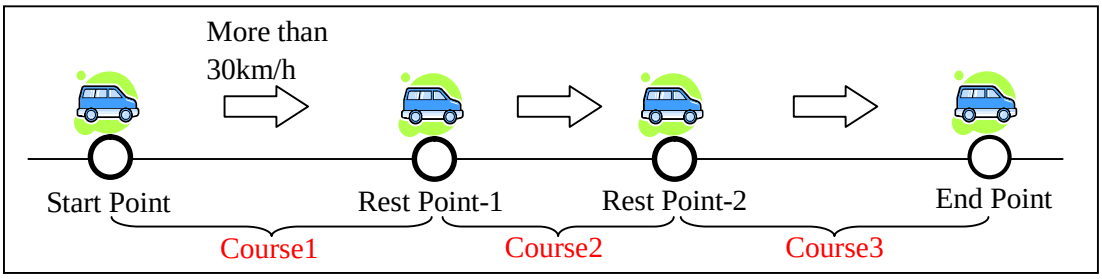
4) Click “OK” and save the data after clicking “Logging[F11]”.



Note: 1) Keep driving at more than 30km/h. (DRIMS can’t generate IRI values at less than 30km/h.)

2) Inspections can be temporarily stopped at rest points. Restart the inspection again after leaving the rest points.

3) Change the “Course Name” every after stopping at rest points (Ex. Course1, Course2, Course3 etc.) so that inspectors can easily identify generated data files along with time history.



[Recommendation for Continuous Inspection Course]

It is strongly recommended that inspection courses should be continuous although rest points can be set in the inspection courses. For instance, as described in Figure-11, if inspectors have more than one choice to set inspection start points, the start points should be set in consideration of the course continuity. Selection of continuous course makes post-processing of acquired data much more efficient. In case that an inspection course shown as "Bad Example" is taken, the 2 separated inspection courses can't be combined in post-processing stage due discontinuity of the courses.

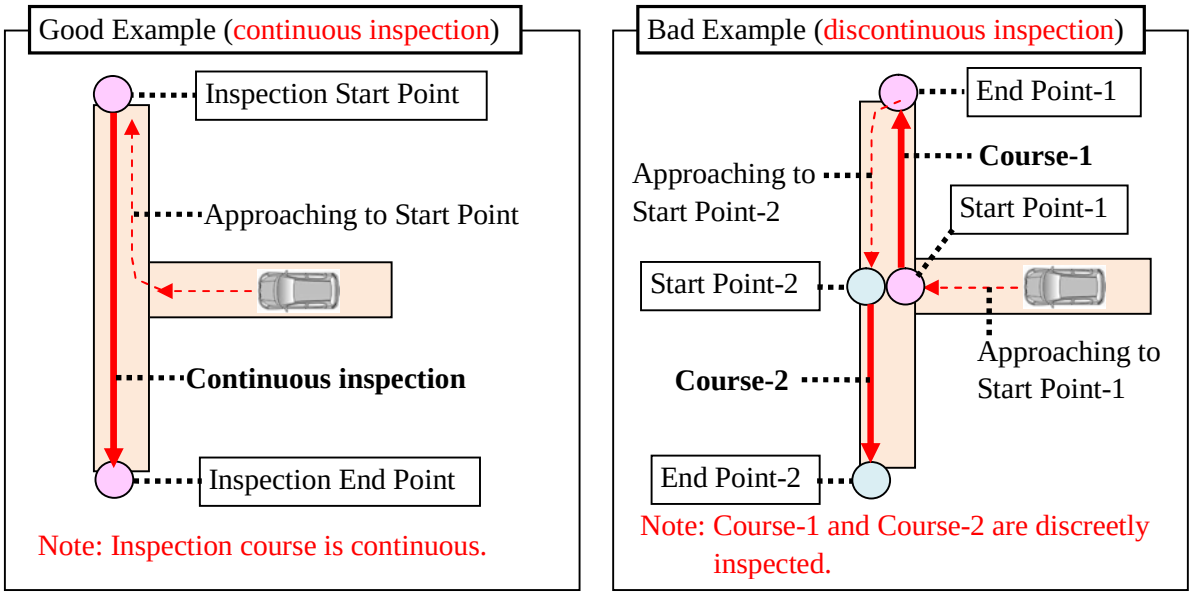
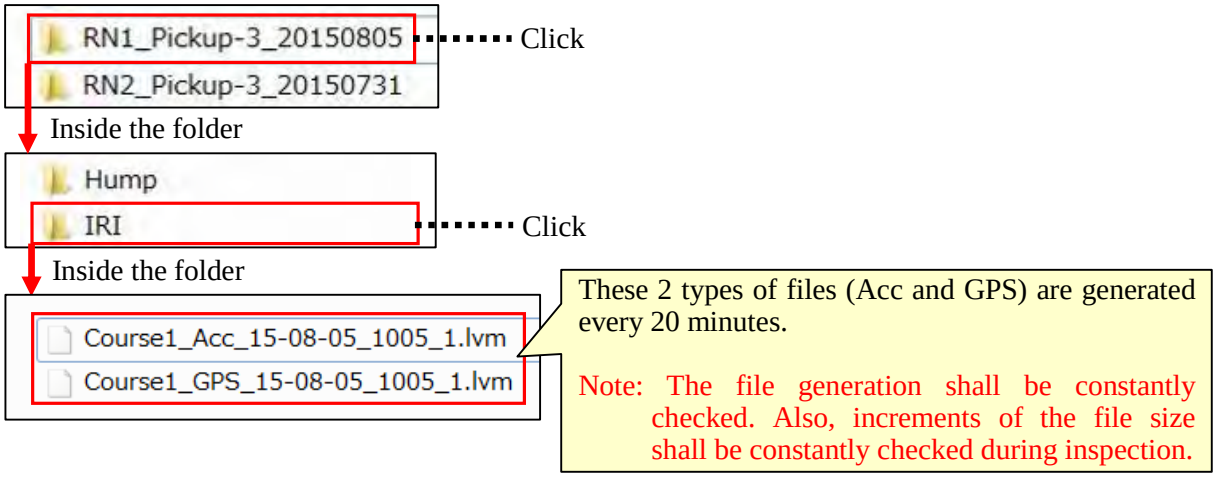


Figure-11 Recommendation for Continuous Inspection Course

Step-4: Check if analysis result is properly saved in the following folder.



[Trouble Shooting (failure in obtaining Acc/GPS files)]

Trouble	Measures to be Taken
1. Acc/GPS files are not generated. 2. Size of Acc/GPS files are not increasing.	To solve this problem, follow the procedure below. **[Measure-1]** 1) Stop IRI measurement and the inspection vehicle. 2) Check connection between DRIMS equipment and the laptop PC. 3) Conduct "Operation Test" explained in Page-20. 4) If it's working fine, get back to IRI measurement again. If Measure-1 doesn't work, proceed to Measure-2. **[Measure-2]** 1) Restart the laptop PC. 2) Redo "Basic Operation of DRIMS" explained in Page-16 through 20 all over again. 3) If it's working fine, get back to IRI measurement again. If Measure-2 doesn't work, the laptop PC might have some problems. In this case, it's better to stop the inspection and carry out the inspection with other laptop PCs on another day.

[Recommendation for Data Check at Inspection End Points]

It's strongly recommended that IRI data obtained through inspections should be closely checked at inspection end points. Desirably, analysis procedure (to be explained in Section 6.2) should be taken as a part of the data checking. As illustrated in Figure-12, if there's anything wrong with the obtained data, inspectors have one more chance to carry out IRI measurement again on their way home. In this way, checking at the end points prevents inspectors from doing inspections again for the same course on another day.

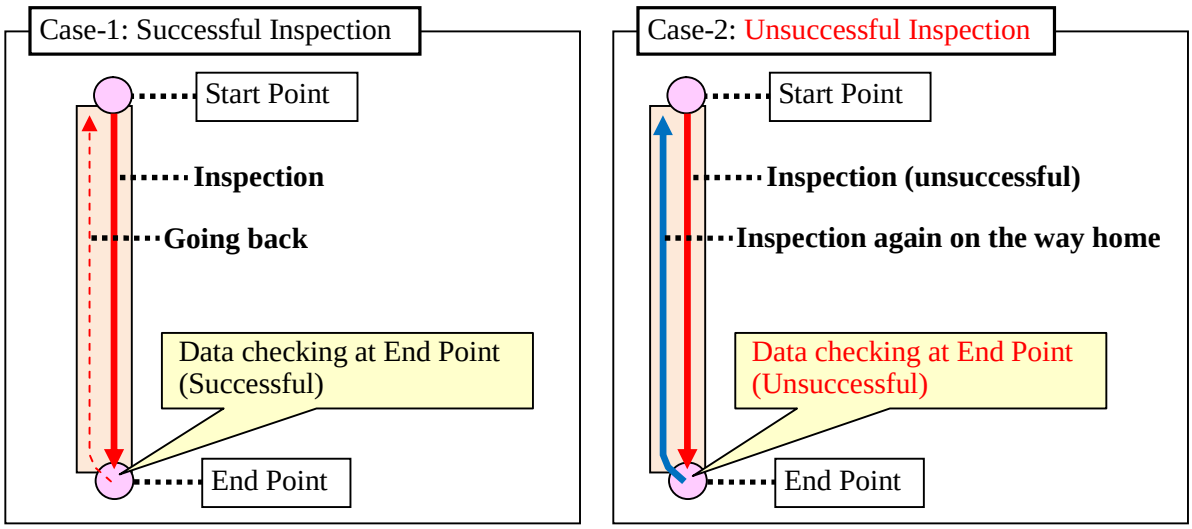
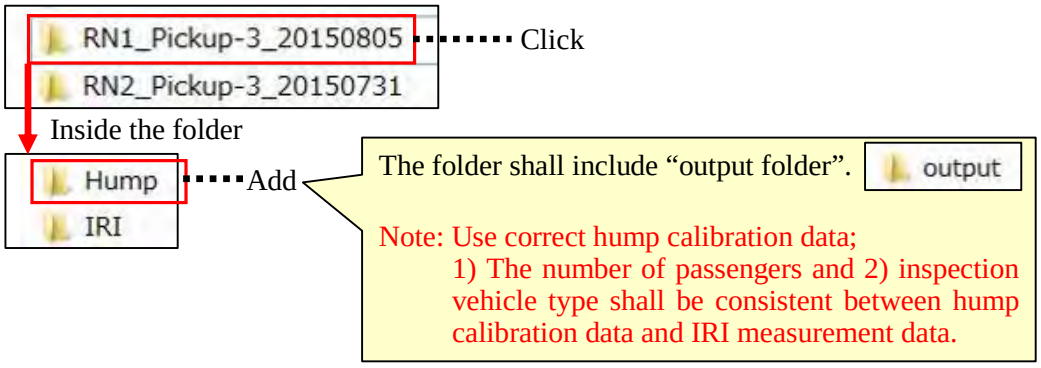


Figure-12 Data Checking at Inspection End Points

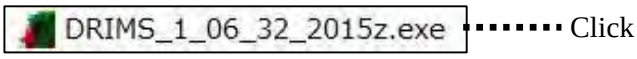
6.2 Analysis for IRI Estimation

IRI measurement results shall be finalized by analysis in accordance with the following procedure.

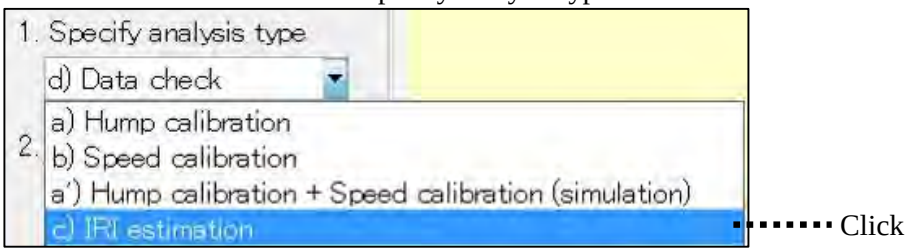
Step-1: Add hump calibration folder (including output) in the folder where IRI measurement results are saved. The number of passengers and vehicle type shall be consistent between hump calibration and IRI measurement.



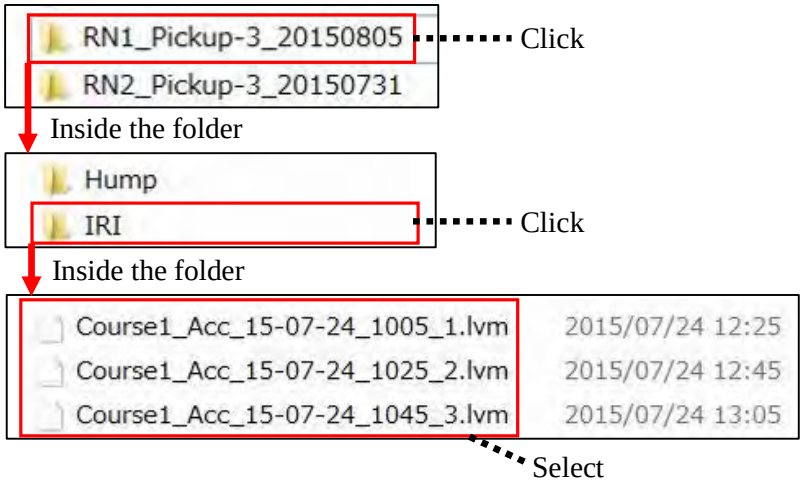
Step-2: Turn on DRIMS Analysis Software



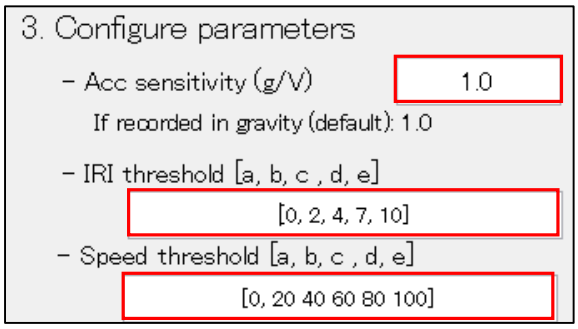
Step-3: Select “IRI estimation” in “1. Specify analysis type”.



Step-4: Click “Acceleration” in “2. Specify input files” and select all the Acc files obtained from IRI measurement.



Step-5: Check if configuration of “3. Configure parameters” is set as follows.

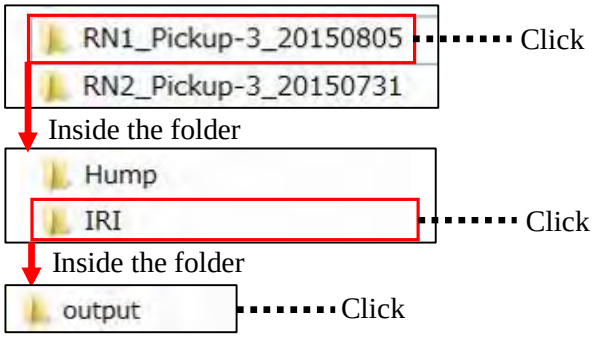


Step-6: Run the calculation

Note: 1) New window pops up when the calculation starts.

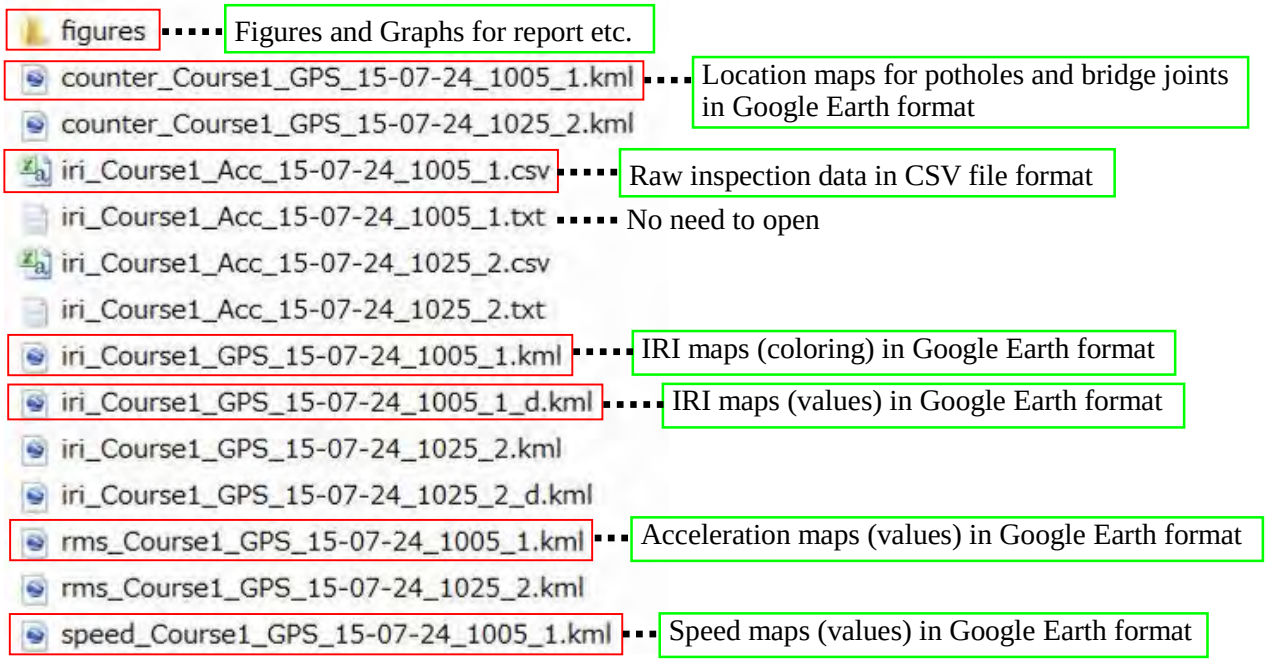
2) The calculation time changes, depending on the number of files.

Step-7: Check if analysis result is properly saved in the following folder.



[Output]

The following data files are to be generated after analysis as outputs of IRI measurement.



CHAPTER 7 Post Processing of Analysis Results

7.1 Outline

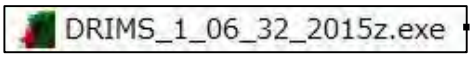
DRIMS Analysis Software has “post processing function” which sorts DRIMS analysis results. Application of the function expedites summarization of inspection results. This section explains procedures of the following 3 functions that can be utilized in data sorting stage.

1) Integration of DRIMS outputs (CSV files and Google Earth files) into one file
2) Calculation of average IRI values at 100m interval
   Note: Originally, calculation interval of average IRI values is 10m.
3) Integration of IRI values into road monitoring system (output of the recorder)

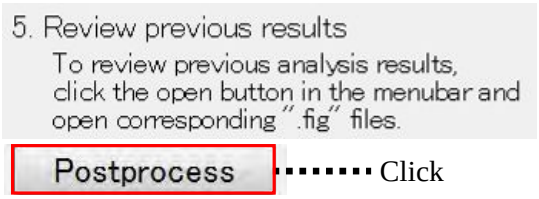
7.2 Integration of DRIMS Outputs into One File

DRIMS outputs (CSV files and Google Earth files) can be integrated into one file in accordance with the following procedure.

Step-1: Turn on DRIMS Analysis Software.

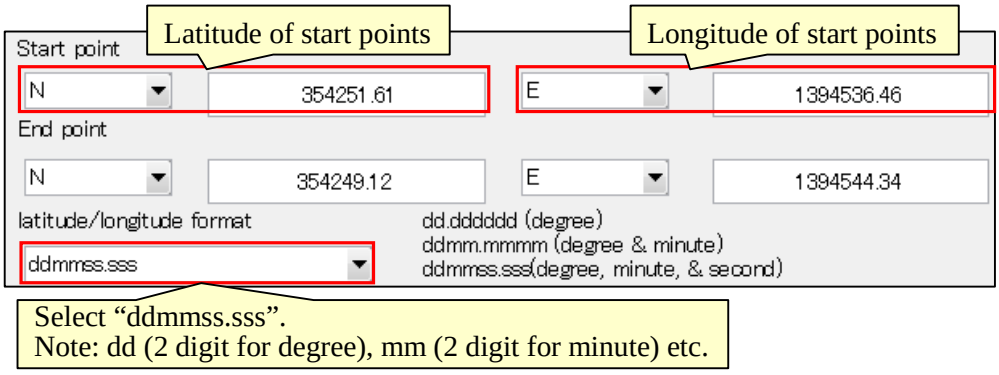


Step-2: Click “Postprocess” in “5. Review previous results”.



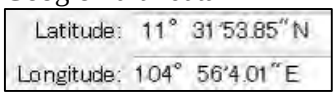
Step-3: Specify the start point and the end point of the inspection course.

Specify the start point and the end point of the inspection course using GPS information of Google Earth files.



[Example of data entry]

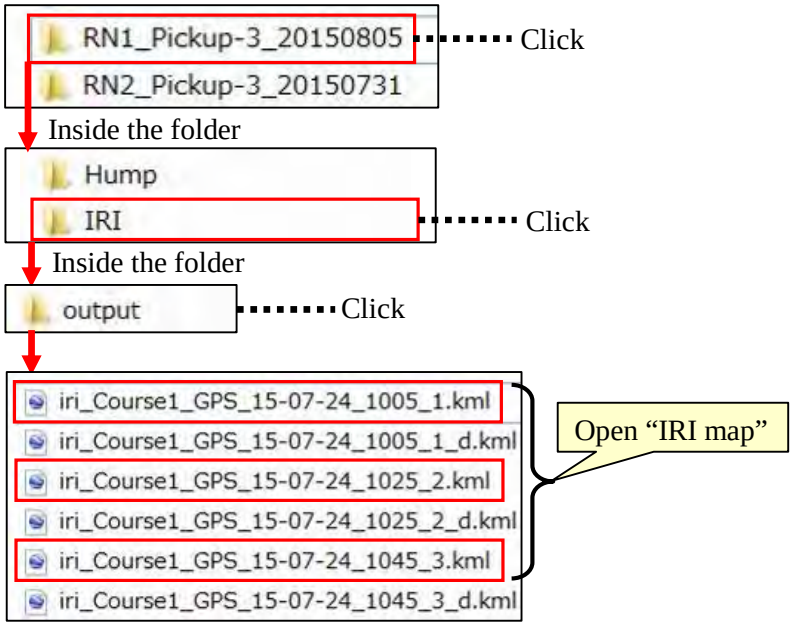
Google Earth data



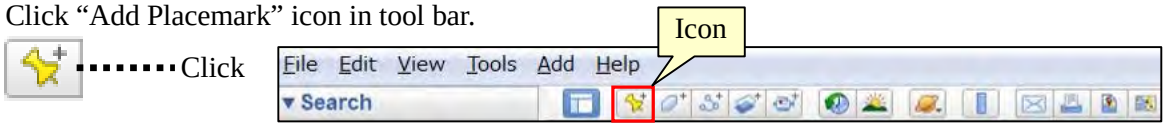
Data entry for DRIMS Analysis Software

Note: Latitudes and longitudes of the above 2 points shall be looked up in Google Earth as follows.

a) Open Google Earth files (IRI map)

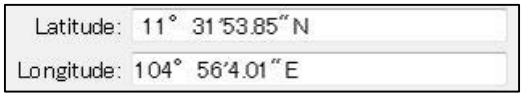


b) Click “Add Placemark” icon in tool bar.



c) Move the icon blinking on the display.

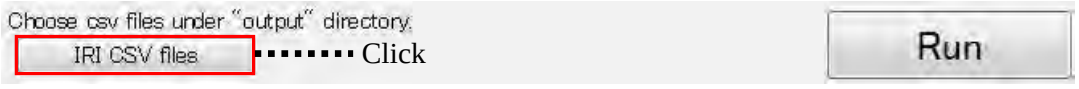
d) Read latitude and longitude of the point (to be entered into DRIMS Analysis Software).



e) Repeat the same process for the end point.

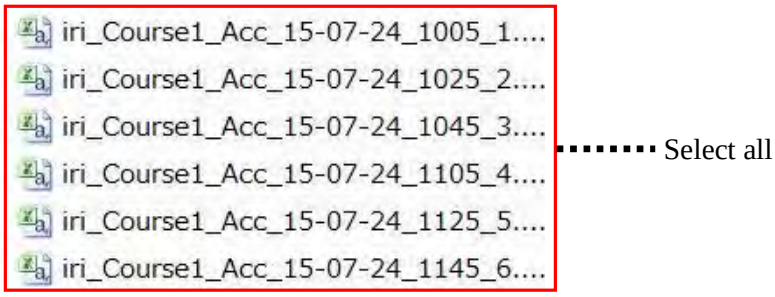
Step-4: Select “IRI CSV files”.

1) Click “IRI CSV files”.

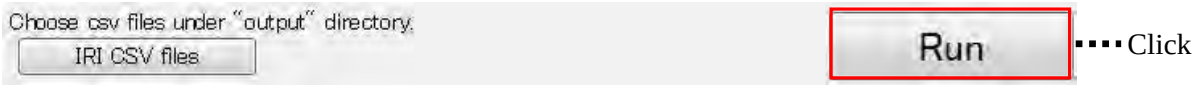


2) Enter the file path of “measurement output folder” in the address bar.

3) Select all the CSV files in the folder and click “OK”.



Step-5: Click “Run”.

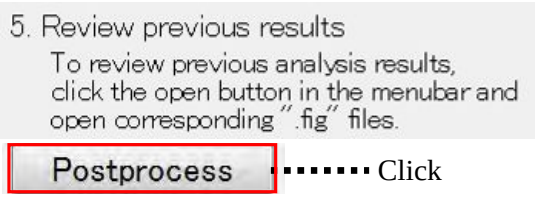


Step-6: Check the Generated Data Files

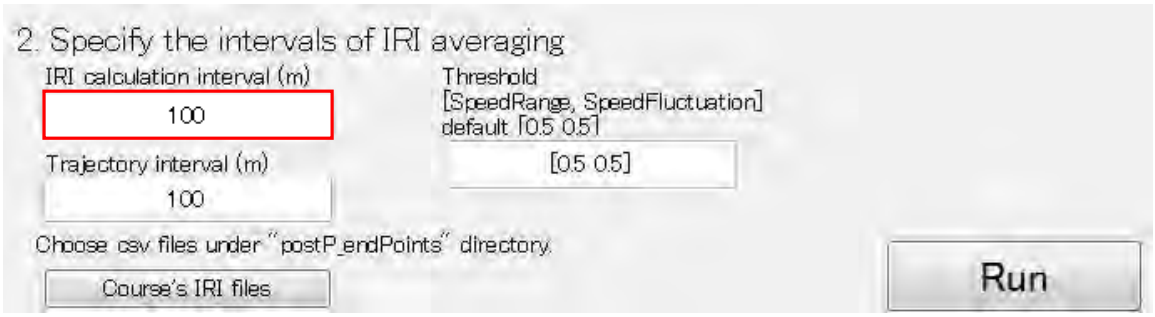
7.3 Calculation of Average IRI Values

Calculation interval of IRI values in CSV files can be changed from 10m to 100m by the following procedure.

Step-1: Click “Postprocess” in “5. Review previous results”.

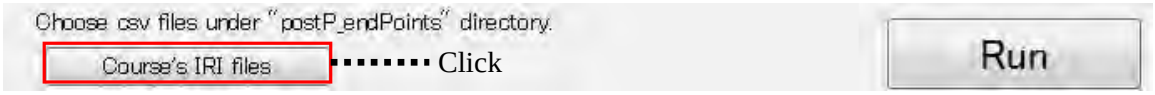


Step-2: Enter “100” in “IRI calculation interval (m)”.



Step-3: Select “Course’s IRI files”.

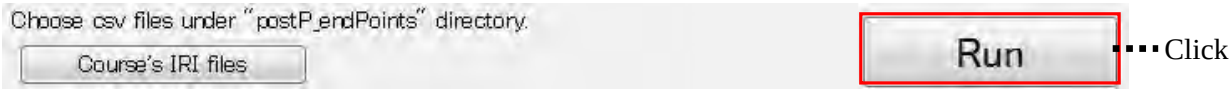
1) Click “Course’s IRI files”.



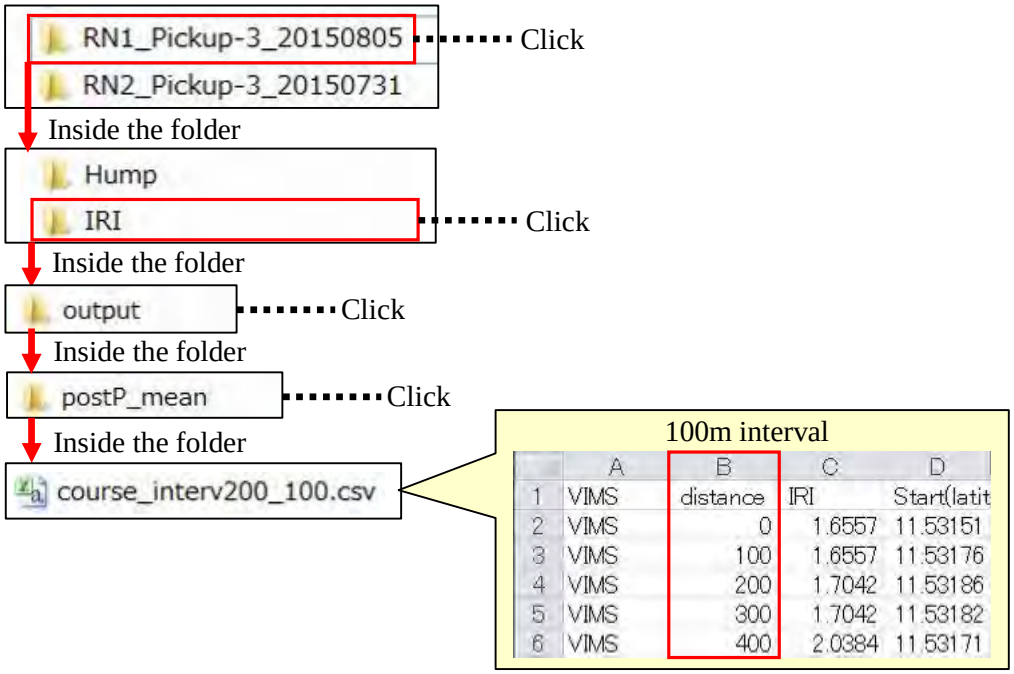
2) Enter the file path of “postP_endPoints” folder (generated in “Section 8.2”) in the address bar.

3) Select the CSV file in the folder and click “OK”.

Step-4: Click “Run”.



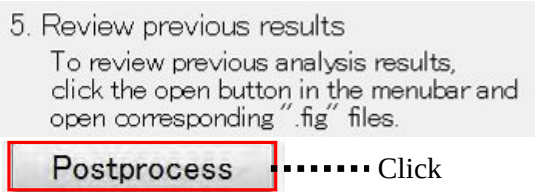
Step-5: Check the Generated Data File.



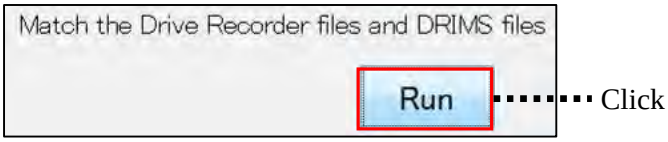
7.4 Integration of IRI Values into Road Monitoring System

IRI Values can be integrated into the road monitoring system by the following procedure.

Step-1: Click “Postprocess” in “5. Review previous results”.

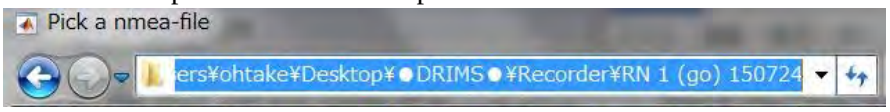


Step-2: Click “Run” for “Match the Drive Recorder files and DRIMS files”.

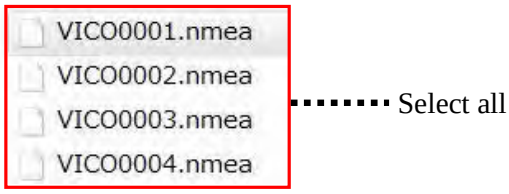


Step-3: Select “nmea files”.

1) Enter the file path of “recorder output folder” in the address bar.

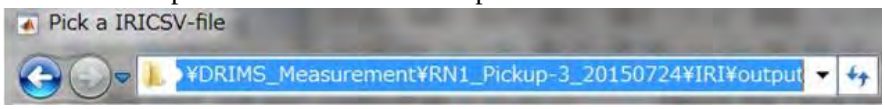


2) Select all the “nmea files” (GPS information obtained by the recorder) and click “OK”.

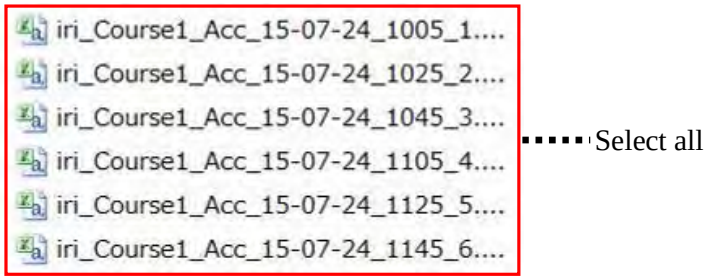


Step-4: Select CSV files.

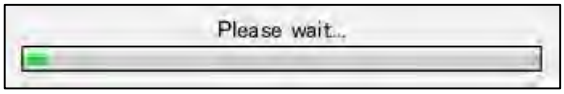
1) Enter the file path of “measurement output folder” in the address bar.



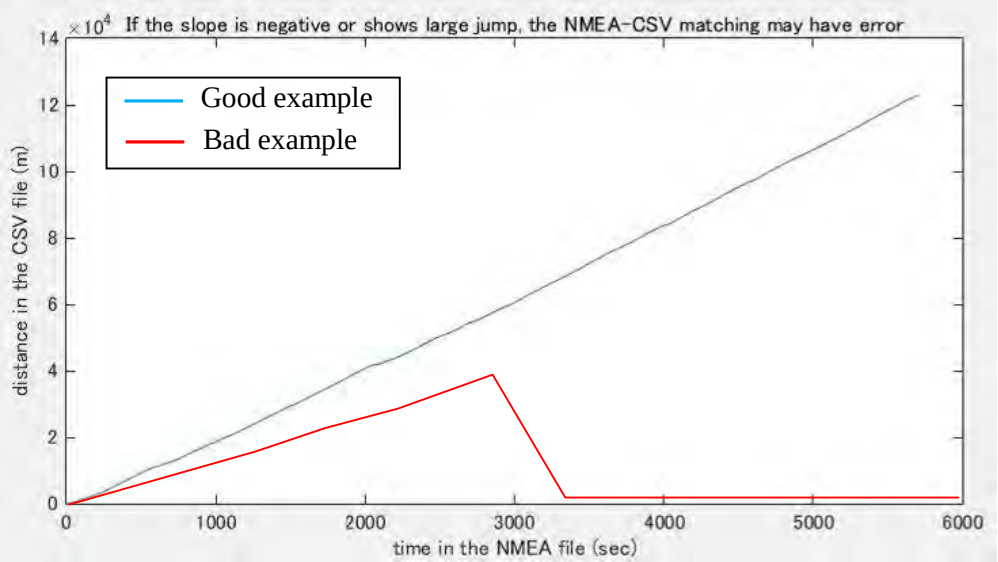
2) Select all the CSV files.



Note: 1) After selecting CSV files, data integration starts with the following pop-up window.



2) If the integration is successfully done, a linear graph is to be given. In case that the graph is not linear, check if correct “nmea files” and CSV files are selected and redo the process.



Step-5: Check the Result of Data Integration

1) Open “RegistratorViewer” (road monitoring system software).

RegistratorViewer.exe ····· Click

2) Check if the altitude graph has been replaced with the IRI graph.

Basically, IRI values range from 2 to 15. If the values are out of the range, most probably the graph still indicates altitude.

CHAPTER 8 Data Storage in Database

8.1 Objective of Data Storage in Database

Objective of data storage in database is to sustainably monitor and compare road conditions between before and after repair works. As shown in Figure-13, change of road conditions shall be quantitatively evaluated by certain criteria such as IRI in order to clarify the effectiveness of road repair works.

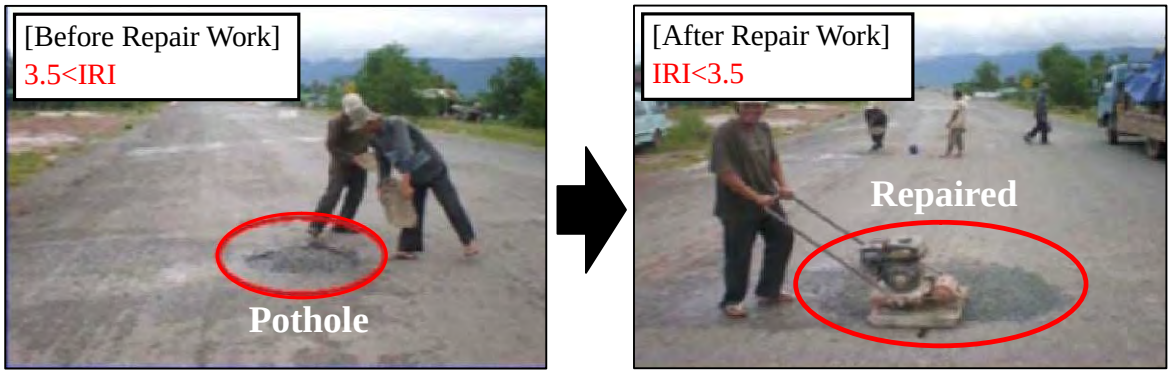


Figure-13 Comparison of Road Condition between before and after Repair Works

8.2 An Example of DRIMS-based Database

8.2.1 Overall Structure of Road Inspection Database

Road inspection data should be stored in hard disk drive whose data capacity is 1TB to 3TB (hereafter called “database”). Basically, the database should consist of the following 4 folders;

Folder-1: Measurement → DRIMS measurement/analysis data (for back-up)
Folder-2: Movie → Output-1: Recorded movies
Folder-3: IRI Map → Output-2: Road condition map in Google Earth format
Folder-4: Inventory → Output-3: Road inventory in Excel file format

All the DRIMS-related files are to be manually stored into either of the above 4 folders after inspection and subsequent analyses.

8.2.2 Folder-1: Measurement (DRIMS Back-up Data)

Folder-1 stores DRIMS measurement/analysis data for back-up. The details of folder-1 structure are already shown in Figure-6 (page-22).

8.2.3 Folder-2: Movie (Output-1)

Folder-2 stores recorded movies with GPS locations. The movies can be used as road monitoring system. As illustrated in Figure-14, the road monitoring system is combination of movies, GPS location maps, driving speed (time history based), IRI values (time history based), and speed meter & odometer. The system is very useful for reviewing the inspections. An example of folder-2 structure is shown in Figure-15.

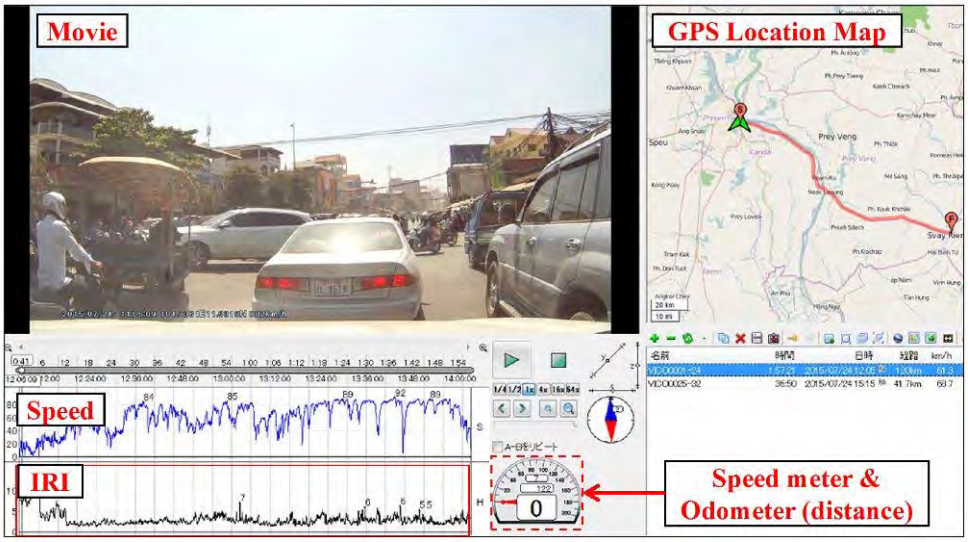


Figure-14 Recorded Movies with GPS Location

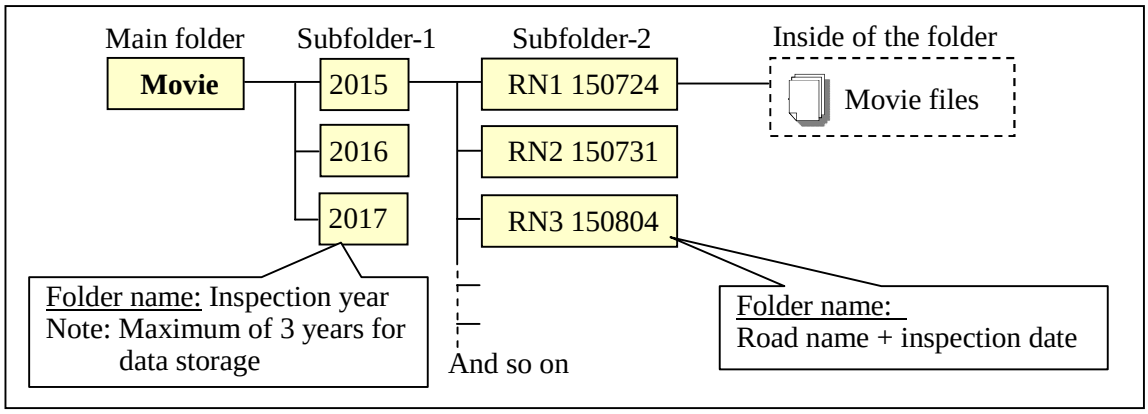


Figure-15 An example of Folder-2 Structure

8.2.4 Folder-3: IRI Map (Output-2)

Folder-3 stores road condition maps in Google Earth format (hereafter called “IRI map”). As shown in Figure-16, road conditions are indicated by 5 different colors on IRI maps, depending on their IRI ranges. An example of folder-3 structure is shown in Figure-17.

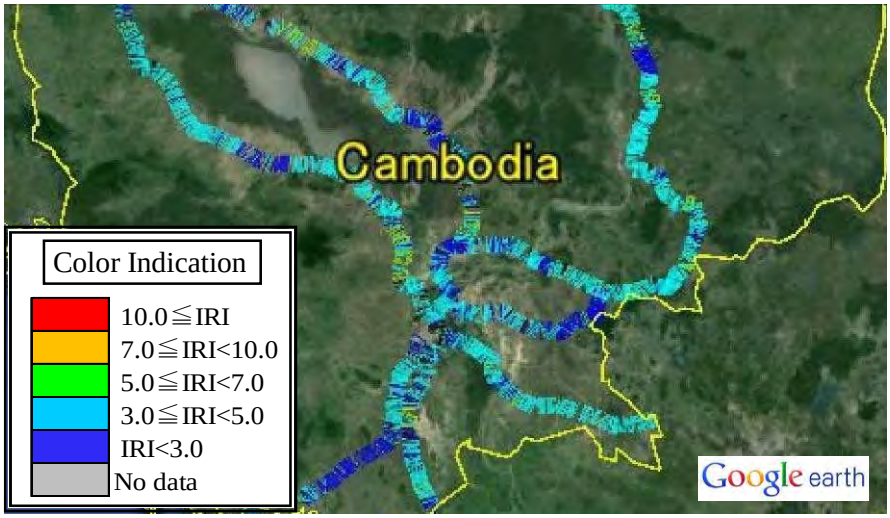


Figure-16 Road Condition Map (IRI Map)

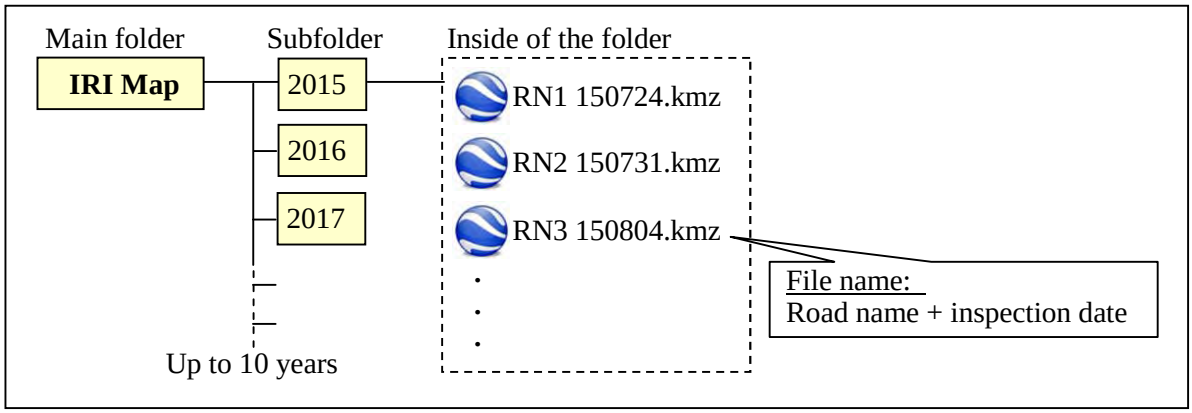


Figure-17 An Example of Folder-3 Structure

8.2.5 Folder-4: Inventory (Output-3)

Folder-4 stores road inventory that is to be prepared using DRIMS inspection data that is given as IRI data sheet in CSV file format as shown in Figure-18. The data sheets include time of recording, distance (location of measurement), IRI values (at 10m interval), GPS information, driving speed, number of identified defects, and number of bridge expansion joints.

DRIMS	distance	IRI	latitude	longitude	altitude	speed	Pothole	Joint
7/24/2015 3:05:30 AM	0	7.68909	11.53151	104.935	14.8	17.72911	0	0
7/24/2015 3:05:45 AM	10	7.68909	11.53156	104.9351	14.1099	17.72911	0	0
7/24/2015 3:05:48 AM	20	7.68909	11.53159	104.9352	15.0071	17.72911	0	0
7/24/2015 3:05:50 AM	30	7.68909	11.53162	104.9353	15.4388	17.72911	0	0
7/24/2015 3:05:51 AM	40	7.68909	11.53165	104.9354	15.5284	17.72911	0	0
7/24/2015 3:05:53 AM	50	7.68909	11.53168	104.9355	15.3843	17.72911	0	0

Figure-18 IRI Data Sheet

It's recommended that road inventory should be prepared based on information in the IRI data sheet in order to more visually summarize inspected roads conditions. An example of road inventory format is given in Figure-20. In case of the example, road conditions are assessed by 5-grade evaluation criterion that is defied in combination with IRI and visual inspection results. An example of folder-4 structure is shown in Figure-19.

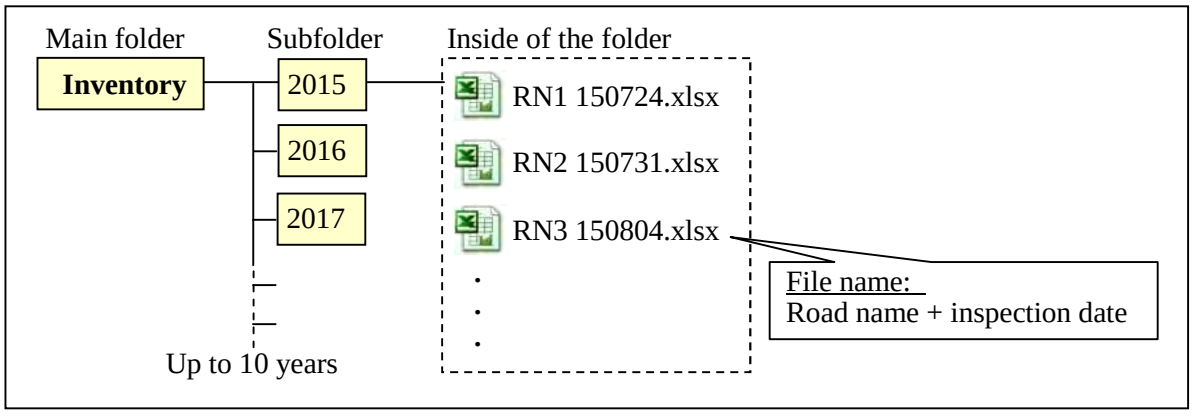


Figure-19 An Example of Folder-4 Structure

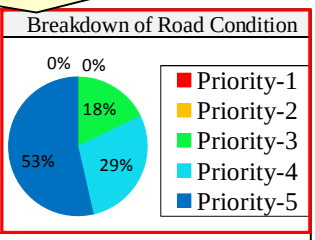
[Road Inventory (detailed road condition)]

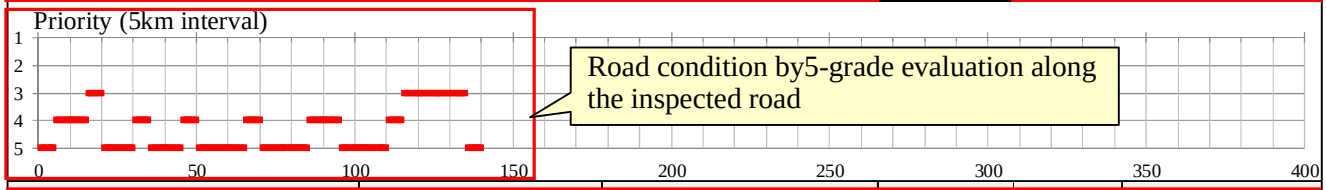
5-grade evaluation criterion of road condition

IRI Range \ Visual Rating	Very good	Good	Fairy Good	Fair	Poor
IRI<3.5	Priority-5 No or small repair			Priority-4 Small repair	Priority-3 Repair
3.5≤IRI<7.0	Priority-3 Repair			Priority-2 Repair	
7.0≤IRI	Priority-1 Urgent repair				

Basic road information and road condition

(1)	Road Name	RN3			
(2)	Road Length (km)	135.4			
(3)	Pavement Type	AC			
(4)	Date of IRI measurement	6/Aug/2015			
(5)	Start Point & End Point	Start	PK0+000	End	PK135+400
(6)	Average IRI (Total Section)	2.1			
(7)	Visual Rating (Total Section)	Indicator N	1.49	Evaluation	Poor
(8)	Priority (Total Section)	Priority-3	Repair		





Road condition by5-grade evaluation along the inspected road

(9) Location From	(9) Location To	(10) Average IRI Per 100m	(10) Average IRI Per 1.0km	(10) Average IRI Per 5.0km	(11) Visual Rating (Per 5.0km) No.of Defects Per 100m	(11) Visual Rating (Per 5.0km) No.of Defects Per 5.0km	(11) Visual Rating (Per 5.0km) N	(11) Visual Rating (Per 5.0km) Evalu-ation	(12) Priority (Per 5.0km)	(13) Pavement Type	(14) Remarks No. of Bridge Joints	(14) Remarks Major Findings
4 km + 0	4 km + 100	1.9			0						0	
4 km + 100	4 km + 200	1.9			0						0	
4 km + 200	4 km + 300	1.9			0						0	
4 km + 300	4 km + 400	1.9			0						0	
4 km + 400	4 km + 500	NaN	2.1	2.0	0	0	0.00	Very good	Priority-5 No or small repair	To be defined	0	
4 km + 500	4 km + 600	NaN			0						0	
4 km + 600	4 km + 700	2.7			0						0	
4 km + 700	4 km + 800	2.7			0						0	
4 km + 800	4 km + 900	2.0			0						0	
4 km + 900	5 km + 0	2.0			0						0	

Detailed road condition (evaluation at 5km interval)

[Road Inventory (summary of road condition)]

Province (DPWT) No.	Province (DPWT) Name	Location From	Location To	Ave. IRI	Visual rating N	Visual rating Evaluation	Priority Rank	Priority Discription
24	Phunom Penh	0 km	5 km	2.0	0.00	Very good	5	No or small repair
24	Phunom Penh	5 km	10 km	1.8	0.60	Fair	4	Small repair
4	Kandal	10 km	15 km	2.7	0.80	Fair	4	Small repair
4	Kandal	15 km	20 km	2.4	1.40	Poor	3	Repair
4	Kandal	20 km	25 km	2.6	0.20	Good	5	No or small repair
23	Takeo	25 km	30 km	2.8	0.20	Good	5	No or small repair
23	Takeo	30 km	35 km	2.3	0.60	Fair	4	Small repair
23	Takeo	35 km	40 km	2.2	0.00	Very good	5	No or small repair
23	Takeo	40 km	45 km	2.5	0.00	Very good	5	No or small repair
23	Takeo	45 km	50 km	2.8	0.60	Fair	4	Small repair

Figure-20 An Example of Road Inventory

CHAPTER 9 Checklist for DRIMS Operation

9.1 Objective and Outline of Checklist

It is recommended that entire DRIMS operation procedure explained in this guide line should be carried out in accordance with “Checklist for DRIMS Operation” shown in the next page. The objective of checklist application is to avoid typical failures and get the series of operations done most efficiently. It is sure that the application of the checklist should substantially contribute to improvement of operators’ practical knowledge and skills on DRIMS operation. The checklist is formulated as a table consisting of the following 4 items;

1) DRIMS operation stages (a total of 8 operation stages explained in this guideline)
2) Page numbers of this guideline in which detailed explanation for the checklist items is shown.
3) Checklist descriptions
4) Checkboxes for confirmation

9.2 An Instruction for Checklist Application

Checklist descriptions are placed in the table in order of actual DRIMS operation procedure. Therefore, operators are recommended to complete the checklist items in the order, filling the checkboxes after completion of each item. Here is a recommended procedure for the checklist application.

Step-1: Check which “Operation Stage” you are in, and in what chapter instructions are given.
Step-2: Read checklist descriptions and find instructions in the guideline, referring to page number indicated next to each checklist description.
Step-3: Carry out activities specified in the checklist descriptions, following the guideline instructions.
Step-4: Fill in checkboxes, upon completion of checklist descriptions.

It should be noted that checklist descriptions of “Basic Operation of DRIMS” are to be checked before both “Hump Calibration” and “IRI Measurement”.

As for operation stage of “Preparation of Road Inventory”, refer to “Guideline for Routine Maintenance Using IRI”.

Checklist for DRIMS Operation

Operation Stage	Page	Checklist	Checkbox	
Installation of Software into Laptop PCs (Chapter 2)	5-8, 15	DRIMS Measurement Software is installed in laptop PCs, and the laptop PCs are licensed by DRIMS activation codes.		
	9-11	DRIMS Analysis Software is installed in laptop PCs.		
Installation of DRIMS Equipment into Vehicles (Chapter 3)	2	All the equipment shown in Table-1 (Page-2) is ready to be installed.		
	13	Accelerometer is installed in a proper way above one of rear tires on opposite side of driver seats; in case of left hand drive vehicles, the accelerometer is to be installed above the right-side rear tire. The accelerometer is attached to solid part of vehicle body such as steel material.		
	13	No obstacles are put around the fixed accelerometer.		
	13	Cables have sufficient free margins (not stretched).		
	13	DAQ is fixed to vehicles in rear seats.		
	13	The USB cable of DAQ is connected to USB 3.0 port.		
	14	Power of the laptop PC is secured by DC-AC inverter.		
	14	The time of the laptop PC is adjusted. The time of the recorder is synchronized with that of the laptop PC.		
	14	GPS is set near side window to capture a satellite signal.		
Basic Operation of DRIMS (Chapter 4)	These items shall be checked before both hump calibration and IRI measurement.		Hump	IRI
	16	DRIMS measurement software is activated normally.		
	17	Data Entry for “Vehicle Registration” is properly done.		
	18	Data Entry for “Driving test” is properly done.		
	18	Data Entry for “GPS” is properly done.		
	19	Error check is done properly.		
	19, 20	Operation test is carried out before actual inspections. Generation of Acc/GPS files is confirmed during the operation test.		
Hump Calibration (Chapter 5)	24	Appropriate site for hump calibration is selected (enough space & flat surface).		
	24	The number of passengers and vehicle type are the same as those for IRI measurement.		
	16-20	Checking for Basic Operation of DRIMS is complete.		
	24	A color cone is set at the start point. Humps are set about 50m from the start point.		
	24, 25	Constant driving speed of 20km/h is maintained about 5 seconds before and after vehicles get on the humps. If you fail to drive at constant speed of 20km/h, don’t save the data and carry out the calibration again.		
	24	Hump calibration is conducted at least 5 times.		
	26-28	Analysis for 5 calibration results is carried out at the site right after the calibration. Desirable analysis result shown in Figure-10 (P.28) is confirmed.		
IRI Measurement (Chapter 6)	30	Inspection start points and end points are clarified.		
	24	The number of passengers and vehicle type are the same as those for hump calibration.		
	16-20	Checking for Basic Operation of DRIMS is complete.		
	31-32	Generation of Acc/GPS files is constantly checked. Also, increment of the file size is constantly checked during inspections. (If there’s anything wrong with the data acquisition, refer to Page-32.)		
Analysis for IRI Estimation (Chapter 6 & 7)	33	Appropriate calibration data is used for analysis (consistency in the number of passengers & inspection vehicle types)		
	33, 34	IRI Estimation is conducted in accordance with “Section 6.2”.		
	35-37	CSV files/Google Earth files are integrated by post processing.		
	37, 38	Average IRI values (at 100m interval) are calculated by post processing.		
	39, 40	IRI values are integrated into recorded movies.		
Preparation of Road Inventory	-	Road inventory is prepared in accordance with “Guideline for Routine Maintenance Using IRI”.		
Data Storage in Database (Chapter 8)	41-44	The following inspection outputs are saved in “Road Inspection Database”. 1) DRIMS measurement/analysis data 2) Recorded movies 3) IRI map (Goodle Earth format) 4) Road inventory (Excel format)		

Appendix: Configuration and Operation of Road Monitoring Device

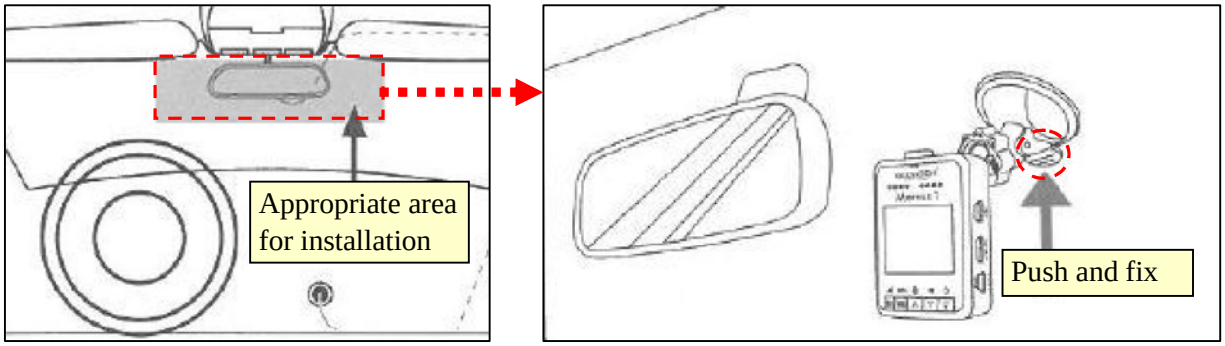
CHAPTER 1 Introduction

In addition to DRIMS (for IRI measurement), road monitoring device (road condition recorder) can be manipulated as an option. Application of the device could make road maintenance management more efficient. This chapter describes basic operation of a road monitoring device. (Product name: Vico-Marcus 1)

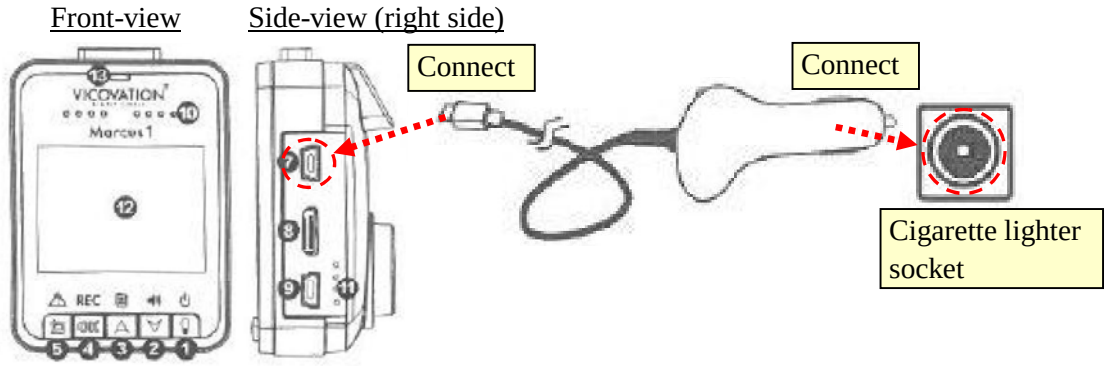
CHAPTER 2 Installation of Equipment into Vehicles

Road monitoring device (hereafter called as the recorder) shall be installed into vehicles as the following procedure.

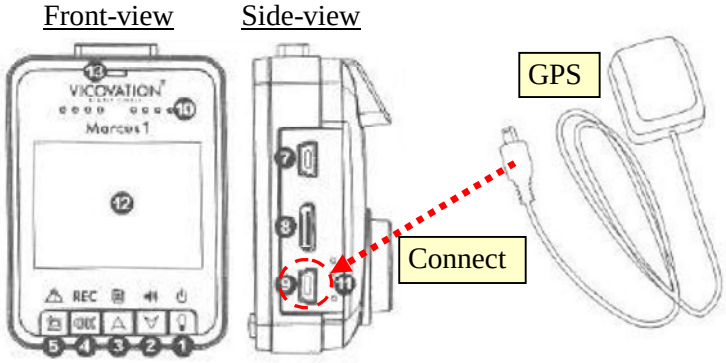
Step-1: Install the recorder near the rear view mirror.



Step-2: Connect the recorder with a cigarette lighter socket.



Step-3: Connect the recorder with a GPS.

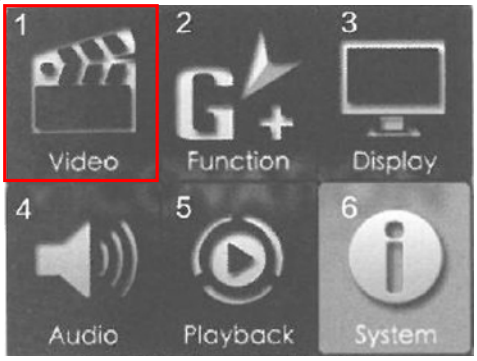


CHAPTER 3　Configuration of the Recorder

The recorder shall be configured with the following procedure.

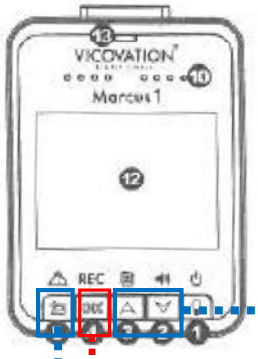
Step-1: Configuration of “Video”

1) Set the cursor on “Video” and select it.



(Main menu)

[Basic Operation]

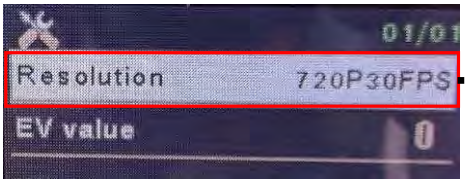


Press to move the cursor.

Press to select items.

Press to go back to previous screen display.

2) Select “Resolution” and set it as “720P30FPS”.



720P30FPS

3) Go back to the main menu.

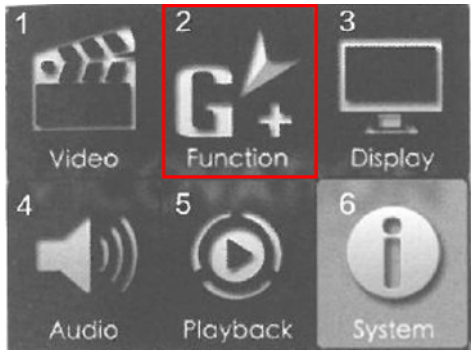
Note: The following table shows maximum recording capacity of each SD-card. (Application of 32GB SD-Card is recommended.)

	1080p 30fps	720p 30fps
8GB	75 mins	121 mins
16GB	166 mins	260 mins
32GB	347 mins	530 mins
Video Bit Rate	12Mb/s	8Mb/s

[SD-Card]

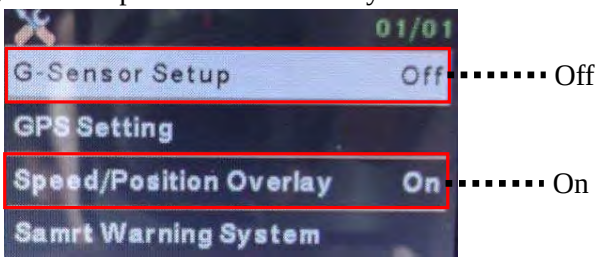
Step-2: Configuration of “Function”

1) Set the cursor on “Function” and select it.



2) Select “G-Sensor Setup” and set it as “Off”.

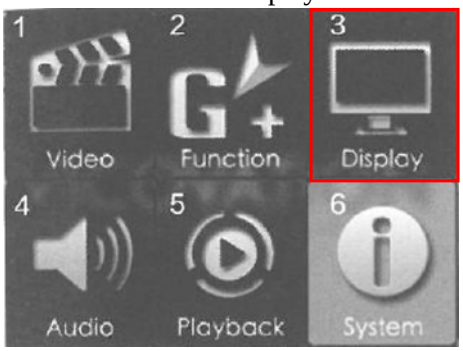
3) Select “Speed/Position Overlay” and set it as “On”.



4) Go back to the main menu.

Step-3: Configuration of “Display”

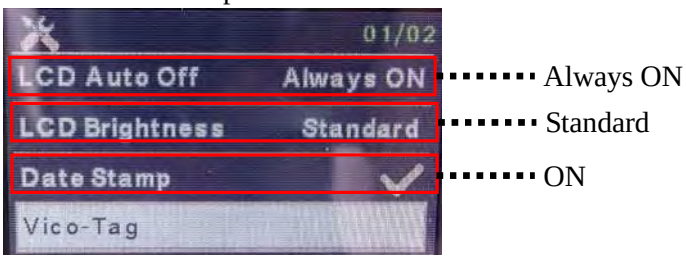
1) Set the cursor on “Display” and select it.



2) Select “LCD Auto Off” and set it as “Always ON”.

3) Select “LCD Brightness” and set it as “Standard”.

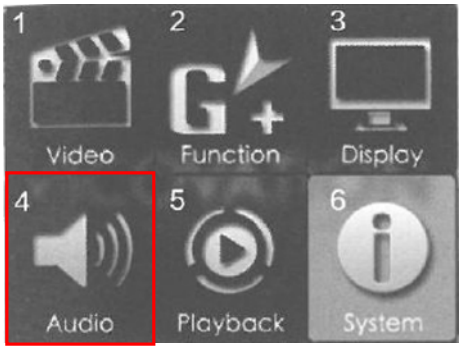
4) Select “Data Stamp” and set it as “ON”.



5) Go back to the main menu.

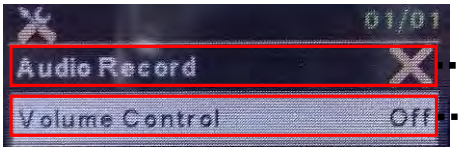
Step-4: Configuration of “Audio”

1) Set the cursor on “Audio” and select it.



2) Select “Audio Record” and set it as “Off”.

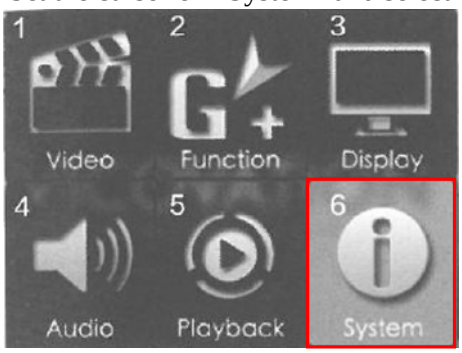
3) Select “Volume Control” and set it as “Off”.



4) Go back to the main menu.

Step-5: Configuration of “System”

1) Set the cursor on “System” and select it.



2) Select “Clock Setting” and set the time.

3) Select “Time Zone Setting” and set GMT (Greenwich Mean Time) as “+07:00”.

4) Go back to the main menu.

5) Proceed to recording screen display.

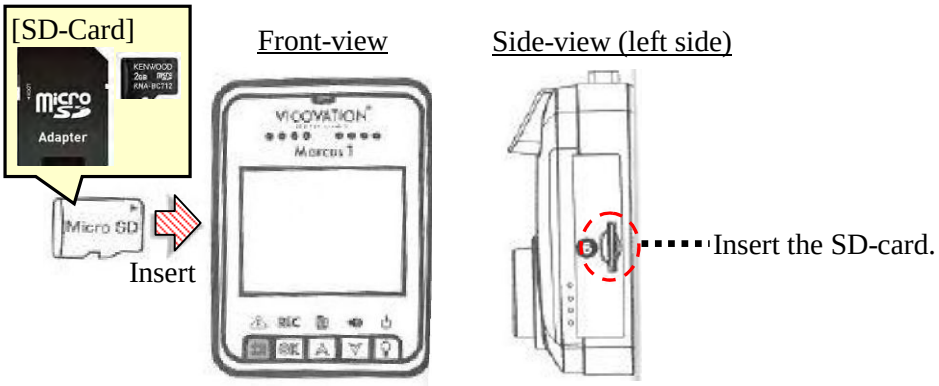
CHAPTER 4　Operation of the Recorder

The recorder can be operated by following the procedure explained below.

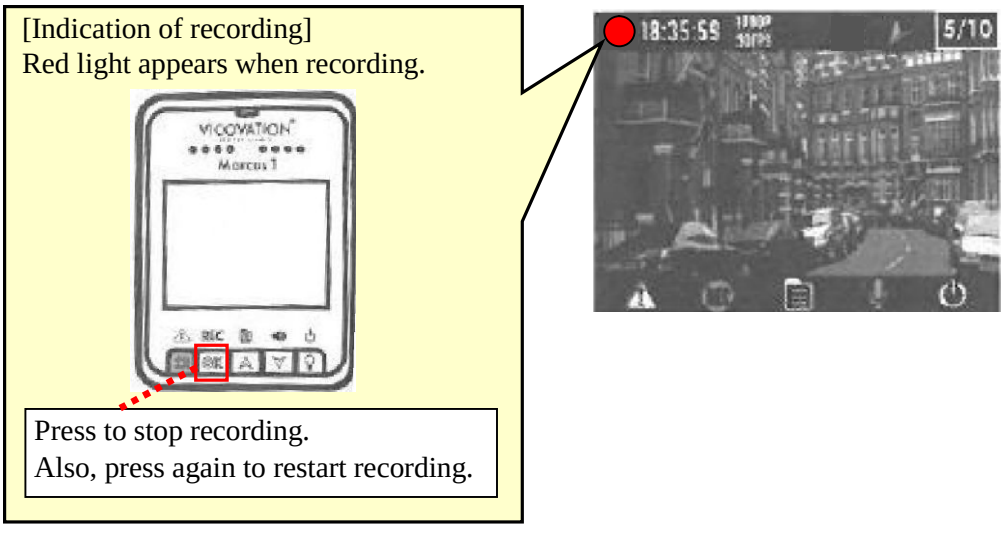
Step-1: Check if GPS is functioning properly.

Indication of GPS function

Step-2: Insert SD-card into the recorder.

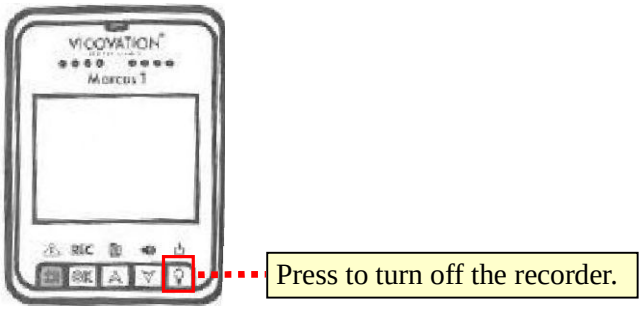


Note: Recording automatically starts after inserting the SD-card into the recorder. Press “REC button” to stop recording. Also, press “REC button” again to restart recording.



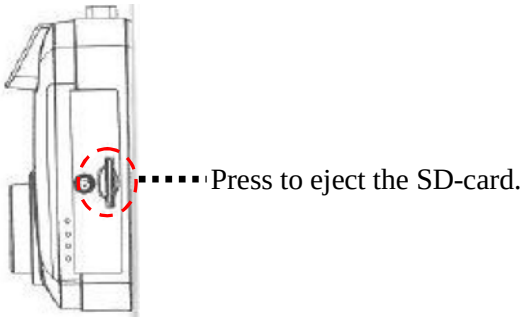
Step-3: Eject the SD-card properly

1) Turn off the recorder.



2) Press the SD-card to eject it from the recorder.

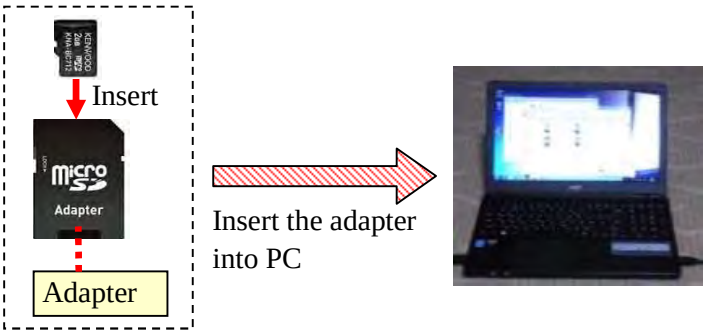
Side-view (left side)



Spep-4: Move the obtained data from the SD-card to PC.

1) Inset the SD-card into an adapter.

2) Insert the adapter into PC and move the obtained data.



CHAPTER 5　How to Play Recorded Movies

5.1　Overview of Road Monitoring System

Recorded movies can be played as road monitoring system by free software called “Registrator Viewer”. As shown in Figure-A1, the software consists of:

1) Monitor,
2) GPS location map,
3) Driving speed (line graph format; relationship between driving speed and time history),
4) IRI values (line graph format; relationship between IRI values and time history), and
5) Speed meter & odometer (distance in km).

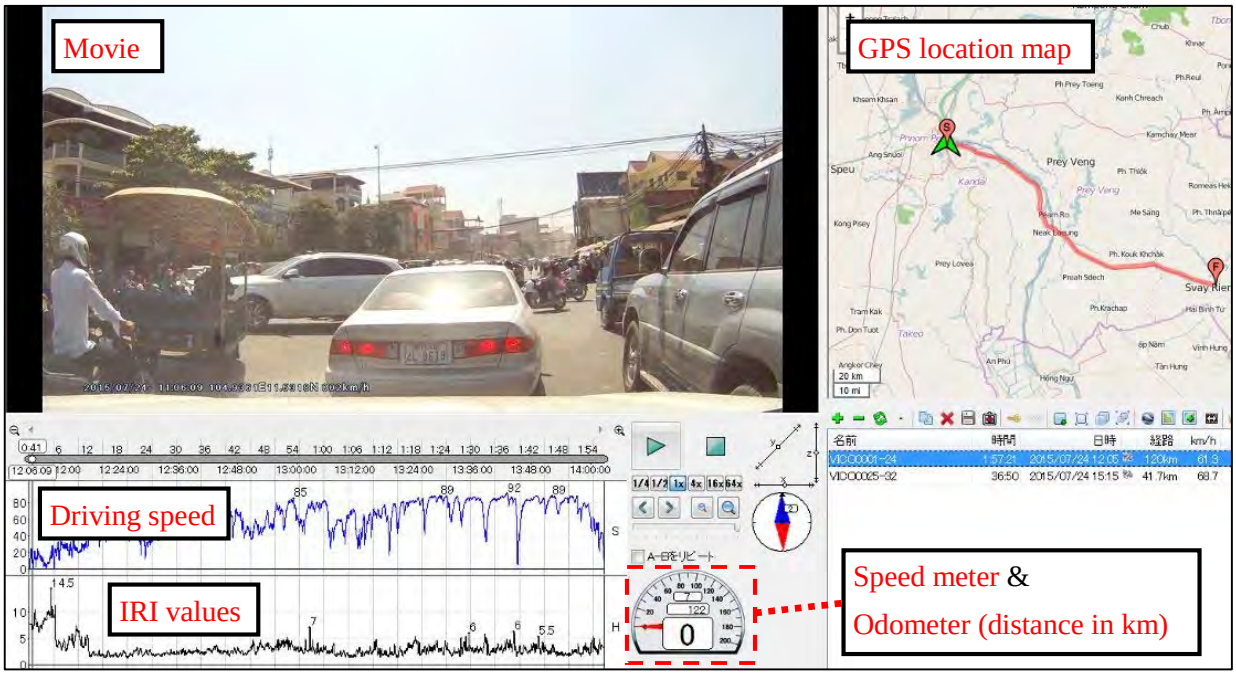


Figure-A1　Screen Structure of Road Monitoring System

The monitor enables operators to see road surface conditions closely as if they were examining the road for themselves. Additionally, the operators are able to confirm certain locations of monitored road conditions with the GPS location map. The certain location can be confirmed by checking the odometer (distance in km from inspection start point). Above all, the most impressive feature of this system is indication of the road surface conditions in a quantitative manner by IRI. Movies are played with IRI values of monitored road surface, which enables the operators to both visually and quantitatively evaluate inspected road surface conditions without going to the sites.

5.2 Basic Operation of Road Monitoring System

The software can be operated by following the procedure explained below.

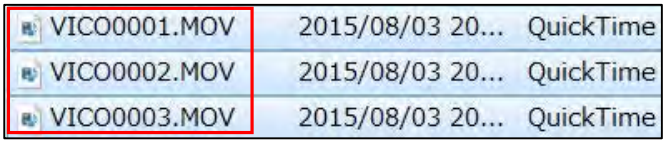
Step-1: Open “RegistratorViewer” (road monitoring system software).

Step-2: Open files

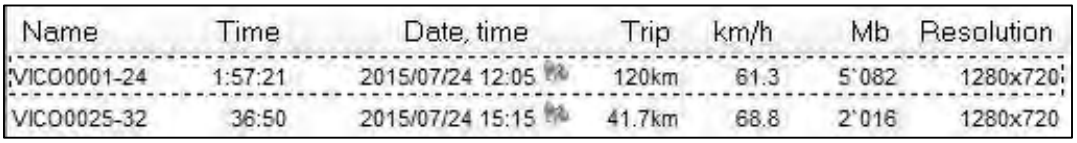
1) Click “File” and “Open”.

2) Select certain folder.

3) Select and open movie files.



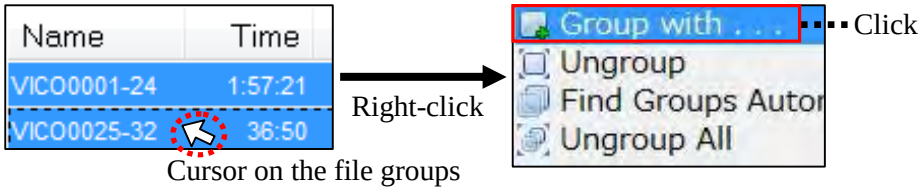
The selected files are to be displayed in the lower right of the screen as shown below.



Step-3: Integrate the listed files.

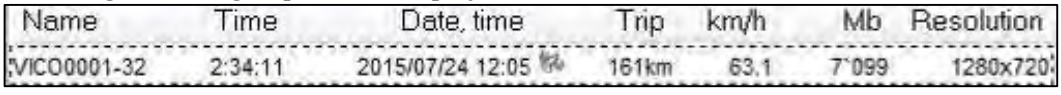
1) Select the listed file groups

2) Click the right button of PC mouse with the cursor on the selected file groups.



3) Confirm if the selected files are checked and click “Group”.

The integrated file group is to be displayed as follows.



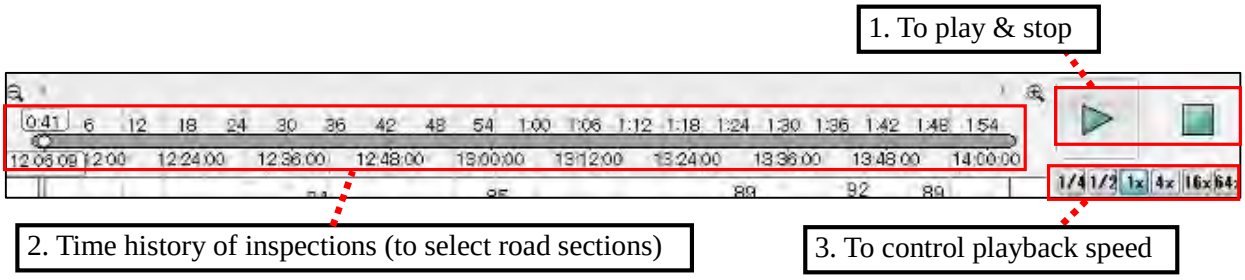
Step-4: Play the movies with basic functions.

1) Click “Play ▶” and “Stop ■” to monitor the road condition.

Note: After clicking “Play ▶”, the icon turns into “Pause ❚❚”.

2) Click any part of “Time History Bar” to select road sections.

3) Choose and click “playback speed 1/4 1/2 1x 4x 16x 64x” (6 types of playback speed).



5.3 Advanced Operation of Road Monitoring System

Besides the basic operation procedure explained above, the software has additional operational functions.

(1) Selection of Road Sections from the View of GPS Location

Operators can choose certain road sections for observation from the view of GPS location. As shown in Figure-A2, road sections can be selected by clicking certain locations on the GPS location map. This function is effective in checking conditions of certain road sections such as areas where heavy rain is constantly observed.

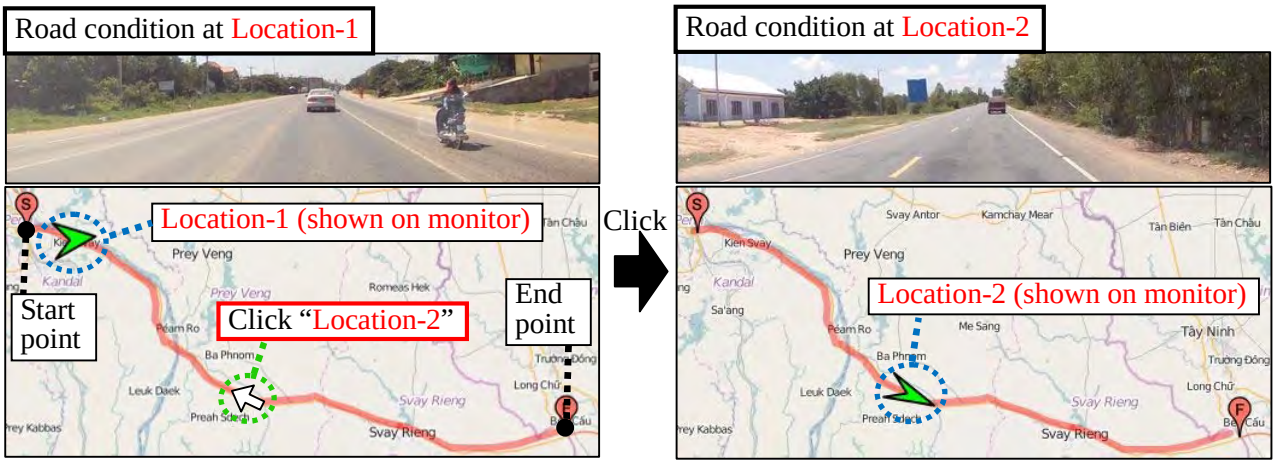


Figure-A2 Selection of Road Sections from the View of GPS Location

(2) Selection of Road Sections from the View of IRI

Operators can also choose certain road sections for observation from the view of IRI that gives specific values for evaluation, depending on conditions of the inspected road sections. As shown in Figure-A3, road sections can be selected by clicking any part of the IRI graph. This function is very useful to efficiently identify deteriorated road sections.

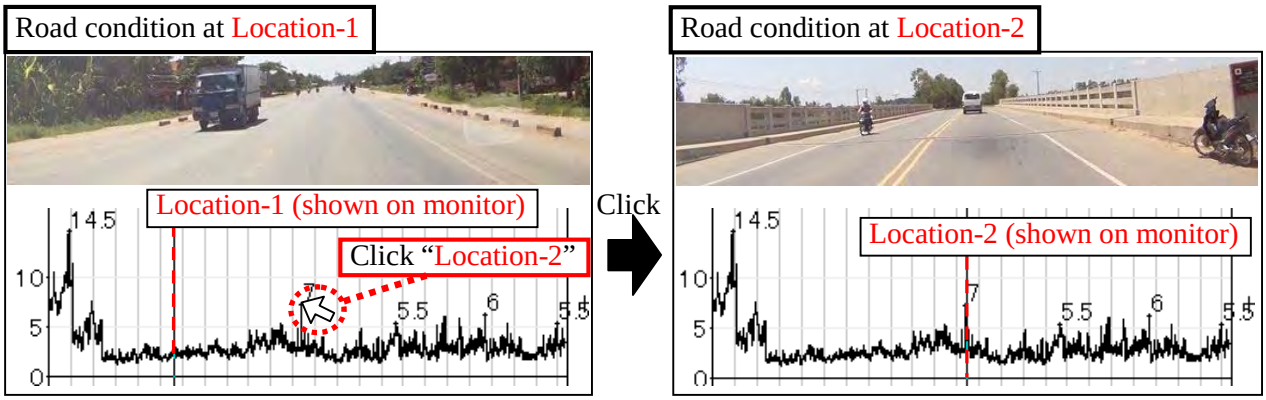
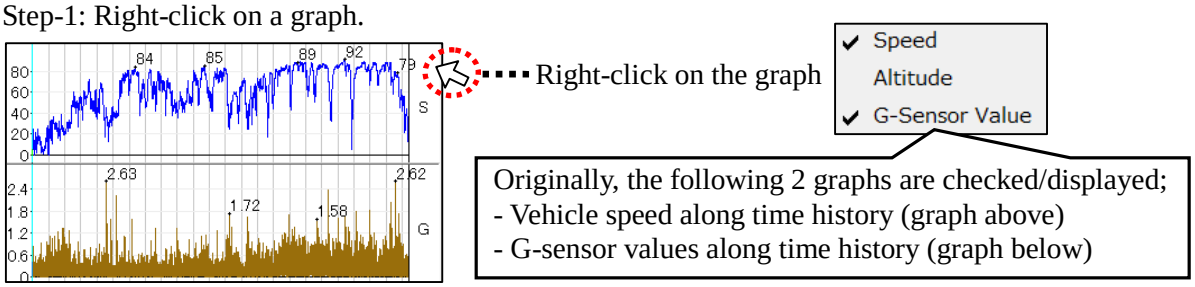


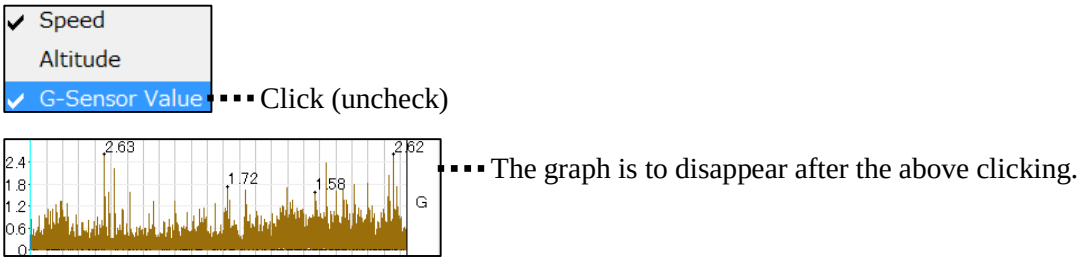
Figure-A3 Selection of Road Sections from the View of IRI

In case that IRI graph is not shown on the display, it can be displayed by the following procedure.

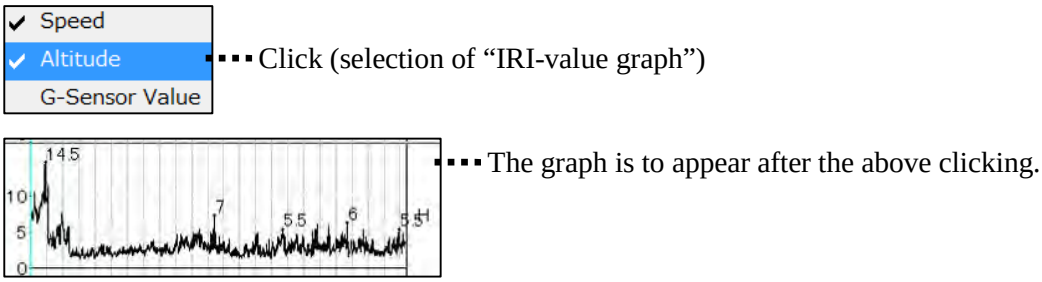
Step-1: Right-click on a graph.



Step-2: Uncheck "G-Sensor Value" and check "Altitude".



Step-3: Check "Altitude".



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