

# Utilization of Probe Vehicle Information in Disasters in Japan

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## SUMMARY:

Road information is one of the most important information for vehicles of emergency service, rescue and other disaster response organizations. However, it is difficult to get ever-changing road status of wide area in real-time, and sufficient road information is not provided in actual disasters.

Therefore we focused the utilization of probe vehicles (vehicles installed GPS and communication devices) and have tackled to display utility of probe vehicle information and realize sharing circumstance of them in disasters. First, we explained the characteristics of probe vehicle data in past disasters and the effects for disaster reduction are discussed.

Second, we report our research and implementation activities for provision of vehicle tracking map (Toreta Road Map). After the 2007 Niigataken Chuetsu-oki earthquake, we provided a Toreta Road Map as part of effort to apply probe vehicle data to disaster reduction. Vehicle trajectory and traffic regulation information are plotted on the map of DRM (Digital Road Map) which is shown road network simply. The map shows roads can be able to pass and is understood easily. Another map is shown average moving speed in each links calculated by using vehicle probe data and back ground map was used Google Earth with high visibility. The problems raised are discussed.

Third, provision services of vehicle tracking maps conducted by automobile companies, car navigation companies, information provider companies and so on after the 2011 Tohoku Earthquake are introduced. Particularly vehicle tracking map provided by ITS Japan on the website of Google Crisis Response is explained in detail. The map was composed of collected probe vehicle data which are provided by Honda Co. Ltd., Pioneer Corporation, Toyota Motor Corporation, and Nissan Motor Corporation.

Forth, the large number of car drivers was lost their lives due to tsunami wave, however when and where each casualties encountered tsunamis are not identified. And a solution for it is very limited. We indicate the approximate times and places can be identified analysing probe vehicle data and provision of tsunami alert information to car drivers will be very important.

*Keywords: probe vehicle, vehicle tracking, information sharing, The 2011 off the Pacific coast of Tohoku Earthquake*

## 1. INTRODUCTION

As use of vehicles is necessary for rescue and recovery activities during/after disasters, traffic and road information is vital for disaster responders. For solving this problem, the authors have focused attention on probe vehicle data, and have studied on utilization of probe vehicle data for disaster reduction (Hada et al. 2007a, 2007b, 2008). As the result of those effects, after the 2011 off the Pacific coast of 2011 Tohoku Earthquake, vehicle tracking map (called “Toreta-Road Map”) was provided promptly, it was very helpful in rescue and recovery activities.

In this paper, first, utilization of probe vehicle data for disaster reduction in Japan before 2011 Tohoku Quake is reviewed. Second, activities on provision of Toreta-Road Map conducted by private sectors after Tohoku Quake are introduced. Third, track vehicles damaged to tsunami are extracted and those behaviors are analysed.

## **2. UTILIZATION OF PROBE VEHICLE DATA**

### **2.1. Significance of road information in disasters**

Vital information and its sharing in large-scaled disasters were discussed by major utility companies in Tokyo metropolitan area, and a road administrator and National Police Agency (Hada et al. 2007a). Since most of rescue and recovery operations are necessary for use of vehicles, it was reached conclusion that information of passable road to destination in affected area is quite essential for disaster responses (Hada et al. 2007b). Despite the remarkable progress had made recently in the fields of information and communication technology, there was no generally accepted solution for this problem. Two major causes were raised, (i) administrators become victims, (ii) higher-priority operations such as lifesavings arise.

### **2.2. Probe vehicle data**

For solving this problem, the authors focused attention on vehicle data installed car navigation system with GPS. We conceived that passable roads are able to be shown by collecting vehicle tracking data. Location information and driver behavior obtained by running vehicles are generally called probe vehicle data or flowing car data in traffic field. The world first probe car system for estimating reliable travel time and avoiding traffic congestion was released by Honda Motor Co., Ltd. as Internavi floating car system (The number of members is more than a million in August 2011.) in 2003 autumn. At the present, auto companies and navigation companies keep pace and large number of data has been accumulated everyday.

### **2.3. 2004 Mid-Niigata Prefecture Earthquake and a field test in 2006**

The authors investigated probe vehicle data in 2004 Mid Niigata Prefecture Earthquake as a past disaster. In this disaster, because of the large number of road regulations more than 200 and lack of road information, most of emergency vehicles took much time to the destination. We plotted trajectories of vehicles and road regulation information on GIS. Trajectories of probe vehicles can be utilized for judgement which road is available (Hada, et al 2008). Since the number of probe vehicles is not enough, most of roads are not travelled by vehicles. Hence road without trajectory cannot be judged whether passable road or not.

Information sharing platform developed in the research project was applied to Mitsuke City in Niigata Prefecture, Japan as a field test involved by municipality, prefecture, Central government, and road administrators and utility companies. As a part of a field test, a probe vehicle run actually and trajectories of vehicle were shared among disaster related organizations. According to evaluators composed of practitioners who had a lot of experiences in disasters, the effectiveness of sharing passable roads as vehicle trajectories utilized probe vehicle was shown (Hada, et al 2007b).

### **2.4. Provision of Toreta Road Map in 2007 off Mid-Niigata Prefecture Earthquake**

Off Mid-Niigata Prefecture Earthquake occurred in July 16, 2007. We visited Kashiwazaki City which located closed to the epicenter the day after next, and show a prototype of vehicle tracking map to headquarters. Since it was not enough to grasp road situation in wide-area at that time, HQ strongly requested us to use the map. With cooperation of Honda Motor Co. Ltd., Toreta Road Map was decided to provide on the Internet on trial. 2 types of the map were made. One is a map plotted both trajectories produced by probe vehicle data and traffic regulations announced by Niigata Prefecture Police on DRM (Digital Road Map) which is standardised map in traffic field (**Figure 1.**). Another is 3 classified average speeds on Google Earth (**Figure 2.**).

This provision of Toreta Road Map is positioned as the world first case that road situation is visualized by utilized probe vehicle data in actual disasters. The effectiveness of sharing probe vehicle data and vehicle tracking map were indicated to the public (Hada, et al 2009). Problems were raised as follows, - improvement of usability such as scalability (the map was provided by PDF files), - consensus

building in both of drivers and administrators.

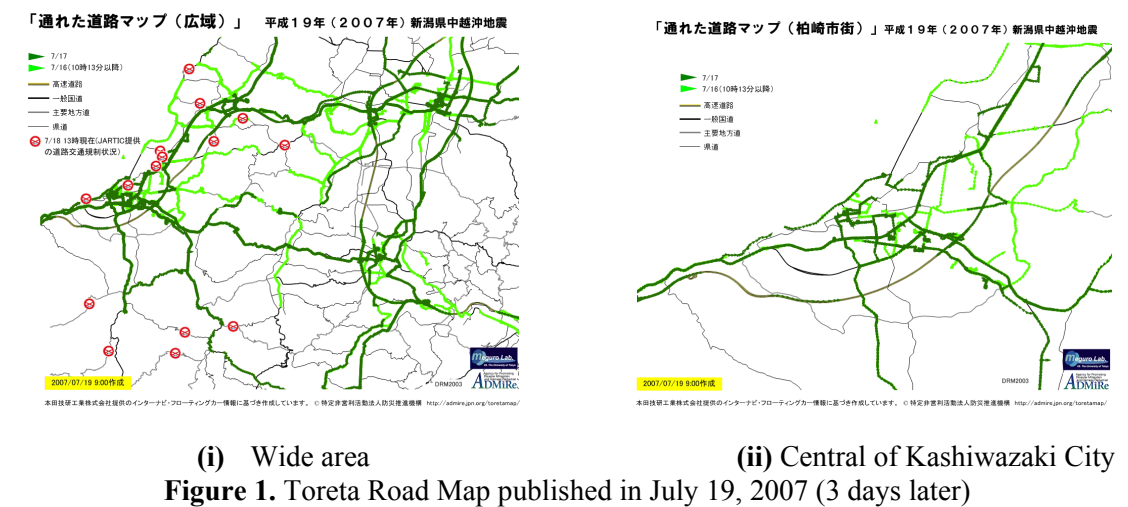


Figure 1. Toreta Road Map published in July 19, 2007 (3 days later)

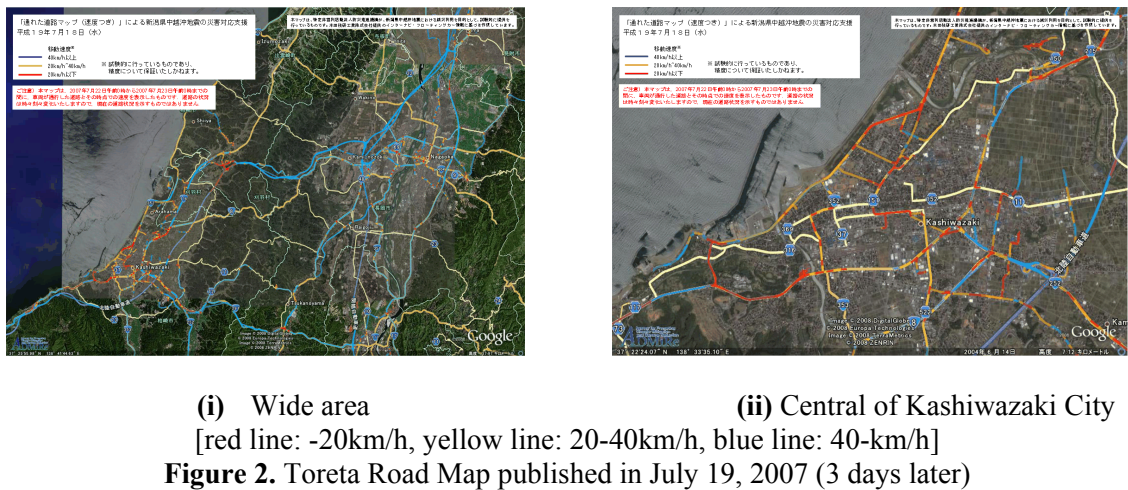


Figure 2. Toreta Road Map published in July 19, 2007 (3 days later)

3. TORETA ROAD MAP (VEHICLE TRACKING MAP) AFTER 2011 TOHOKU QUAKE

The 2011 off the Pacific coast of Tohoku Earthquake was a magnitude 9.0 (Mw) undersea megathrust earthquake off the coast of Japan that occurred at 14:46 JST on Friday, 11 March 2011. In this chapter, provisions of Toreta Road Map (vehicle tracking map) conducted by auto companies, car navigation companies and so on is reviewed.

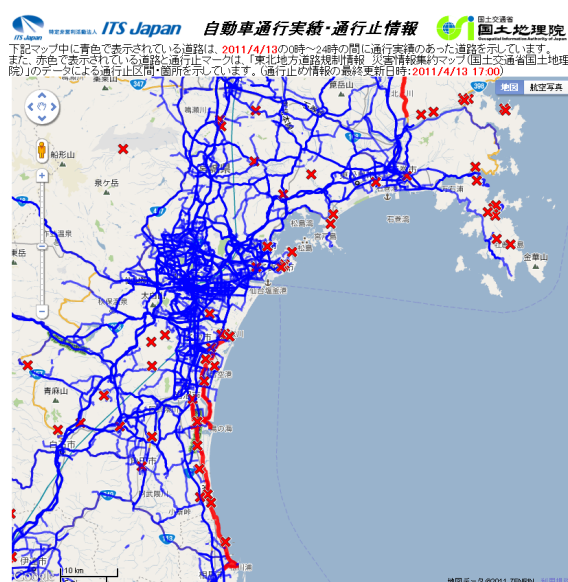
3.1. Outline of provision of map

Table 1. shows outlines of provision of map in time-line after the quake. On the next day, March 12, Honda Motor Co. Ltd. began to provide a map on Internavi website as kmz file format including data of Pioneer Co. . Particularly noteworthy about this is two points, quickness, and provision of kmz file format. According to adopt kmz file format to be easy in secondary use, several improved maps with additional contents were made and provided by third parties/persons. Also the maps linkaged with several mash up systems built after the quake, this had significant impact to various sectors. On March 15 the map was began to exposure on the website of Google Crisis Response, social cognition about the map was getting higher and higher. Toyota Motor Co. devised to expression of data qualification by using two lines which were classified by extent of traffic volume. On March 19 ITS-Japan NPO, released a map integrated vehicles data provided by Honda, Pioneer, Toyota and Nissan on website as Google Maps. On March 23, information of road regulations were added to the map by ITS-Japan NPO (Figure 3. (i)). On the other hand, passable roads by auto (passenger vehicle)

do not automatically mean that those are available for large vehicles such as truck and fire-fighting vehicle. Mapion Co. Ltd. released Toreta Road Map for large vehicles produced by using truck probe data provided by Isuzu Motors Ltd.(Figure 3. (ii)).

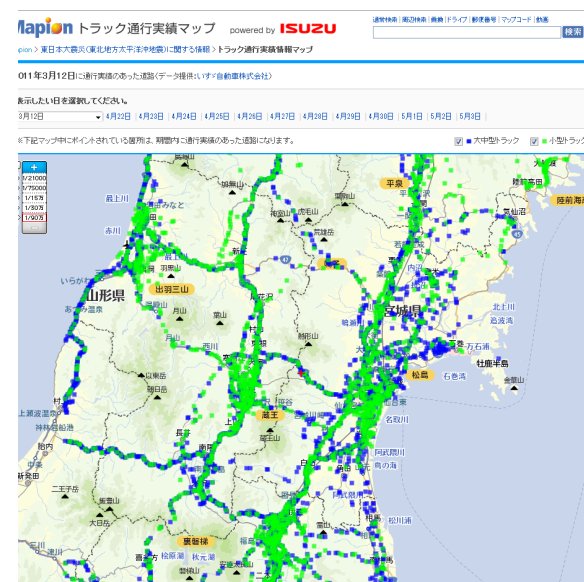
**Table 1.** Outlines of provision of map in time-line after 2011 Tohoku Earthquake

Day	Activity
12 March	Honda Motor Co. Ltd. released a map on Internavi website as kmz file format including data of Pioneer Co. .
15 March	The map provided by Honda was began to exposure on the purpose built website of Google Crisis Response.
16 March	Toyota Motor Co. released a map on Gbook website as kmz file format.
19 March	Ubiqlink Co. (Nomura Research Institute Co. Ltd. after July 1, 2011) released a map on website as Google Maps.
19 March	ITS Japan NPO released a map integrated vehicles data provided by Honda, Pioneer, Toyota and Nissan on website as Google Maps.
25 March	Mapion Co. released a map integrated data of driving management service by Isuzu Motors Ltd..



(i) provided by ITS-Japan NPO(2011)

Blue lines: trajectory of vehicle, red cross: road regulation



(ii) provided by Mapion Co. Ltd.(2011)

Blue point: large and medium truck, green point: small truck

**Figure 3.** Examples of Toreta Road Map (Vehicle Tracking Map) after 2011 Tohoku Earthquake

### 3.2. Characteristics of those activities

Although we had tackled to create frameworks to provide Toreta Road Map in disasters in around 2008-2009, most auto companies had not care nothing for B to B collaborations (Hada et al. 2009). Except Honda had provided the map before the event, the other companies had no experience to provide maps and probe vehicle data. Reasons why auto companies provided maps and probe vehicle data despite they were not interested in, we think reasons why catastrophic and wide range damages occurred, and it was quite clear that road information was necessary for not only rescue/recovery operations but also survivors in suffered area.

According to those activities, raised problems previously were solved. About a problem that it cannot be judged whether roads without trajectory mean not passable road or only no vehicle data, to increase data volume by data integration with association of companies realizes higher quality of the map, and to use two lines which were classified by extent of traffic volume becomes to express the data qualification. About another problem that vehicle trajectories by passenger vehicles do not automatically mean that large vehicles can pass those roads, to produce the map by truck probe data



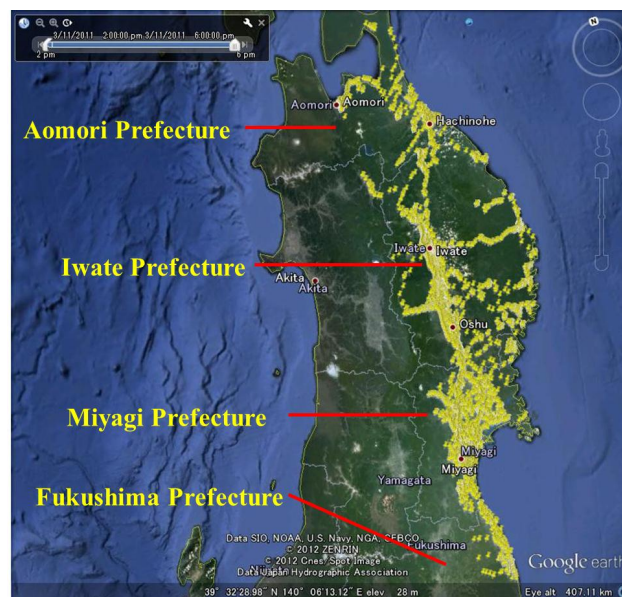
solves it. Future issue is how to realize and create permanent framework for provision of Toretta Road Map in disasters.

#### 4. TRUCK TRAJECTORY ON 2011 TOHOKU EARTHQUAKE

More than 90 % of cause of death by 2011 Tohoku Earthquake is death from drowning by tsunami. Large number of running vehicles were suffered by tsunami, however it was little data to analyse when/where drivers encountered tsunami and how situation is around there at that time. In this chapter, by using probe vehicle data provided by Isuzu Motors Co., suffered trucks are extracted by tsunami and those behaviours are discussed.

##### 4.1. Probe vehicle data

Based on probe vehicle data provided by Isuzu Motors Co. on the day (March 11, 2011) of the occurrence of the event, behaviours on trucks in suffered area before/after the quake are analysed. **Figure 4.** shows locations of trucks in study area where is more than north latitude of 37 degrees and 20 minutes and mainly located in north Fukushima, Miyagi, Iwate and Aomori Prefecture including devastated coastal area by tsunami. The number of trucks recorded at 0 p.m. to 6 p.m. was 686. Since this data is collected for driving management service, time interval of each location record (latitude and longitude) is 10 minutes and/or more.



**Figure 4.** Study area (Yellow Point indicates locations of trucks)

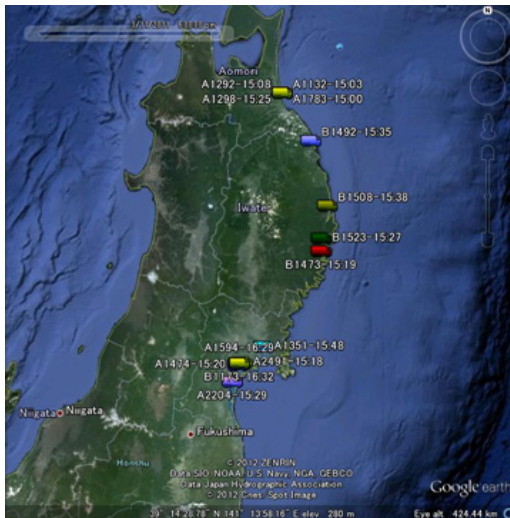
##### 4.2. Extraction of suffered trucks

It is vital to specify suffered trucks and analyse the behaviours for reducing loss of suffered vehicles by future tsunami and discussing measures for drivers' safety. By using inundation area map provided by Geospatial Information Authority of Japan (2011), disappeared truck probe data after the event and inside of inundation area are extracted as suffered trucks. 16 trucks are specified (**Table 1.** and **Figure 6.**). **Table 1.** shows that the num. of vehicles with movement, nothing: 6 trucks, within 2km: 4 trucks, 2km to 5km: 3 trucks, and more than 5km: 3 trucks. All of trucks without movement were parked in warehouse located at the coastal area. A2204 and B1173 in 3 trucks whose movement is more than 5km moved to warehouse estimated as destination and suffered in the coastal area (**Figure 6.**).

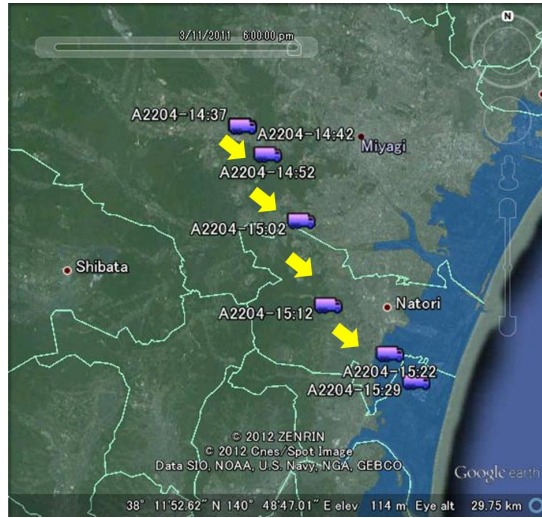
**Table 2.** Behaviour of suffered truck (after 2 p.m., 11 March 2011)

ID*	Num. of data	Start time	Time in disappeared	Distance (km)
A1132	7	14:12	15:03	-
A1199	9	14:52	16:03	1.5
A1292	6	14:01	15:08	-
A1298	5	14:06	15:25	-
A1351	2	14:02	15:48	-
A1474	3	15:00	15:20	2.8
A1594	4	14:58	16:29	-
A1598	7	14:27	15:27	3.2
A1783	4	14:04	15:00	-
A2204	6	14:37	15:29	20
A2491	8	14:01	15:18	3.9
B1173	14	14:01	16:32	16
B1473	8	14:01	15:19	9.8
B1492	12	14:01	15:35	1.7
B1508	18	14:00	15:38	1.9
B1523	11	14:11	15:27	1.2

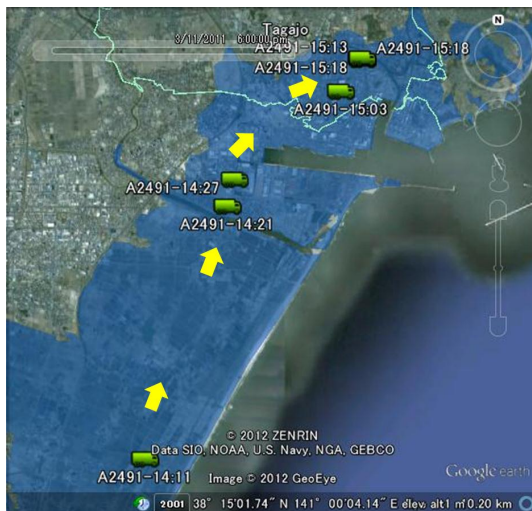
\* A: large and medium truck, B: small truck



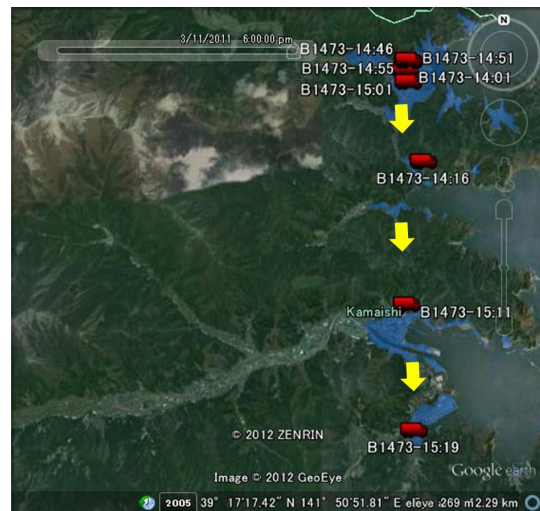
**Figure 5.** Extracted suffered trucks by tsunami



**Figure 6.** Movement of suffered truck (A2204)



**Figure 7.** Movement of suffered truck (B1473)



**Figure 8.** Movement of suffered truck (A2491)

**Figure 7.** shows B1473 was running on national road along the coastal are in Sanriku. A2491 was moving to the north along the coastal area in Sendai Plain (**Figure 8.**). In the same as the other trucks, any evacuation behaviours on 16 suffered trucks are not confirmed.

#### 4.3. Significance of probe vehicle data

As the mentioned above, there was no evacuation behaviour of suffered trucks. Although the reason is thought that commercial trucks have to arrive at destinations on time, this result raises an issue how to persuade drivers to evacuate and deliver proper information in each drivers.

At the present based on protection of personal data, a large amount of recorded probe vehicle data are not analysed to clear the behaviour of survival and suffered vehicles after the quake. As great earthquakes and damaging tsunamis along Suruga and Nankai trough will occur in the near future, proper information delivering to drivers and building evacuation measures for vehicles are being significant issue to solve.

### 5. CONCLUSION

In this paper, we introduce and discuss utilization of probe vehicle information in disasters and future issues in Japan. First, utilization of probe vehicle data for disaster reduction in Japan before 2011 Tohoku Quake is reviewed. It is shown that series of our activities lead to utilization of probe vehicle data in disasters. Second, activities on provision of Toreta-Road Map conducted by private sectors after 2011 Tohoku Quake are introduced. We point that major problems raised previously were solved and future issue is how to realize and create permanent framework for provision of Toreta Road Map in disasters. Third, suffered trucks by tsunami are extracted and those behaviours are analysed. Any evacuation behaviours of 16 suffered trucks are not confirmed. We concluded that proper information delivering to drivers and building evacuation measures for vehicles are being significant issue to solve.

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