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THE USE OF BIG DATA AND SOCIAL NETWORKS FOR DISASTER MANAGEMENT

A PIARC TECHNICAL REPORT

TECHNICAL COMMITTEE 1.5 *DISASTER MANAGEMENT*

PIARC

STATEMENTS

The World Road Association (PIARC) is a nonprofit organization established in 1909 to improve international co-operation and to foster progress in the field of roads and road transport.

The study that is the subject of this report was defined in the PIARC Strategic Plan 2020– 2023 and approved by the Council of the World Road Association, whose members are representatives of the member national governments. The members of the Technical Committee responsible for this report were nominated by the member national governments for their special competences.

Any opinions, findings, conclusions and recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of their parent organizations or agencies.

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EXECUTIVE SUMMARY

2023R22EN

THE USE OF BIG DATA AND SOCIAL NETWORKS FOR DISASTER MANAGEMENT

A PIARC TECHNICAL REPORT

PIARC's Technical Committee 1.5 - Disaster Management, has established a task related to the 'Use of Big Data and Social Networks for Disaster Management. This task considers new information evolutions such as big data and social networks. It involves an international literature review, collection and analysis of case studies and engagement with worldwide road administrations to learn from global experience to promote knowledge sharing.

As part of this research, TC 1.5 – Working Group 1 (WG1) carried out an international survey. The main themes of survey questions were the Types of Big Data and Social Network information collected and the frequency of collection, validation techniques and ensuring the accuracy of the collected data, data analysis and dissemination (technologies, software, etc.), benefits to the road administration and road users, and application with COVID-19 pandemic.

From survey responses analysis, which came from 22 countries with a continent breakdown as follows; 8 (Asia), 8 (Europe), 5 (America) and 1 (Oceania), the following results were obtained:

1. Production of a briefing note to provide an overview of the project methodology and summary of findings on survey results.

2. Collection of 11 case study related to the survey main topics, which came from Japan (3), China (1), South Korea (1), Chile (1), Czech Republic (2), Spain (1), New Zealand (1) and Poland (1).

Analysis shows extensive collection and analysis of Big Data and information from Social Networks is taking place during the disaster/emergency lifecycle. Most of this information relates to traffic, infrastructure and weather data.

This technical report contains a brief summary of survey results and case study analysis, conclusions and recommendations for decision-makers and international organizations.

CONTENTS

1. INTRODUCTION

PIARC's Technical Committee 1.5 - Disaster Management has been requested to continue work commenced by the Technical Committee E.3 on the last cycle 2016 - 2019. This task related to the *'Gathering and diffusion of information for disaster management, taking into account new evolutions such as big data and social networks'.*

This project during the current cycle has a complementary focus, involving an international literature review, collection and analysis of case studies and engagement with worldwide road administrations to learn from global experience to promote the sharing of knowledge. The overall aim of the project is defined as follows;

- Study how to process vast amounts of information acquired from the Big Data and Social Networks rapidly and efficiently to extract necessary and reliable information for disaster management.
- Study how to evaluate the accuracy of information from Big Data and Social Networks and ensure the quality of the information related to disaster management.
- Study how to disseminate disaster information efficiently among road users and the relevant parties through social networks.
- Identify best practice and disaster management techniques using relevant case studies of recent evolutions in information, communication areas such as Big Data and Social networks.

For this Technical Report, big data and social networks can be defined as follows:

BIG DATA is defined as the data extracted from open or closed source databases. It may relate to extensive data sets that may be analyzed computationally to reveal patterns, trends, and associations, especially relating to human behavior and interactions.

SOCIAL NETWORKS are defined as the data generated by various activities of "people" such as opinions, evaluations, and behavior, e.g., Facebook, Twitter, WeChat, HI5, WhatsApp, etc.

1.1. THE PURPOSE OF TECHNICAL REPORT

The purpose of this technical report is to provide decision-makers with the following information:

- International survey results
- Collected case study analysis
- Conclusions, recommendations and next steps for the project.

2. METHODOLOGY

For this research, a mixed methodology was utilized, described by O'Leary as 'incorporating quantitative and qualitative paradigms, approaches, concepts methods and/or techniques in a single study' (2017, p.164). Initially, it was assumed that data would be available and compartmentalized, but this was not the case. What is evident is that an array of limited data is available internationally and a survey has been conducted across several organizations to access this information.

In support of this project, a literature review will be conducted to establish familiarity with other research projects in this area and understand what is already known about the subject.

2.1. CONDUCTED SURVEY

The survey aimed to capture the different ROAD RELATED TECHNOLOGIES THAT ARE USED DURING THE DISASTER / EMERGENCY MANAGEMENT LIFECYCLE for data collection and analysis, as well as to collect case studies or projects to learn from global experiences whilst sharing best practice across road administrations worldwide.

This survey is made up of 15 questions falling under seven main themes as follows;

- Types of Big Data and Social Network information collected and the frequency of collection.
- Validation techniques and ensuring the accuracy of the collected data
- How data is analyzed (technologies, software, etc.).
- Uses of collected data and to who and how the information is disseminated.
- Benefits to your road administration and road users.
- Covid-19 and the application of Big Data and Social Networks
- Any relevant information about case studies, implemented projects or obstacles you faced during the implementation of specific technologies.

The survey was distributed through PIARC in English, French and Spanish and disseminated to the PIARC First Delegates worldwide, and it was available in physical and digital format.

2.2. FINAL SURVEY RESPONDENT INFORMATION

For this technical report, the following information provides a high-level summary of the survey results.

- A total of 46 responses to the survey, from 22 countries with a language breakdown as follows: 41 (EN), 2 (FR) 3 (ES)
- 22 countries with a continent breakdown as follows; 8 (Asia), 8 (Europe), 5 (America) and 1 (Oceania)
- 11 case studies were received as a contribution from TC members (China, Poland, Japan, Chile, Czech Republic, Spain, Australia and South Korea)

2.3. CASE STUDY COLLECTED

The cases studies collected are examples of the use of information management, related to roads and emergencies, in different countries of the world. Below is a list of the eleven titles and authors.

#	TITLE	AUTHOR	COUNTRY
1	Presumption of road conditions using connected cars with IoT and Big Data	Tomohiro FUJITA	Japan
2	Stuck vehicle detection system using AI image analysis	Tomohiro FUJITA	Japan
3	Road traffic performance data system in Japan	Tomohiro FUJITA	Japan
4	The system of providing current traffic data from the entire territory of the Czech Republic	Jan GRUBER	Czech Republic
5	GALILEO system	Jan GRUBER	Czech Republic
6	Investigation of Highway Frost Disaster in High latitude Frozen Soil Regions in China	Hongwei ZHANG	China
7	Safe CAR(Cooperative Accidents Response)	Jongwook JO	South Korea
8	Information management in GDDKiA	Piotr CHAŁKA	Poland
9	Open Source for road emergency information	Marcelo MEDINA	Chile
10	Dynamic management of information on the effects of volcanic eruptions on road traffic on the island of La Palma (Spain)	Antonio GRANADOS	Spain
11	Rapid Structural Assessment of a Pavement Network Following a Major Flooding Event	Neil FISHER	New Zealand

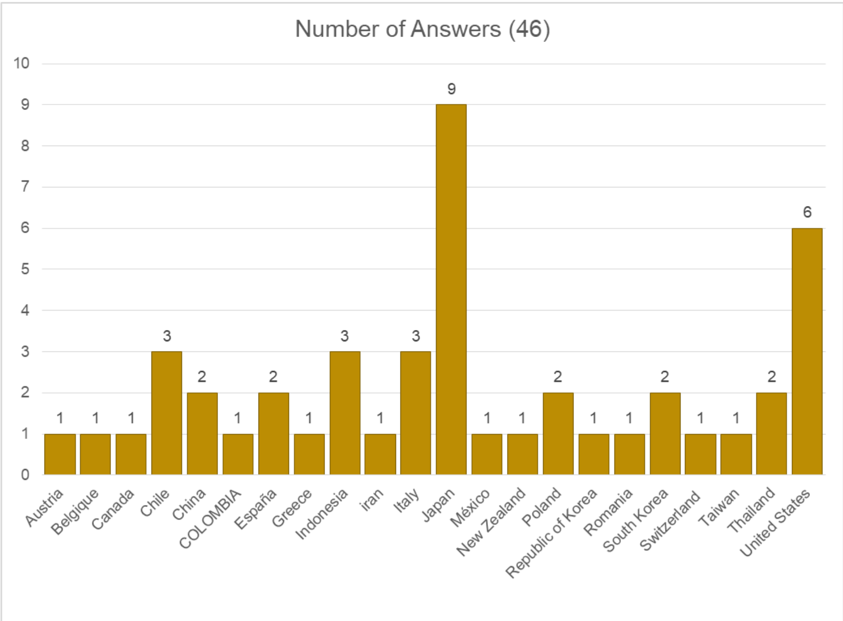
3. SUMMARY OF RESULTS

This survey objective was to capture the different road-related technologies that are used during the DISASTER / EMERGENCY MANAGEMENT LIFECYCLE for data collection and analysis, as well as to collect case studies or projects to learn from global experiences whilst sharing best practice across road administrations worldwide.

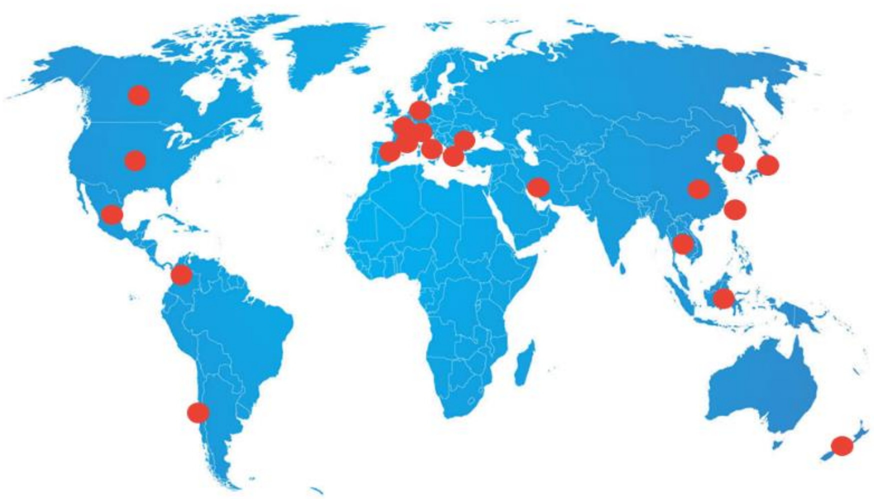
3.1. SURVEY RESPONSES

3.1.1. Basic Information

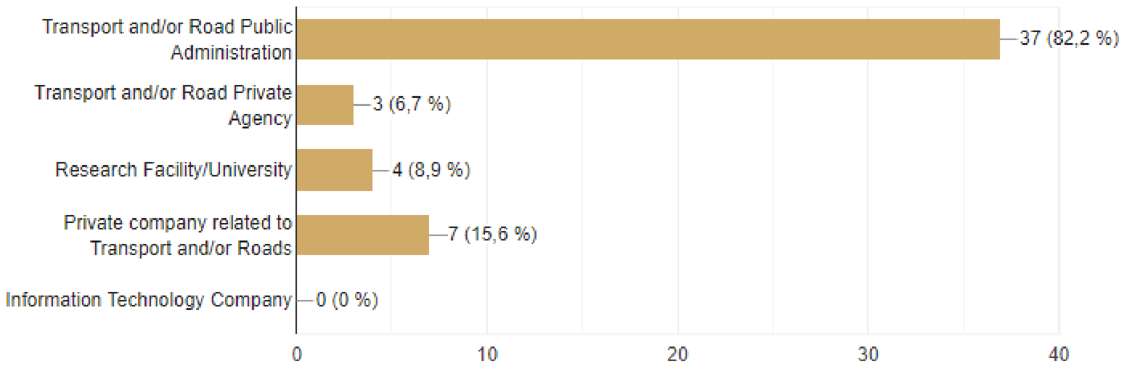
In total, there were 46 respondents to this survey. The following chart highlights that this included 22 separate countries. Of note are the high completion rates from Japan (9) and the US (6).

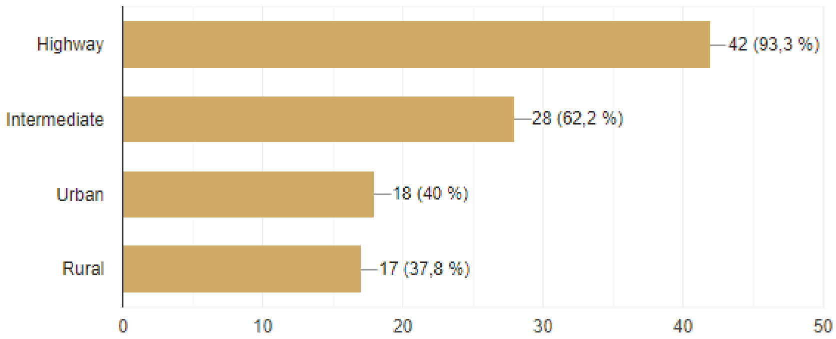


The following map shows the continental breakdown of respondents with both Asia and Europe featuring most highly in the survey completion rates.

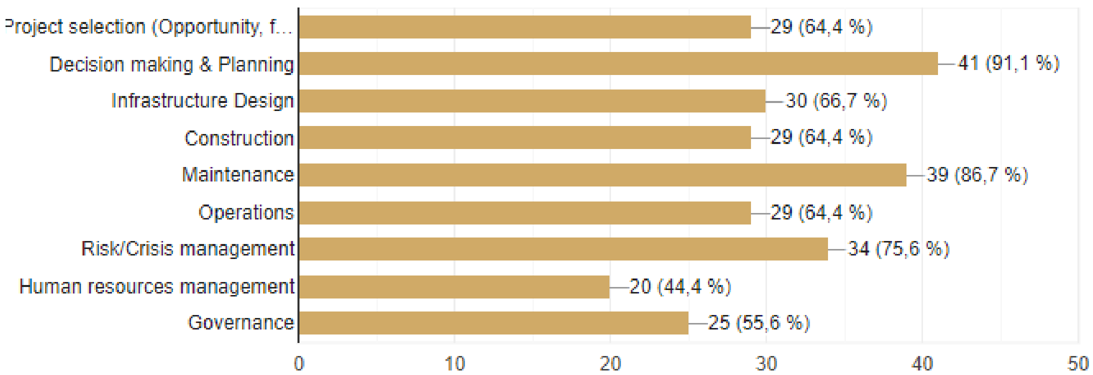


One interesting point of analysis from the survey's respondents showed that from a range of contributors, the Transport and Road Public Administration sector provided most survey responses.

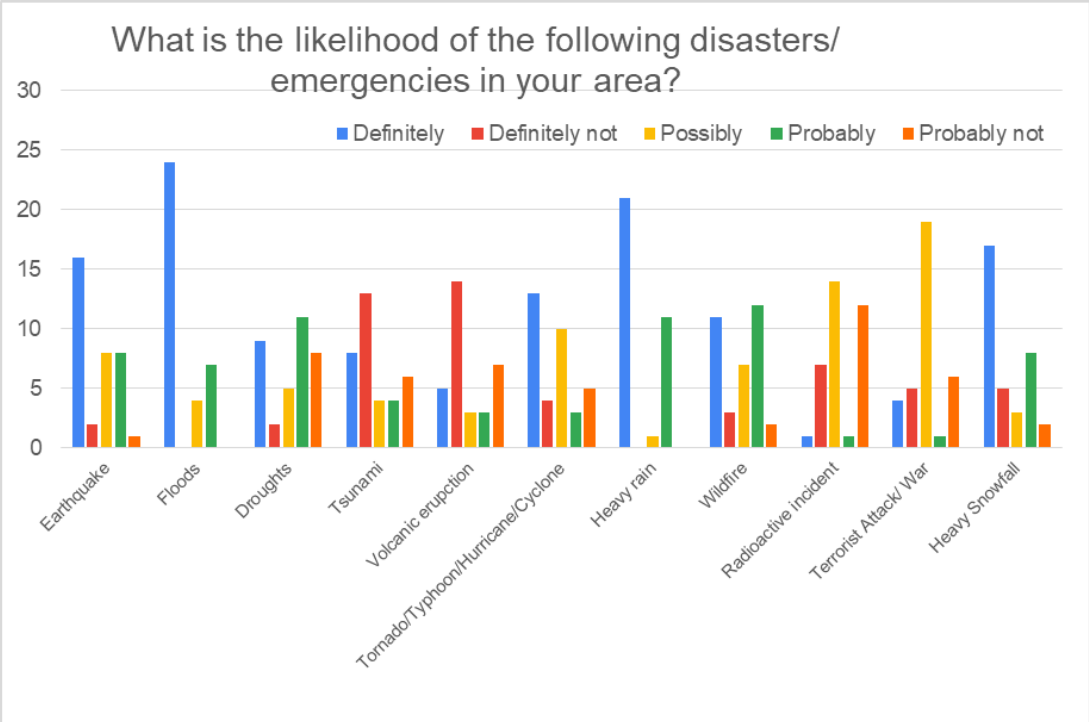




Of all survey respondents, analysis shows that those in the decision making & planning followed by operations provided most responses.

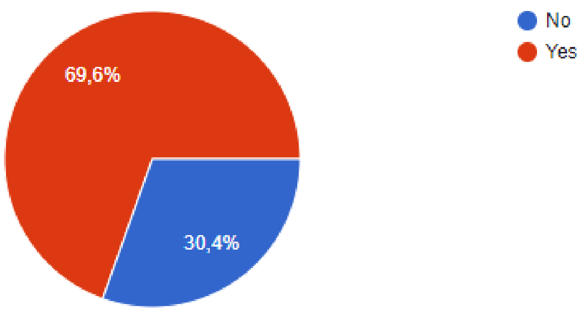


The chart below provides information to the question regarding the likelihood of disasters in your area, it is evident that there is a wide range of events. Of note is the prevalence of Heavy rain, floods, heavy snowfall and earthquakes.

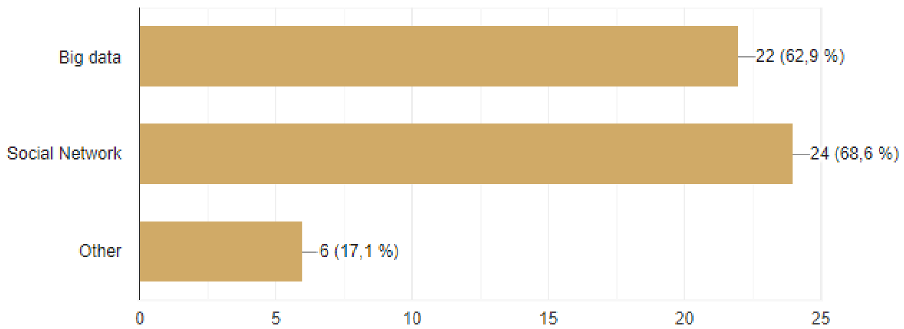


3.1.2. THEME 1: Types of Big Data and Social Network information collected and the frequency of collection

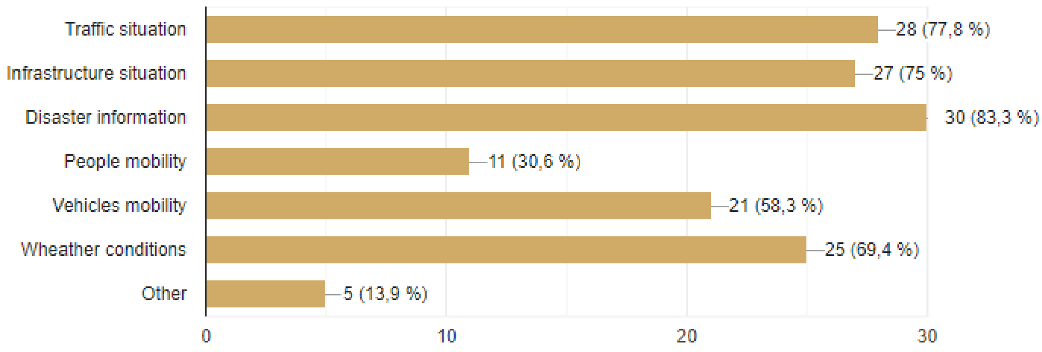
Q1 - Does your organization collect and analyze Big Data and/or information from Social Networks during any stage of the disaster /emergency lifecycle?



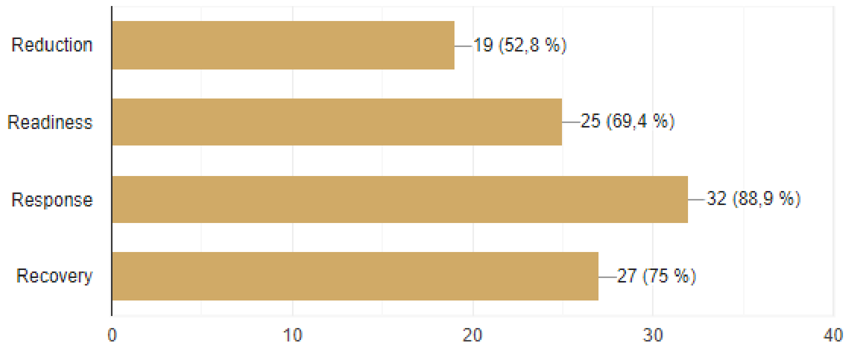
Type of data source



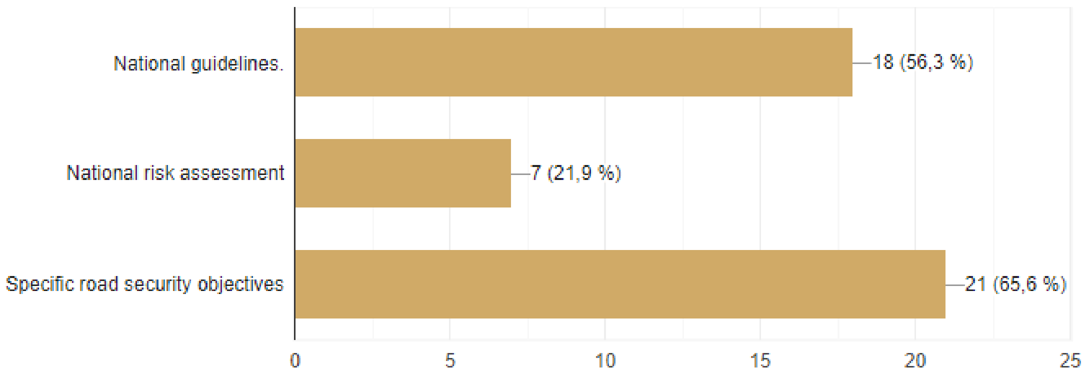
Kind of data



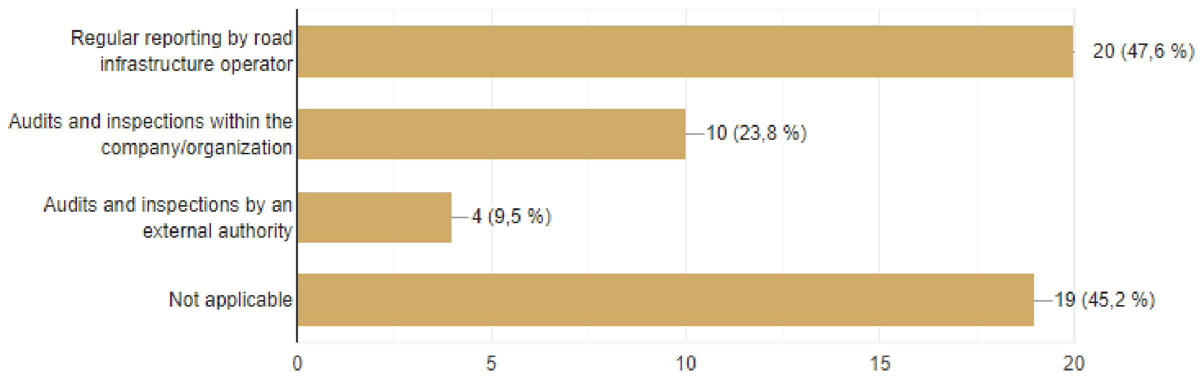
Which purpose



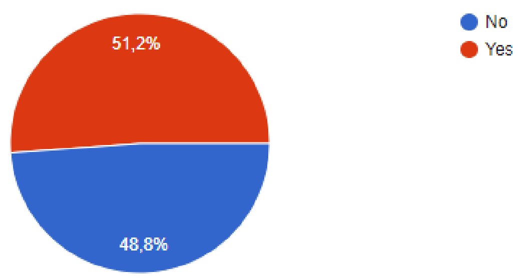
Q2 - Does your procedure to collecting BIG DATA and/or information from Social Networks refer to any of the following?



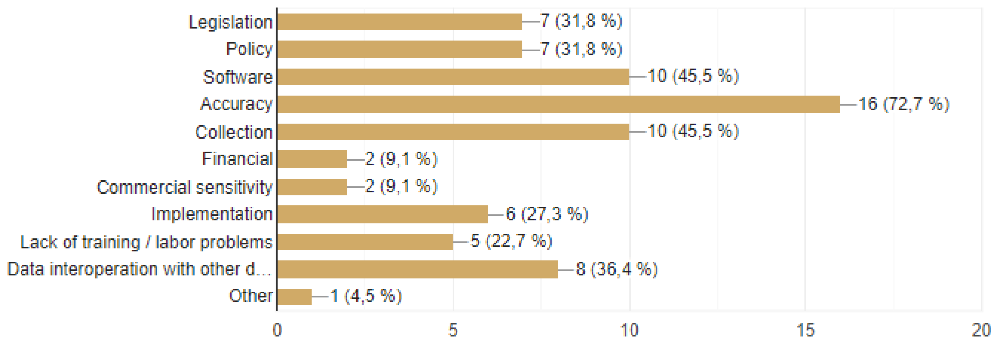
Q3 - Is your existing procedure of BIG DATA and/or information from Social Networks collection subject to:



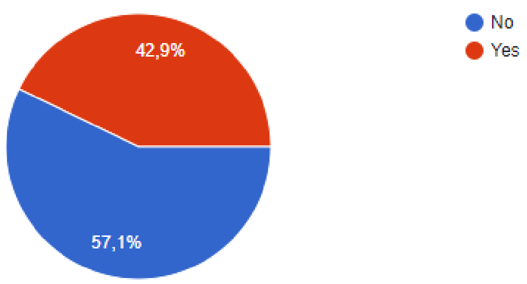
Q4 - Have you found any significant challenges for Big Data information coming from OPENED SOURCE?



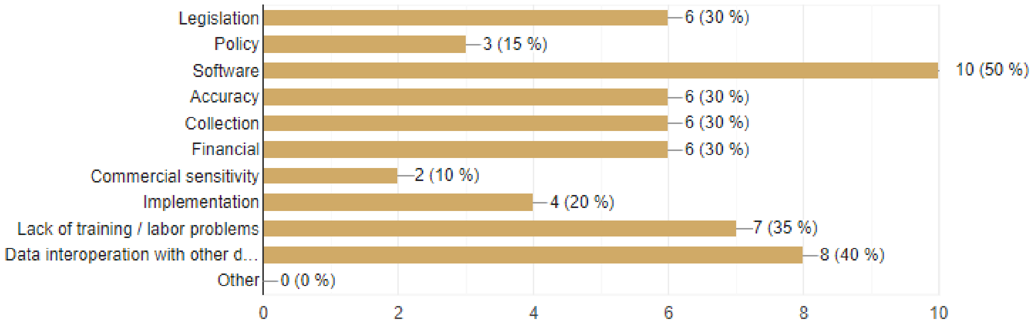
Please specify what you found and any reasons you found for this.



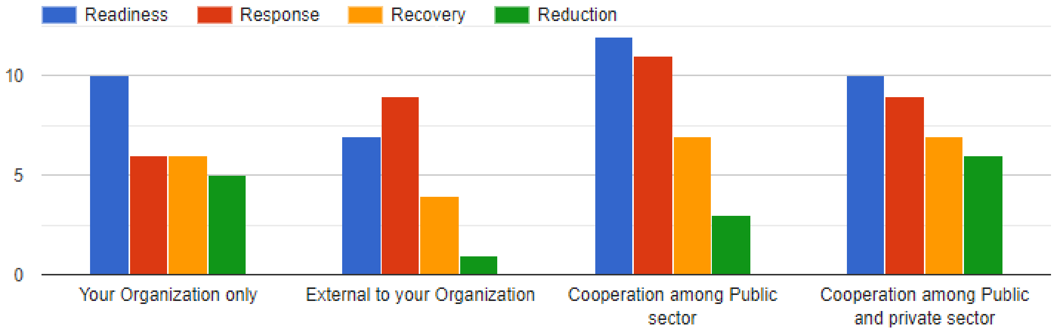
Q5 - Have you found any significant challenges for Big Data information coming from CLOSED SOURCE?



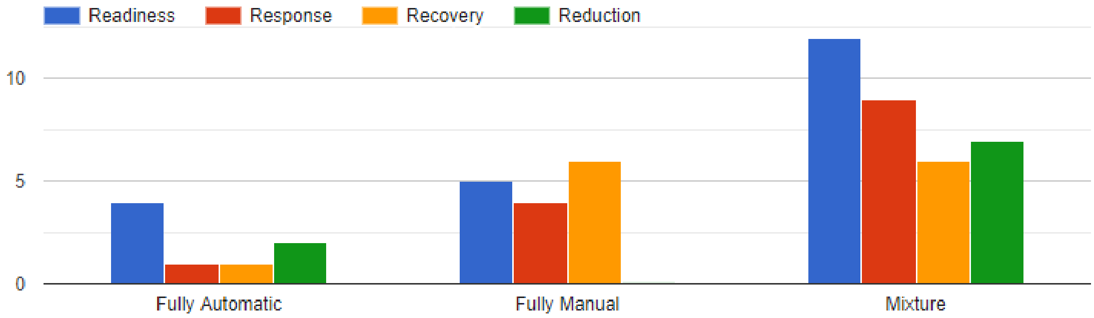
If yes, please specify what reasons you found for this:



Q6 - Who collects the information during the Readiness phase of the disaster/ emergency lifecycle?

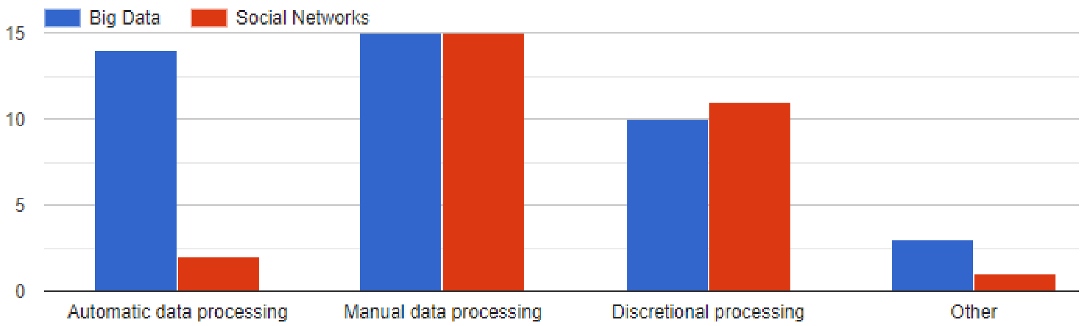


Q7 - What kind of collection method do you use?

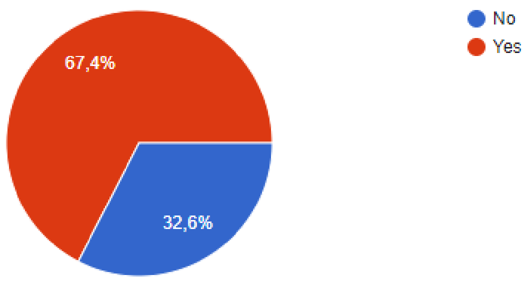


3.1.3. THEME 2: Validation techniques and ensuring the accuracy of the collected data

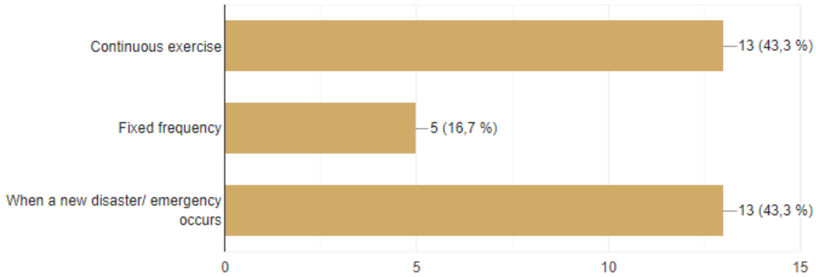
Q8 - What systems and process do you have in place to ensure the information provided from Big Data and Social Networks is accurate?



Q9 - Is the Information collection plan revised?

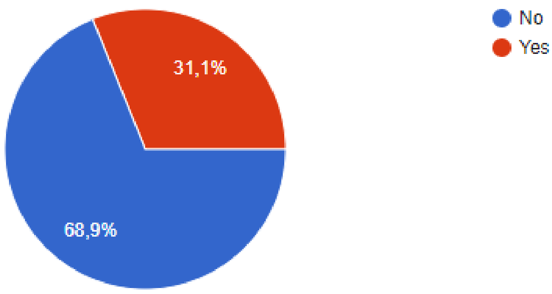


How is it done?



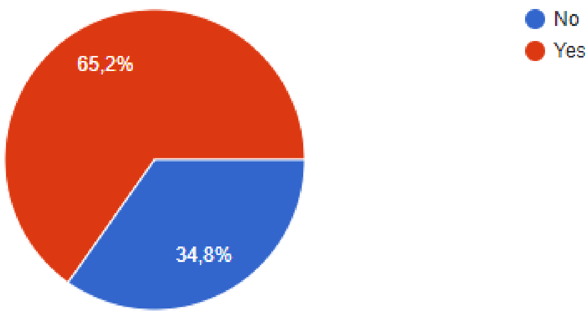
3.1.4. THEME 3: How data is analyzed (technologies, software, etc.)

Q10 – Does your organization have any technology, systems or processes to analyze the information received from Big Data and Social Networks during the disaster/ emergency lifecycle?



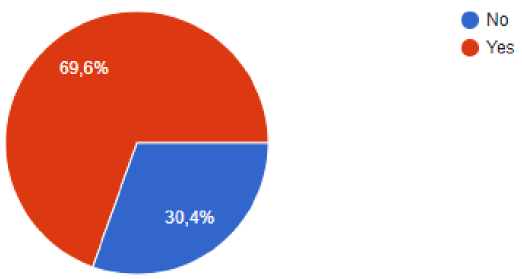
3.1.5. THEME 4: Uses of collected data and to who and how the information is disseminated

Q11 – Is there any recognized pathways, communication channels and/or dissemination list for access to any Big Data and/or Social Networks information during the disaster/ emergency Lifecycle? E.g. email, news, maps, etc.

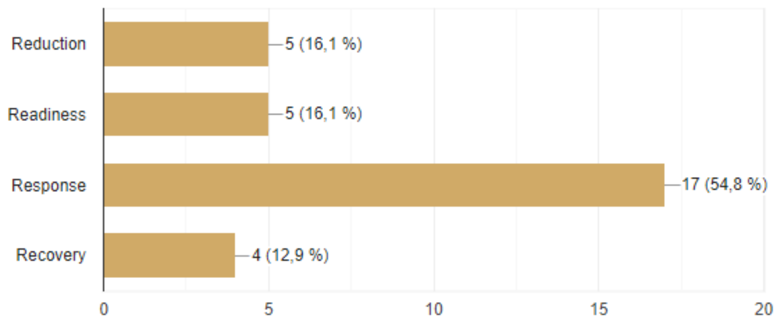


3.1.6. THEME 5: Benefits to your road administration and road users

Q12 - Has your organization achieved any benefits from the application of using Big Data and/or Social Networks information during the disaster/ emergency lifecycle?

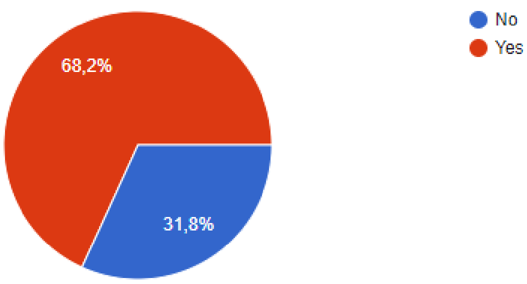


Please identify which area?

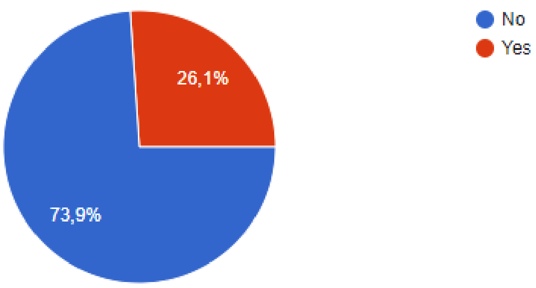


3.1.7. THEME 6: Covid-19 and the application of Big Data and Social Networks

Q13 - Does your country have or intend to have a Covid-19 Application?



Q15 - Does your organization use new or existing Big Data or Social Networks to deal with emergencies from COVID-19?



4. CASE STUDY ANALYSIS

4.1. CASE STUDY COLLECTED

The cases studies collected are examples of the use of information management, related to roads and emergencies, in different countries of the world.

4.1.1. Japanese Case study

Status:

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ROAD TRAFFIC PERFORMANCE DATA SYSTEM IN JAPAN

EXECUTIVE SUMMARY

This report introduces “Road traffic performance data system”. This technology can help you to provide the passable road to road users.

INTRODUCTION

Japan went through many natural disasters such as typhoons, heavy rainfalls, heavy snowfalls, floods, landslides, earthquakes, tsunamis, and volcanic eruptions. In recent years, Japan has been suffered tremendous damages due to climate change. For example, the number of occurrence of precipitation over 50mm/hour has been increased in Japan. The number is about 1.4 times higher than it was 30 years ago1). It is expected to increase further in the future. Heavy rainfalls can make highways impassable due to anything covered road, bridge scour and so on.

ANALYSIS

Roads are critical infrastructure for emergency response, evacuation, and post-disaster recovery when a disaster occurs. Road traffic information is important to help the various activities because the road traffic condition momently changes.

ALTERNATIVES

The Ministry of Land, Infrastructure, Transport and Tourism (MLIT) started using big data for road management in 2009. Now, the system to collect the big data which is probe information is called "ETC2.0". The system mutually communicate between ETC2.0 devices installed in vehicles, and roadside equipment installed on highways (Fig.1). In addition to the ETC2.0 probe information, vehicles probe information owned by private vehicle manufacturers can be used in disasters based on disaster recover agreements (Fig.2). Using the probe information, passable road map can be timely produced in disasters. The map can help the many activities in disasters.

Fig.1 Feature of ETC2.0[2)]

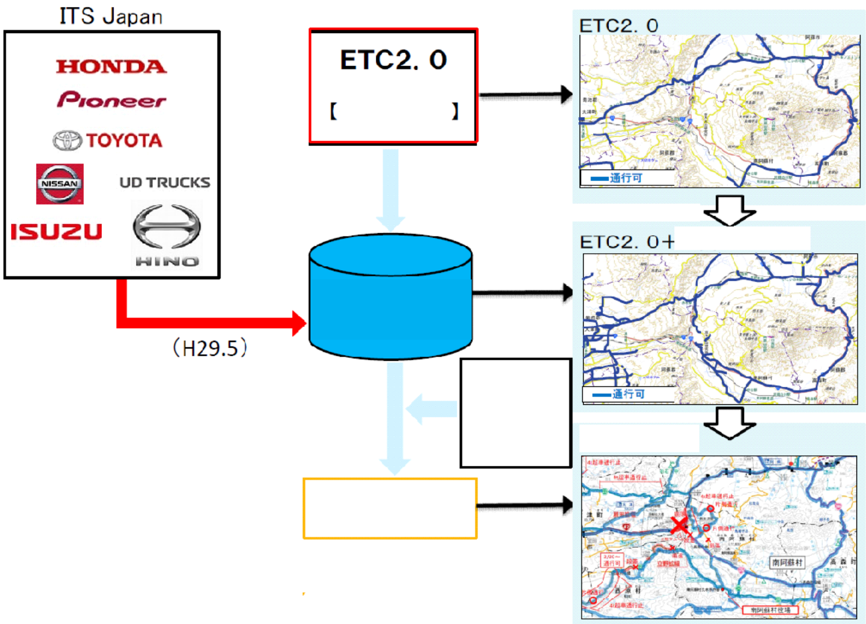

Fig.2 Traffic performance data system in Japan[3)]

Development of rainy season front in July 2020 caused significant rainfall over western and eastern Japan. The maximum 24hours precipitation for the period were the most in recorded history at many observatories particularly in the Kyushu region4). Due to the heavy rainfall, there were a lot of severe damages to the transportation network. Some of the roads caused severe traffic jam. The traffic jam had a significant impact on evacuations and the transport of emergency supplies5).

MLIT's website and social networking service released the passable road map 23 times as shown in Fig.3.

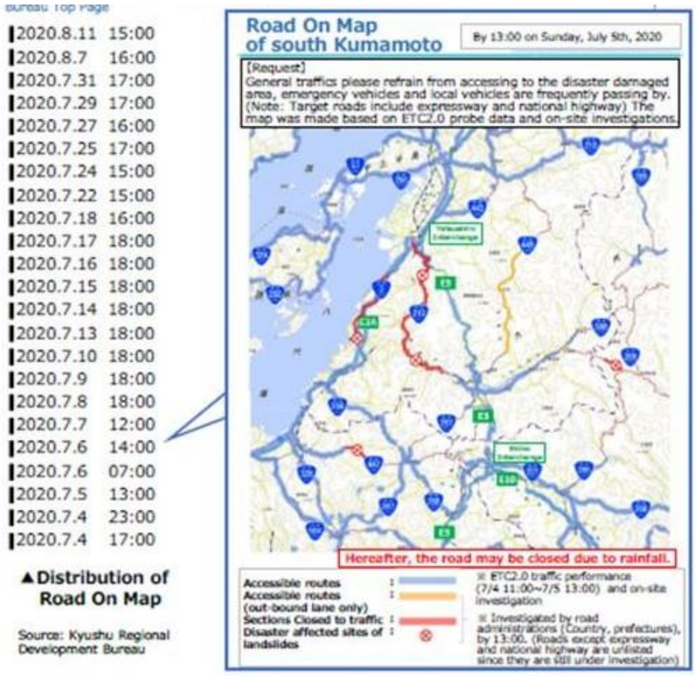

Fig.3 Provision of passable roads on map[5)]

The map was used by the Self-Defense Forces, police, and firefighters to select routes to rescue human lives. In addition, the traffic jam was relieved as shown in Fig.4. The map was seem to be useful for road users, too.

Fig.4 Effect of the system[5)]

RECOMMENDATION

MLIT has indicated a vision for roads in Japan. One of them is that “Road that protect people’s property from disasters”. In order to achieve the goals, it is necessary to have the vehicles which are responsible for logistics to go to passable road during a disaster. I recommend to construct of a system that informs the vehicles of the best detour.

CONCLUSION

Road traffic performance data system using probe information from ETC2.0 and private companies is useful for various post disaster activities. In future, it is expected that more probe information can make us release the passable road map more quickly and in detail.

REFERENCE

- MLIT: https://www.mlit.go.jp/common/001057297.pdf (in Japanese)
- MLIT: https://www.mlit.go.jp/road/ITS/j-html/etc2/pdf/01.pdf (in Japanese)
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- A. Matsuo(2022): Risk Management for a disaster with "Road-On Map", VI World Winter Service and Road Resilience Congress, 2022 (in printing)

4.1.2. Japanese Case study

Status:

Author: Tomohiro FUJITA

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STUCK VEHICLE DETECTION SYSTEM USING AI IMAGE ANALYSIS

SUMMARY

This report introduces "Stuck vehicle detection system using AI image analysis". This technology can help you to make decision quickly for disaster management when a vehicle stuck.

INTRODUCTION

Stuck vehicles can cause serious road traffic problems. In fact, some stuck vehicles due to snow-covered road caused long time road closure of 66 hours and long lined vehicles of 1,500 vehicles in 2018 (Fig. 1). One of the reasons seems to be stuck heavy vehicles and late detection of stuck vehicles. Stuck vehicles are not infrequently for hilly roads in snow-covered area in winter season. It is important to detect the stuck vehicles and respond as soon as possible.

Fig. 1 - Road traffic problem in 2018[1)]

ANALYSIS

Road administrators have monitored road condition in front of many CCTV monitors at the road information room (Fig. 2). However, the road administrators should do multi tasks such as emergency call, control of electric guide boards. The Ministry of Land, Infrastructure, Transport and Tourism (MLIT) made a trial using AI system to detect the stuck vehicles to assist the agents.

Fig. 2 General monitoring of stuck vehicles[2)]

ALTERNATIVES

Vehicles, type of vehicles and the speed are detected by using CCTV image as shown in Fig. 3 AI analysis is conducted in this process. Deep learning is used as AI analysis to detect the stuck vehicles. In order to improve the capture rate, CCTV images for two weeks are used as training data. Traffic characteristics every day of the weeks, hour and weather continue to be learned at the point in normal period. In the result, vehicle capture rate is average 95% using AI analysis.

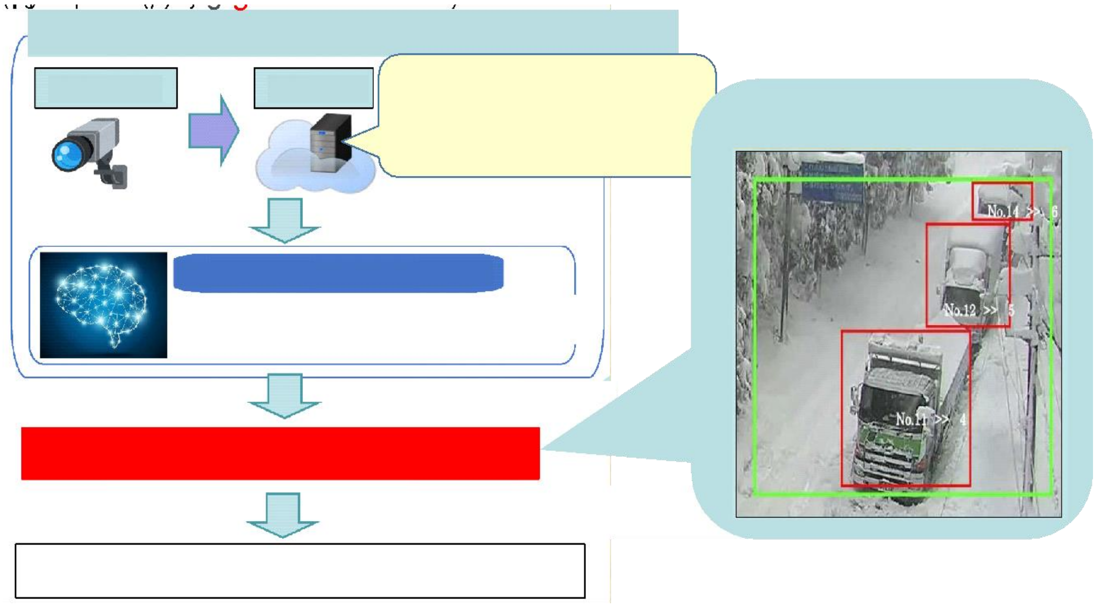

Fig. 3 Automatic detection system[3)]

The system has a feature to send a signal in detection of presage information or the stuck event occurrence. Fig. 2 shows schematic image of traffic volume and travel time in normal, event presage and event occurrence period in the system. Drastic drop of traffic volume and travel time is set as the event presage. The initial value of the drastic drop is set to be 60% less than normal period for traffic volume and less than 20km/h for travel time. If a vehicle has stopped for 10 minutes in addition to the drastic drop of traffic volume and travel time, the system judges the stuck event occurrence. Yellow colored warning light is turned on when the system detects the event presage. Red colored warning lights is turned on and alarm are sounded when the system detects the stuck event occurrence.

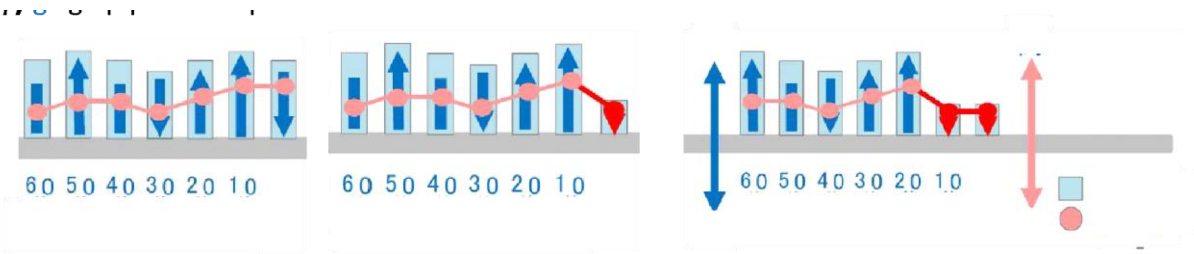

Fig. 4 Traffic volume and travel time between periods[3)]

RECOMMENDATION

MLIT has indicated a vision for roads in Japan. One of them is that in the face of increasingly severe and widespread disasters, a disaster-resistance road network will ensure uninterrupted flow of people and goods to the affected areas, minimizing loss of life and economic losses. I recommend to construct a system that informs the following vehicles of the best detour in conjunction with the stuck vehicle detection system.

CONCLUSION

Stuck vehicle detection system using AI image analysis is useful to achieve Japanese vision. In future, it is expected that more fruitful information can make us convenient.

7. Reference

- MLIT: http://www.hrr.mlit.go.jp/press/2018/03/190319kanazawa.pdf (in Japanese)
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4.1.3. Japanese Case study

Status:

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PRESUMPTION OF ROAD CONDITIONS USING CONNECTED CARS WITH IOT AND BIG DATA

SUMMARY

This report introduces “Presumption of road conditions using connected cars with IoT and Big Data”. This technology can help you to provide the detail weather conditions on road to users.

INTRODUCTION

Japan went through many natural disasters such as typhoons, heavy rainfalls, heavy snowfalls, floods, landslides, earthquakes, tsunamis, and volcanic eruptions. In recent years, Japan has been suffered tremendous damages due to climate change. The number of occurrences of rainfall of 50mm/h or more is approximately 1.4 times that of about 30 years ago (Figure-1).

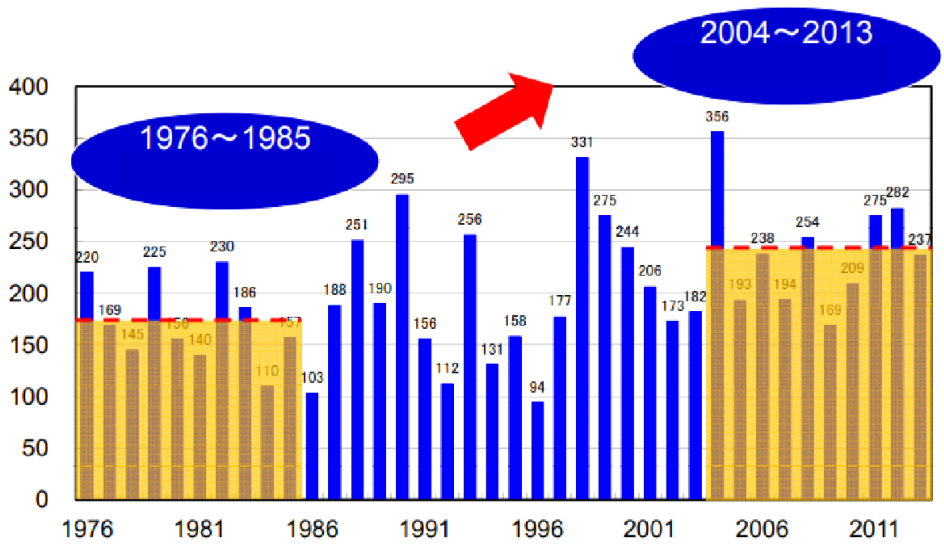

Fig. 1 - Precipitation trend in Japan

ANALYSIS

More than ever, there is a need for localized and immediate weather information and information on how to respond to such events. In order to meet these needs, it is necessary to obtain more detailed and accurate weather conditions in real time. Various technologies for this aim are developing. One of the technologies is introduced below.

ALTERNATIVES

Connected cars with IoT technology provide driving data and car condition data. These car data can be used to capture events that affect the driving and behavior of the car. By combining and AI analyzing car and weather data, road conditions are trying to be presumed by car manufacturer and weather Information Company (Figure-2). By now, water cover, ice-cover and precipitation are targeted as the road conditions.

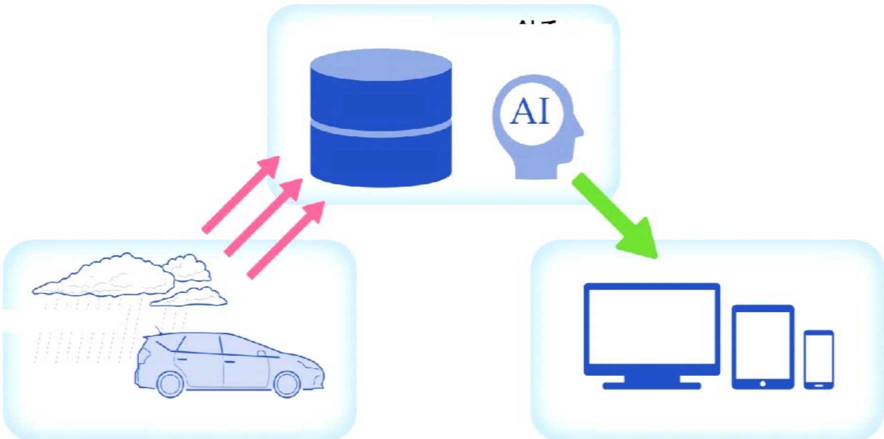

Fig. 2 Road condition presumption

In regard to the water cover car speed and pressure on the accelerator pedal are used. The speed of the car through a water-covered road in relation to the amount of the pressure becomes slower than through a non-water covered road. In regard to ice-cover, car and weather data are used. The brake and driving data can be used for detection of car slip point on road. Temperature, snowfall, rainfall at the slip point are combined analyzing to detect an ice-covered road. In regard to precipitation, wiper operation data is used. It has been found that the area where cars with wipers in operation generally coincides with the rainfall area. The presumed road conditions are indicated on map (Fig. 3 and Fig 4).

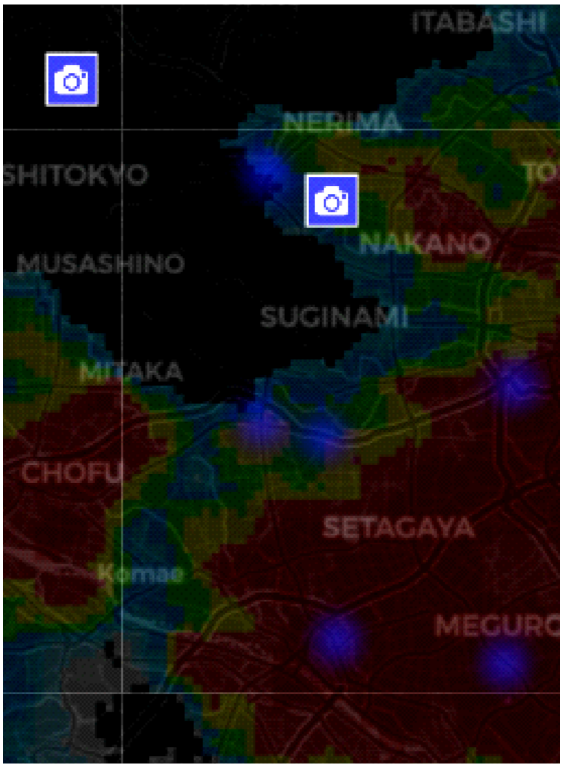

Fig. 3 - Water-covered road

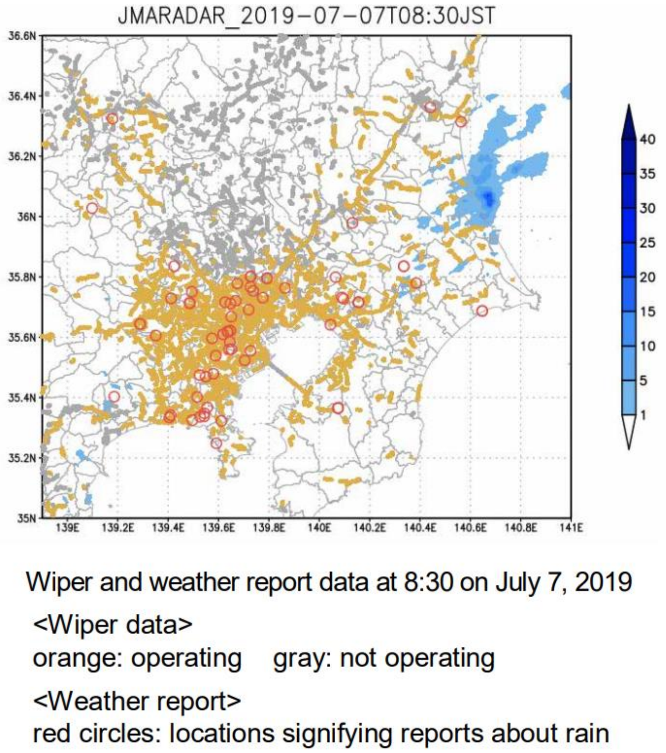

Fig. 4 - Precipitation presumption

RECOMMENDATION

The acquisition and utilization of big data, such as weather information on road should be promoted through collaboration among industry, government, and academia.

In promoting this, a big data platform should be built and rules should be established. In addition, road administrators should strive to improve their technical capabilities in data science in order to properly implement these measures.

CONCLUSION

Presumption of road conditions using connected cars with IoT and Big Data is useful for disaster management process before and after disaster. In future, it is expected that more connected cars information can make us presume more detailed road conditions.

7. Reference

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- https://global.toyota/en/newsroom/corporate/30483256.html
- https://weathernews.jp/s/topics/201911/030095/（in Japanese）

4.1.4. Chinese Case study

Status: Investigation for highway

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INVESTIGATION OF HIGHWAY FROST DISASTER IN HIGH-LATITUDE FROZEN SOIL REGIONS IN CHINA

EXECUTIVE SUMMARY

Frozen soil refers to all kinds of rocks and soils with a certain amount of ice crystals inside and the temperature kept below 0 degree for a long time. According to time of the ice in the soil remains frozen, it can be subdivided into three types: short-term frozen soil, seasonal frozen soil and permafrost.

The regions of frozen soil in China is about 5.13 million square kilometers, which accounts for 53% of the country’s land area, with significant regional characteristics. In which the permafrost area is about 2.15 million square kilometers, that is to say, about 22% of the country's land is occupied by permafrost.

High-latitude permafrost is mainly distributed in the Northeast and Daxingan Mountains. The thickness is several meters, mostly tens of meters. These high-latitude permafrost are mostly in the form of large continuous and island shapes, which all have high temperatures.

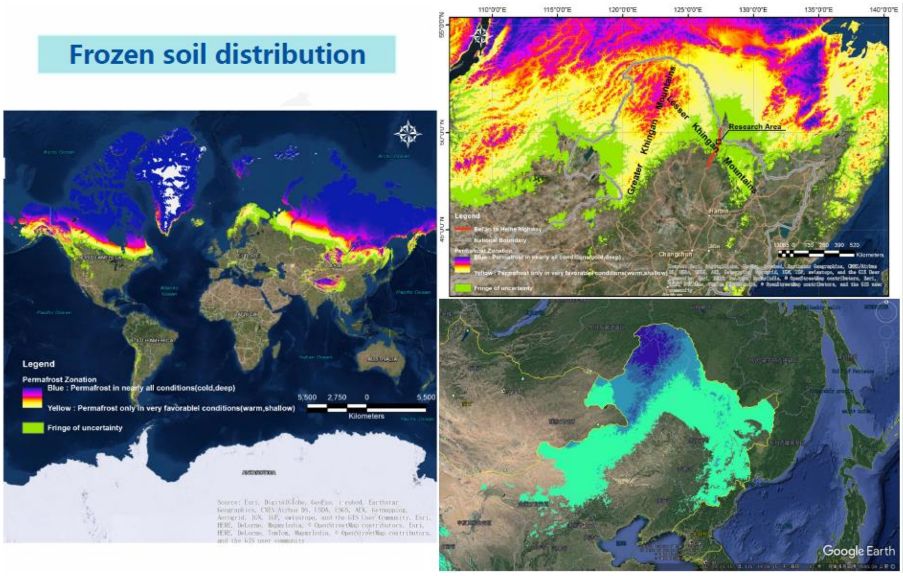

Fig. 1 – Frozen soil distribution in China

INTRODUCTION

Northeast China has experienced dramatic climate warming in the past 100 years. Affected by urbanization and major engineering construction, the permafrost and cold regions of Northeast China have been changed rapidly.

Over the past 100 years, with the global warming, the thickness of permafrost has been thinning, a large number of island-shaped melting areas have appeared, the southern boundary of permafrost has been moving northward, and the area of permafrost has decreased by 26 million km2.

The degradation of permafrost has caused frequent occurrence of engineering and environmental disasters.

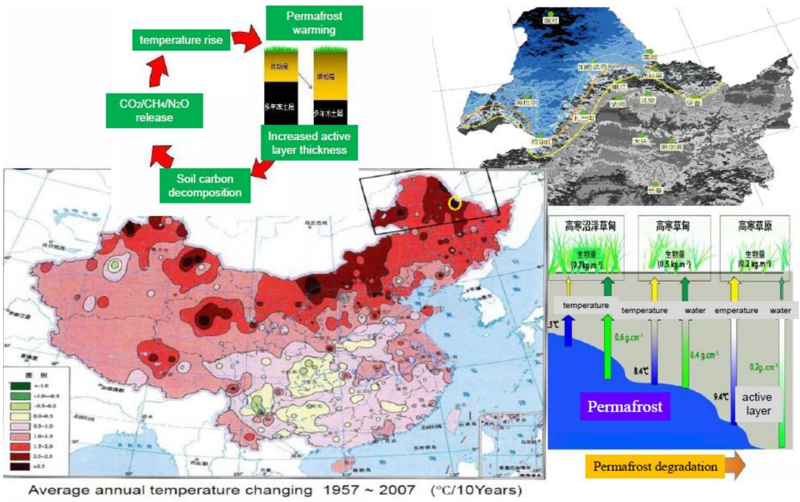

Fig. 2 – Average annual temperature changing

The frozen soil freezes in cold season and melts in warm season, which is greatly affected by the external environment. The alternating state of freezing and thawing makes the mechanical properties of the seasonal frozen soil significantly different. In the cold season, the water migration and the ice-water phase change cause the soil to heave. But in the warm season, the soil settles after thawing. Under the action of freezing-thawing cycles, the alternating occurrence of frost heaving and thawing settlement is a prominent feature of such special soils, which puzzles the construction in seasonal frozen soil areas. Furthermore, the disasters of road engineering in seasonal frozen soil areas frequently occur, causing serious problems for the normal operation of roads and railways. The frost heave, settlement, mud-pumping and cracks of road are major disease forms in the seasonal frozen soil.

Fig. 3 – Highway problems due to subgrade movement

The occurrence of such diseases not only seriously affects the safety and health operation of the road, but also consumes a large amount of maintenance costs. For example, the area of frost boiling in Shen-Dan Highway was more than 6 million square meters, and the freezing-thawing disasters accounted for 1/3(one-third) of the city's roads of Changchun City in China in 2004, with remediation and maintenance costs nearly 200 million Chinese Yuan (30 Mill US$).

Fig. 4 – Highway problems due to frozen soil melting

In Northeast of Inner Mongolia, China, the frozen soil on the foundation has a large ice content, and its physical and mechanical behavior has the characteristics of discreteness and temperature sensitivity, which is important for highway engineering construction. The degraded and melting state of permafrost has brought more difficulties to the construction of the project, and major diseases have occurred in the infrastructure. Moreover, these diseases are in dynamic changes with the seasons, and it is very difficult to manage them, which seriously affects the effectiveness of infrastructure use and traffic capacity.

Fig. 5 – Highway problems due to frozen soil melting

INVESTIGATION AND MANAGEMENT OF HIGHWAY FROST DISASTER

With an investment of more than 6 million yuan (900.000 US$), it is planned to build 15 permafrost observation stations in high-latitude permafrost regions, and 10 of them have been built. The frozen soil observation station mainly includes the monitoring of the frozen soil climate, roadbeds, bridges and tunnels and other traffic facilities.

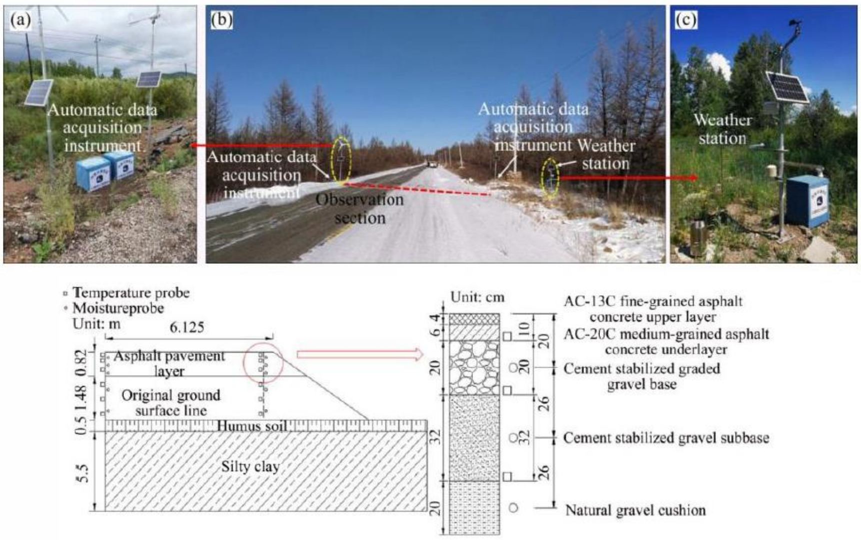

Fig. 6 – Permafrost monitoring facilities

In order to analyze the inside hydrothermal process of the highway asphalt pavement in the deep seasonal frozen soil area, water and temperature observation devices were buried in the test section. All data collection adopted automatic data acquisition instrument, which recorded data every 6 hours. In addition, the weather station was set up near the observation section to provide local weather data. Up to now, the observation section has obtained observation data for nearly six years from 2016 to 2021.

Another monitoring site is BYOB site where buried temperature, humidity, earth pressure, and displacement sensors on the roadbed and road surface at different depth, as well as HHHT monitoring site, where buried sensors on subgrade, lower basement layer, upper basement layer, subsurface to get temperature, moisture, earth pressure, and displacement, including the dynamic weighing to acquire the cars weight.

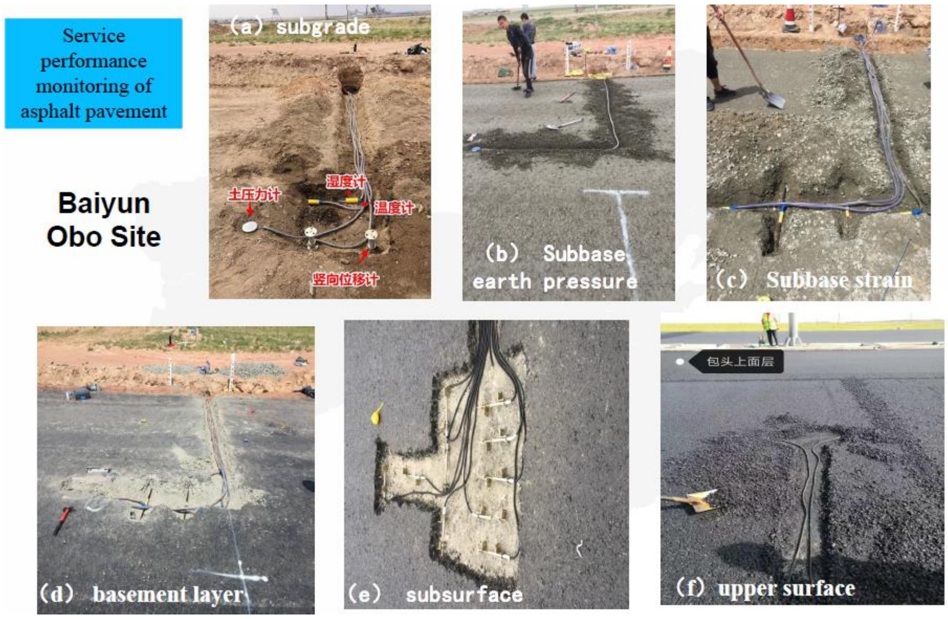

Fig. 7 – BYOB Asphalt pavement monitoring

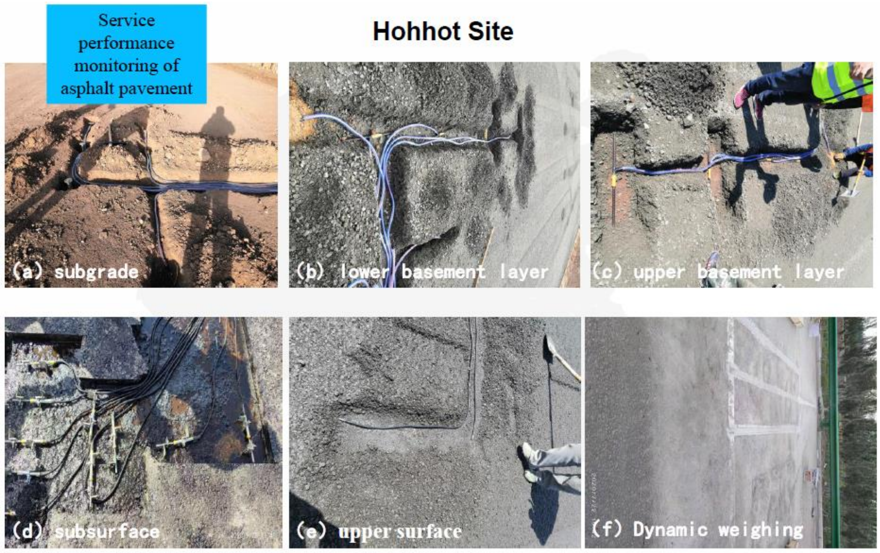

Fig. 8 – Hohhot site Asphalt pavement monitoring

DATA ANALYSIS

The analysis of the temperature versus time at different depths of the asphalt pavement in the observed section, shows the periodic temperature change of the surface layer that can reach 28.6 °C in summer, and -27.4 °C during winter. Meanwhile, Water migration changes periodically over time.

Water content presents significant seasonal variation characteristics on the time scale. In the warm season, the water content of each layer increases with the increasing temperature, and decreases gradually after the soil is completely thawed.

The hydrothermal monitoring and Weather monitoring, remote sensing and Three-dimensional detection which have been performed at the same to form Integrated Detection System. Under this System, Spatial-temporal evolution of remote sensing data, Disaster data evolution and Laboratory experiments three field coupling have been studied to explore frozen soil evolution law.

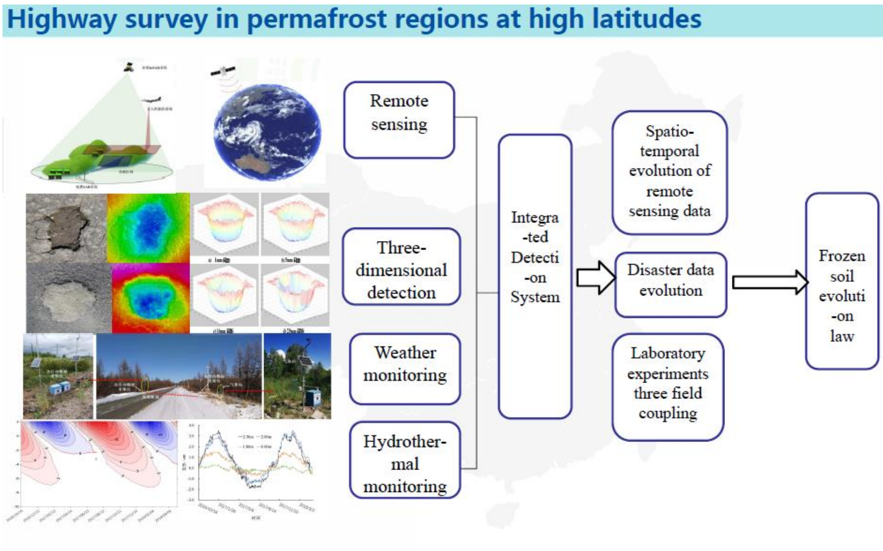

Fig. 9 – Highway survey in permafrost

CONCLUSION

So far, it have been accumulated 6 million data. From these data, we have grasped some laws of road disasters in frozen soil regions and understood the causes of the disasters. We are still in the exploratory stage of using big data for disaster management.

In the future, we want to provide services for government departments, highway management and maintenance departments, and design and construction departments through real-time monitoring of freezing damage. For example, weather monitoring data can provide traffic police and government departments with road icing warning, and they can choose to close the road or release the ice and snow melting agent according to the actual situation. Besides, when there is a traffic accident on the road, nearby cameras will capture and send an early warning to the management department, and the rescue will be decided as soon as possible based on the actual situation.

When a road disaster occurs or road facilities are damaged, it will be reported to the road maintenance management department as soon as possible, and they will be repaired in time according the actual situation. In the future, we will improve the disaster big data management and control platform to achieve these function.

4.1.5. South Korea Case study

Status: Ongoing Project

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SAFE CAR (COOPERATIVE ACCIDENTS RESPONSE)

EXECUTIVE SUMMARY

Korea Expressway Corporation (KEC) provides a cooperative accident response service that contributes to responding quickly to incidents and reducing the number of fatalities in traffic accidents by detecting various abnormal situations on expressways in real time by merging/utilizing GPS big data such as speed, location, time of smartphone navigation applications operated by private companies and CCTV data operated by the corporation.

BACKGROUND AND ANALYSIS

As of 2020, road traffic accident fatality rate of Republic of Korea is 4.0 per 100,000 people which is higher than Japan's 2.7 per 100,000people. There are 1,156 fatalities from 11,016 traffic accidents last five years (Y2014~Y2018) on expressway managed by KEC and particular note is the 'secondary accident' with 299 accidents, 174 people died with a fatality rate of 58.2% during the same period. While the fatality rate of accidents is 10.5% but of secondary accidents is about 5.5 times higher and showing a trend of increasing from 52.2% in Y2014 to 64.8% in Y2018.

* Secondary accident: referring to an accident in which passengers disembarks in or around a vehicle due to an accident or breakdown are run over by vehicles that follow.

ALTERNATIVES

As of 2020, expressway managed by the KEC was about 4,200 km with an average daily use of about 4.5 million vehicles. About 7,800 CCTVs were operating 24/7 to monitor the traffic situation but it took 16 minutes or more for the road manager to recognize abnormal situation such as an accident. KEC is also operating incident detection system such as VDS (Vehicle Detection System) but has a limitation that detection is possible only when the vehicle enters or passes through the detection area.

Meanwhile, SK Telecom, a Korean mobile communication company, is operating a smartphone navigation app service (T-map) that is used by about 13 million people monthly. The app collects and analyzes GPS information such as speed, location, and time of vehicles to provide information such as optimal route search.

The Korean government emphasizes the role of the public sector to reduce the number of fatalities in road traffic accidents. In accordance with merging and utilizing data produced by public sectors and that of private companies, KEC has developed an alternative - Safe CAR - which can promote quicker response to abnormal situations and inform nearby drivers using navigation app to prevent the secondary accident.

IMPLEMENTATION AND SCHEMATIC PRINCIPLES OF SERVICE

The participation of private companies with GPS data was essential for the development of the service but they showed a lukewarm attitude because profitability of the service is not guaranteed. KEC persuaded that it is possible to improve the overall service quality by identifying the abnormal situation detection result which is defined through the GPS data collection and processing algorithm of private companies with CCTVs and manpower of KEC and also to contribute to public safety. By persuasion, KEC was able to induce the participation of private companies, which account for 70% of the domestic smartphone navigation market. In addition, in order to solve information security problems such as hacking threats caused by the inflow of private sector data into the public sector, the development was carried out in cooperation with related departments of government.

Then a private company has developed an algorithm that can detect sudden/hard braking from accidents and/or breakdowns or stops of vehicle on the main road and/or shoulder. KEC has developed software that can automatically switch (pan, tilt, zoom) CCTV after receiving the abnormal situations from an algorithm in real time and also built a dedicated communication network to enhance security. Afterwards, through an app update by a private company, the service was started to the public, starting with expressways in the metropolitan area in Y2020.

Schematic principles of Service (Figure1)

1. Private navigation companies analyze GPS information (such as speed, location, time, etc.) to detect abnormal situations of vehicles.

2. Send type of abnormal situations and GPS information to KEC in real time

3. Automatically switch (pan, tilt, zoom) the roadside CCTV (KEC owned) by using provided information.

4. Staffs of KEC traffic center identify the situation and contact cooperating agencies (Police, Fire brigade, Rescue Etc.) if needed.

5. Feedback the identified information to private navigation companies.

6. Private navigation companies provide the information of incidents to nearby vehicles

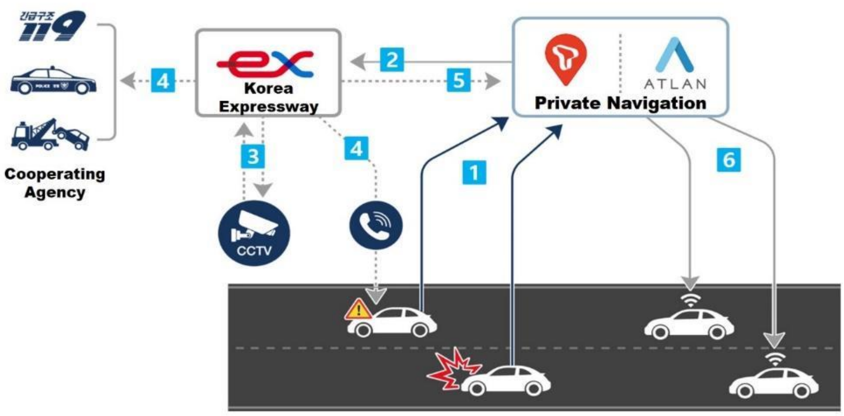

Figure 1. Schematic principles of "Safe-CAR (Cooperative Accident Response)

CONCLUSIONS

According to the internal analysis of the KEC in Y2019, the method for road managers to recognize abnormal situation was reported mainly by road users or CCTV monitoring with processing time of 16minutes and 8seconds. After introduction of safe-CAR, it was analyzed that the processing time was reduced by about 93% to an average of 1 minute and 12 seconds. Also, the recognition method was improved so that the real-time transmission from the private sector could be immediately identified by the road manager through automatic CCTV switching (Figure 2).

<table>
<tr><td>CCTV</td><td>
</td><td>
</td></tr>
<tr><td>Detect time</td><td>Situation 2020. 1. 4. 16:13:53
KEC recognize 16:15:01 (1m8s)</td><td>Situation 2020. 7. 2. 16:34:55
KEC recognize 16:38:01(3m 6s)</td></tr>
</table>

Figure 2. Example of Service

Approximately 220 abnormal situations are detected on a daily average on expressways of metropolitan area. If more private companies which own the navigation apps are able to participate, it will be possible to track and observe 3.3 million vehicles in real-time.

4.1.6. Poland Case study

Status: Ongoing Project

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INFORMATION MANAGEMENT IN GDDKIA

EXECUTIVE SUMMARY

Main goal of this case study is to show and describe Poland's solution for managing traffic information on national roads (highest traffic volumes in state).

Along with rapid development of road infrastructure in Poland traffic has risen, but also a number of accidents grew too. National road administrator needed to come up with the idea to manage this situation more efficiently, especially in terms of quicker and more precise gathering and processing information about any occurrence that impairs ability to travel national roads. A special unit was settled in every regional branch of General Directorate for National Roads and Motorways (GDDKiA) which works 24/7 and its duty is to gather, process and disseminate information on accidents and traffic.

INTRODUCTION

Starting in 1989 Poland become a subject to massive political changes, and the main one was transferring into free market economy which needed a proper road infrastructure to work. Preceding socialist era assumed that very few would own a car, and road infrastructure hadn't been developed, what later left new Poland with roads in very poor condition. Also the country needed new road corridors and connections as well as high speed roads.

A very intense road infrastructure development started right after Poland joined European Union (2004). In about 2010 it became obvious that we have a new kind of problem. There was a lot of new roads, also motorways, polish society owned a lot more individual cars, and a number of traffic accidents and obstructions have grown significantly. Poland also become an important transit country connecting eastern and western parts of Europe, which made it even more important to manage situation on roads more effectively. It was also important that not only road users needed a bigger involvement from GDDKiA but also other authorities involved in road safety like fire dep. and police.

ANALYSIS

The most important problem was that national road administration was receiving an important feedback showed by rising numbers of questions direct and indirect about possibilities of traveling due to e.g. traffic jams or accidents, growing demand from police and fire department to assist their actions was a significant factor also.

There was a problem with reacting and deploying road administrator forces and means quickly, efficiently especially after hours, during a night and weekends. We needed to come up with a solution for quicker response and ability to manage input information about accidents and then supervise the course of actions taken.

ALTERNATIVES

Back in 2010 road infrastructure was already significantly developed, the number of individual means of transport was growing, but it was too early for the country to develop ITS systems that would support reacting to traffic situations. There was a need to find a solution that would do the job and which could be applied at a time.

The solution needed to comply with criteria such as:

- 24/7 accessibility
- Gathering, disseminating and processing information
- Providing quicker response to accidents
- Being open to road users as well as authorities
- Plain and simple in terms of working (not enough ITS systems in the field to automate processes)

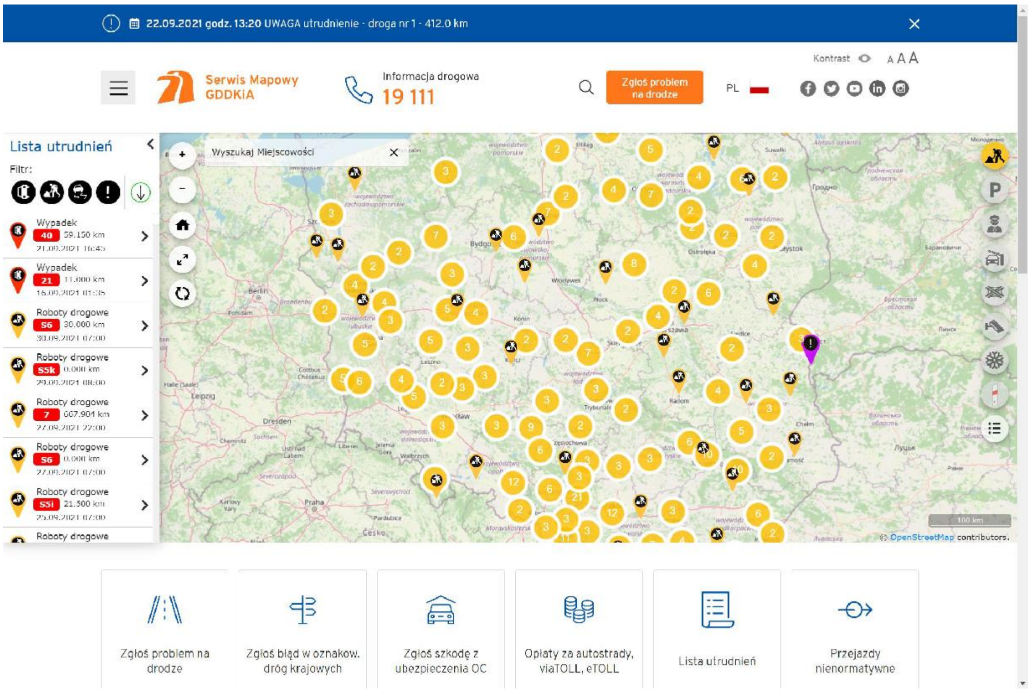

Fig. 1 – ITS System for managing traffic information on national roads in Poland

RECOMMENDATION AND IMPLEMENTATION PLAN

The solution was to settle a special kind of team in organization that's main goal would be to use every source of information to check if there is any problem with transit ability. That team would be in touch with police and fire department in terms of supervising means and measures of road administrator on site of traffic accident, but also inform road users about problems on roads or possible detours as well as informing internal customer and management.

Those teams needed to be settled down in every regional branch of GDDKiA and one in a central bureau that makes 17 of them. Those teams would work 24/7 so each of them needed at least 5 employees to cover 12 hour shifts. We called them PID (in polish Punkt Informacji Drogowej) - Road Information Point, which means Road Information Point.

Main task of PID is to gather, process and disseminate information. Very important reason of their operation is to prevent any inquiry from public to be unattended, even if it's in the middle of the night. It's also an important tool for management to be able to oversee the situation on the roads in any given situation (e.g. PID reports anything that is required like major accidents or other situations that impairs traffic).

A challenge was to design policies concerning working of PID's, place them in corporate architecture so they can do their job correctly and then work on standardization of those teams across all of the regional branches.

CONCLUSION

At present day it is a standard that the administrator of national roads attend every problem affecting its infrastructure 24 hour day and night. PID's work become very important especially as a management tool that supervise if road maintenance forces are correctly fulfilling their duties (means and measures). Demands grew bigger in years and now it's being expected from PID to not only oversee the situation, gather and process information, but also manage various situations on roads actively. It’s even more noticeable during winter due to the fact, that winter maintenance is very important here in Poland (especially concerning serious snowfalls and a demand to keep international connections available even in winter), but also during summer when lots of people travel for vacation and traffic characteristic vary significantly.

The outcome of introducing those teams is apparent and entirely positive. National roads administration become an important partner for other authorities that play important role in fighting dangers on roads, every situation on roads is being monitored and information about it is provided for road users (what enables choosing detour). Also a public image of GDDKiA is stronger as we keep contact with various external clients throughout a whole day.

Fig. 2– Cameras for traffic information on national roads in Poland

4.1.7. Chile Case study

Status: National regulation

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ROADS EMERGENCY INFORMATION MANAGEMENT IN CHILEAN ROAD ADMINISTRATION

EXECUTIVE SUMMARY

Chilean territory is always affected by natural disasters, due to country location on the rings of fire that causes volcano activity, earthquakes and a geography that generate alluviums during summer time, as well as other types of natural disasters (wild forest fire, floods, snow avalanches, tsunamis, etc.). These natural disasters causes several damages to road infrastructures therefore is important to collect relevant information of effects on the road network.

SIEMOP (MINISTRY OF PUBLIC WORKS EMERGENCY INFORMATION SYSTEM)

Since 2015 the Chilean Road Administration has collected relevant information about damages and effects on the road network through a computational Close Source System (world class EAM – Enterprise Asset Management) aimed to manage Road Maintenance Information, and as addendum SIEMOP was implemented on the same platform as a dedicated module for emergencies.

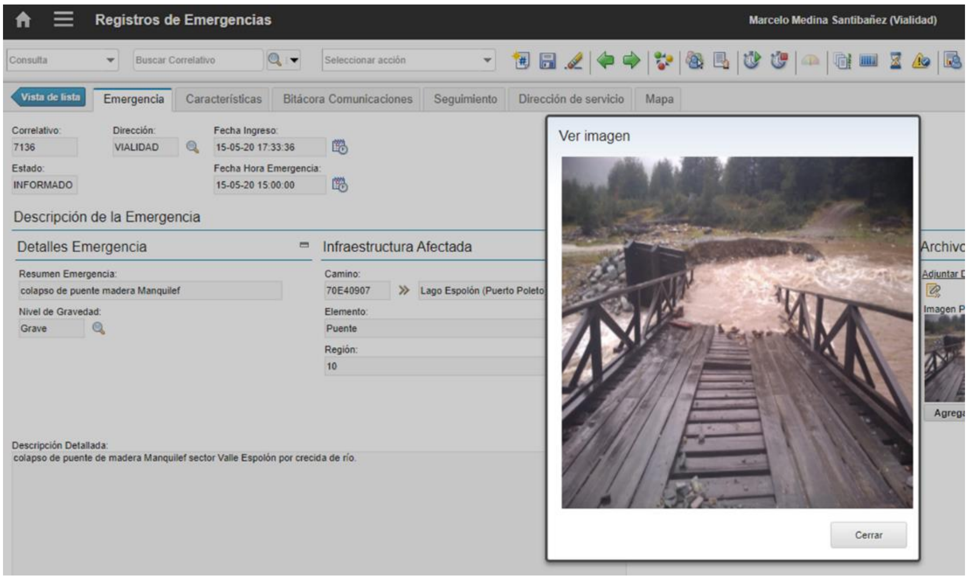

Fig. 1 – Emergency Record on SIEMOP

Closed Source of information allowed us to generate automatically Emergency Maps, with the Emergency Records information, that it is published on internet for road users.

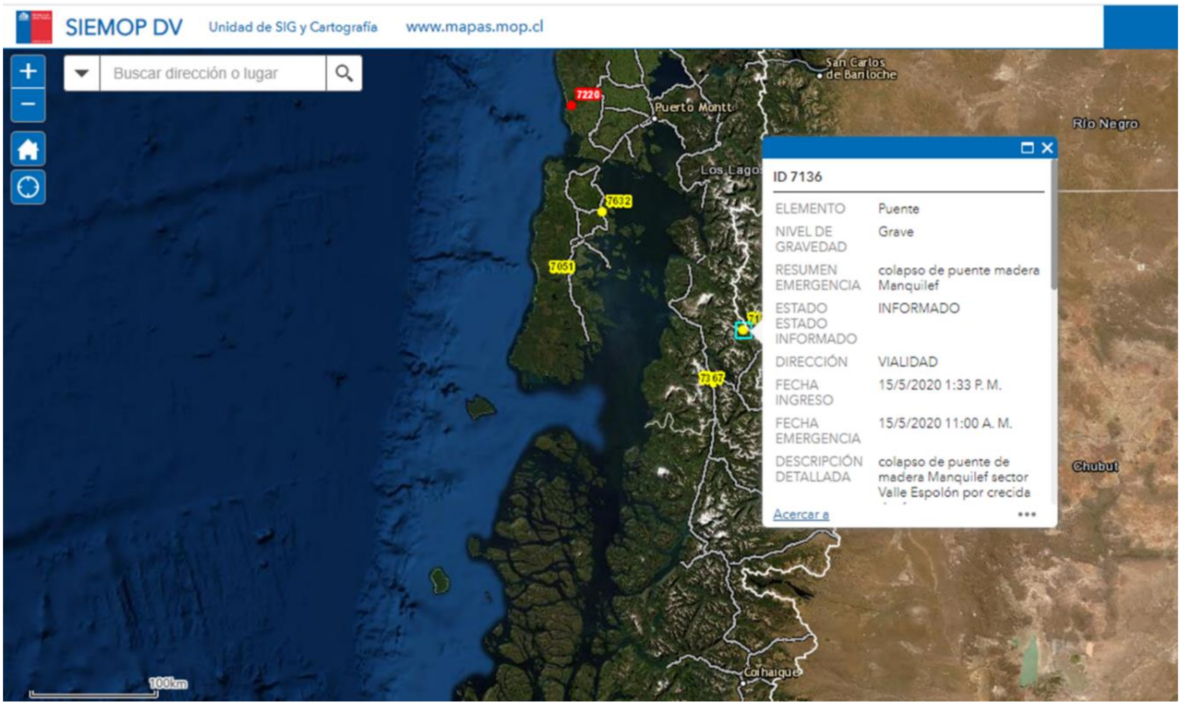

Fig. 2 – Road Administration Emergency Map

Closed Source of information has several benefits, but it is limited due to only Road Administration Agents are allowed to record information.

WHAT'S NEW

Chilean Road Administration is getting a step forward to generate an Opened Source of Information for users, in order to improve service of road network, adding citizen collaboration in the detection of road emergencies and merge it with the Closed Source. This project contains a visual interphase for administrators and a simple mobile application to collect information on site, with the goal of provide a simple channel for reporting problems in the road network, provide background information for incidents management and integrate information in the current systems without generating a parallel system.

BENEFITS TO THE ROAD AGENCY AND ROAD USERS

The information coming from an Opened Source will be collaborative from the community and does not require an injective response. In the other hand, the APP will show the emergencies declared in the SIEMOP, so Emergency Record status must be updated permanently, so it could be related to the information on the Closed Source.

However, Management for Opened Source is different from Closed Source, and it is important to understand the detail on every record will be different from selected source.

As a summary, more relevant information will give the proper support to SIEMOP and will be useful for designers.

CONCLUSIONS AND RECOMMENDATIONS

1. Information during emergency situations is an expensive commodity

2. There is no excuses to collect and manage emergency information, due to road authorities are always asking for relevant and updated information.

3. To implement an emergency system, road network should be very well identified and GPS mapped, and also need detailed information of road components (Road surface and geometry, signaling, existing culvers, drainages, etc.)

4. The huge amount of road network information should be managed by a computational system.

5. Agents training programs are absolutely necessary for Closed Sources and how merge information with Opened Source.

6. Permanent review of the Emergency records will be always necessary, in order to keep updated information available for rad users.

4.1.8. Czech Republic Case study

Status: Ongoing Project

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UNIFIED TRAFFIC INFORMATION SYSTEM (JSDI)

EXECUTIVE SUMMARY

Czech Republic is covered with relatively dense network of roads with suitable density. Roads and highways has about 55.5 thousand km. Roads are divided into motorways, roads, local and special communications. Highways and some main roads carry the largest the share of transport and connect the most important centers. Priorities to handle crisis situations in transport are maintaining the ride ability of transport infrastructure and providing functionality of critical artificial structures, of which the most important are the bridges. The Unified traffic information system (JSDI) service is continuously monitored and broadcasting is optimized from a technical and technological point of view as part of continuous control and research activities.

INTRODUCTION

The Road and Motorway Directorate is administers Road and Motorway Information System of the Czech Republic that includes data collecting, data processing and output data generation for user. The system provides complex environment for traffic data acquisition, processing, sharing, publishing, and distribution. The data include traffic information, current traffic situation news, and traffic events that affect road traffic safety and smooth flow. Data distribution interface is used to bring the vital information to different public service institutions, media, telecommunication operators, traffic news services, transport companies and others.

System secures information concerning restrictive phenomena or events for all users of the network of roads from the ordinary motoring public, shippers and carriers, agencies, organizations and institutions of public administration, the entities crisis management and defense planning, media, operators of traffic information services, telecom operators, legal experts, doctors, etc. Traffic information are spread by radio and TV broadcasting, broadcast RDS-TMC traffic information service telecom operators, internet, data distribution through the data distribution interface, etc.

ANALYSIS

The main objective of the information support processes for ensure continuous, uninterrupted collection of traffic information and traffic data on the current traffic situation, i.e. all phenomena and events that partially or completely limit the flow of practicability or network of roads, directly or indirectly can affect the safety or traffic flow. So, it ensure mutual coordination of procedures and processes for immediate solutions and removing restrictive consequences of phenomena or events (solution of traffic accidents at the event, continually updated information about the event as appropriate to correct the problem and restore operations, monitoring the progress of repairs and maintenance, etc.).

Base on analysis results has created several conditions that extract the data attributes from "agenda" systems of the organizations. Then, the data is automatically sent to National Traffic Information and Control Center (NDIC).

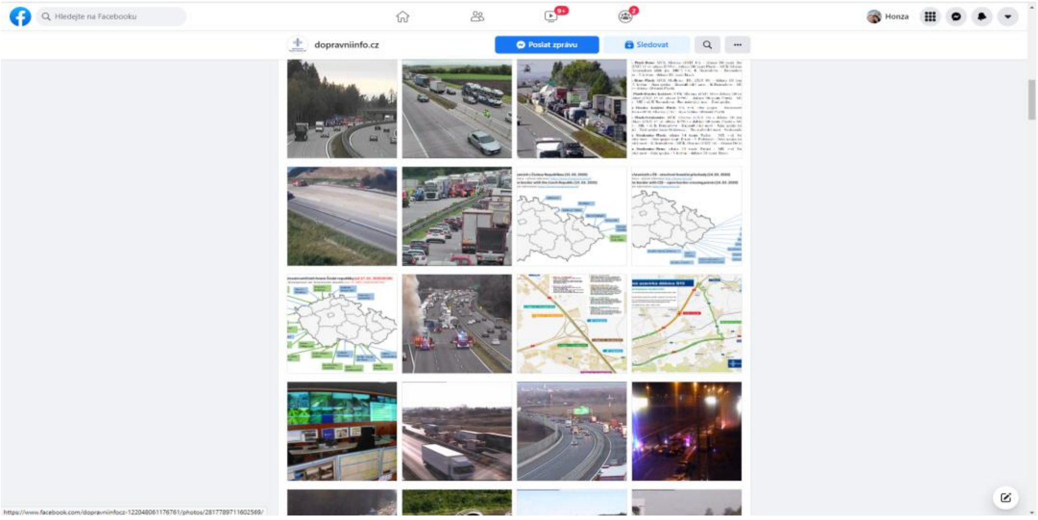
Picture 1: National Traffic Information Center (NDIC) of the Czech Republic

Data collection is handled through standard web services of the data distribution interface. The data may be collected by any legal or natural person who ensures their further effective dissemination in favor of increasing the safety and smoothness of road traffic or who uses them in its information systems to support its own processes and activities related to transport and road traffic.

ALTERNATIVES

Team of operators works on 24/7 basis. The center receives traffic information and traffic data, evaluates traffic situation, and verifies generated traffic information. The center collects information about traffic accidents, closures, vehicle fires, convoys and weather etc. Information and data are provided in particular by Police, Fire brigade, Communications managers of all categories, Road administration authorities of all levels, Municipal and city police, Meteorological Institute, Czech radio, Call Center Assistance Services, E-call, vehicle detection in the opposite direction and Floating car data system.

The voluntary traffic reporter provides the driver with information about problematic road traffic events that he encounters on his journeys. It is a voluntary free activity. In short time to come, the center will be able to control the traffic using powerful telematics systems.



Picture 2: The traffic portal (www.dopravniinfo.cz) on the Facebook

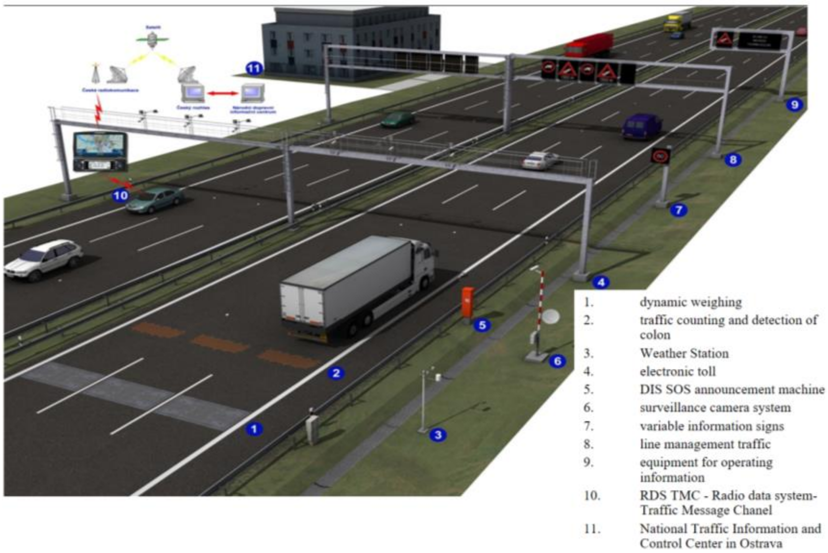
RECOMMENDATION AND IMPLEMENTATION PLAN

Telematics applications (Intelligent Transport Systems - ITS) are modern information and communication technology, which directly on terrestrial communication monitor and validate specific characteristics of operation. Telematics systems allow in the field of communication to continuously monitor and evaluate the characteristics of the traffic flow (traffic density, traffic, average velocity of vehicles, vehicle spacing, etc.), meteorological information (air temperature, road surface temperature, precipitation, visibility, freezing point, etc.), kind of vehicles, their weight, the passage of stolen cars, etc. The output is then verified, geographically localized traffic information provided to the public. Processed traffic information/data is sent using automatic/semiautomatic scenarios to variable message signs on the roads. Traffic information and traffic data will be available within all primary source information systems, as well.

The use of these mechanisms could help in solving the problem of dual use of the designated road network, especially the TEN-T, when dealing with crisis situations where multiple threats accumulate (pandemics, migration, hybrid threats) while simultaneously providing support to the armed forces, which would increase the resilience and robustness of transport systems.

CONCLUSION

Telematics systems allow in the field of communication to continuously monitor and evaluate the characteristics of the traffic flow, meteorological information etc. The information and data are processed in the National transport Information Center (NDIC). Through other telematics information is published for drivers or the operation of their direct control on e-windscreen or dashboard of the vehicle. RDS-TMC is operated in most countries in Europe, some countries are covered by transmitting only part of its territory. In some other European countries prepare for the service launch. Among the most used controllers on the market, there are basically two types of devices: permanently integrated in the vehicle, which is usually already part of the standard equipment of the vehicle when it is purchased, portable, which is mounted in a special holder on the ITS. ITS informs about the current traffic situation or traffic in order to immediately control the communication according to the established rules, which can be even more effective, for example, when connecting to emergency services of the Galileo system.



Picture 3: Scheme of telematics applications

4.1.9. Czech Republic Case study

Status: Ongoing Project

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USE OF THE GALILEO SYSTEM IN THE TRANSPORT SECTOR

EXECUTIVE SUMMARY

Galileo is a European autonomous global positioning satellite system (GNSS) civilian project, that there is no risk of service failure even in exacerbated international situations. Galileo will find the greatest application mainly in transport but also, for example, in the field of security. The list of applications is probably not exhaustive because the public sector is largely responsible for the development of transport infrastructure and traffic management on transport routes. From the point of view of Europe, attention is focused on the transport network of European importance, the so-called trans-European transport network TEN-T. This includes not only transport infrastructure as such, but also traffic management systems and location and navigation systems. The main benefit of the deployment of intelligent systems and services in terms of societal benefits is an increase in the safety of transport and traffic, by warning of a dangerous situation or preventing its occurrence.

INTRODUCTION

Galileo funded by the European Union through the European Space Agency (ESA) provides an accurate and independent navigation system so that the states of the European Union are not dependent on the American GPS system or the Russian GLONASS. Galileo has greater accuracy than GPS (less than one meter). The main benefit of the GALILEO system is, in particular, the provision of sufficiently high-quality services for applications supporting the organization and management of vehicle movement.

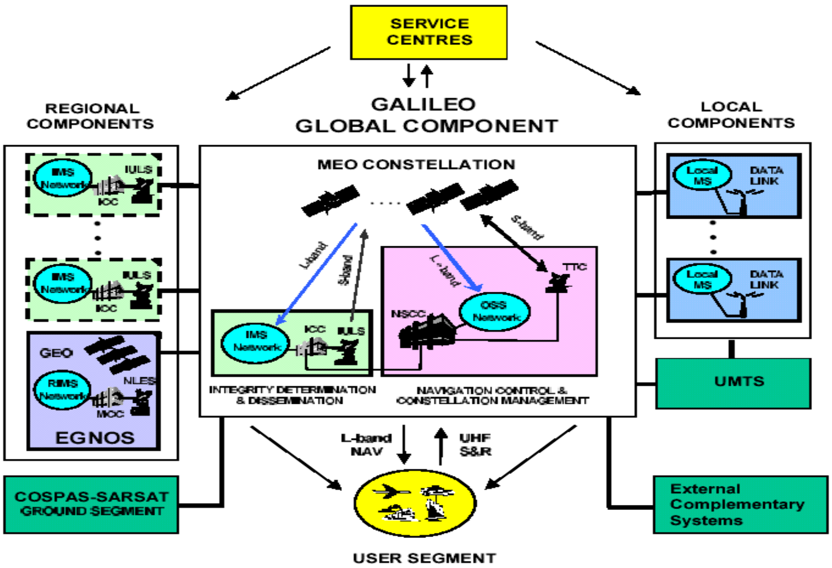

Fig.1: Architecture of the Galileo system

For this reason, the structure (architecture) and the chosen strategy for the development of these applications are becoming more important (in transport, these are mainly the so-called intelligent transport systems and services - ITS).

ANALYSIS

Some of applications are currently offered by the GPS system, but its accuracy and reliability are in many cases insufficient. Galileo should find 80% use, especially in transport, of applications that rely on location information. The basic problem is the use of this location information in related applications. In road transport, systems similar to systems such as rail and air transport are beginning to appear, such as anti-collision systems, automatic vehicle guidance, recognition of the traffic situation in front of the vehicle, etc., in which real position information plays a dominant role.

For example, it will assist police, firefighters and rescuers in search and rescue operations, as in the case of developing "e-Call" system, which automatically detects a serious accident using a device in the vehicle and sends a coded message to the nearest Emergency Call Center. A car equipped with an automatic accident reporting device may send information that a vehicle has crashed and that the vehicle is carrying a particularly dangerous item. The advantage of this system is timely information about a serious event, even if the vehicle crew is unconscious or immobilized. Another advantage of the system is language independence, which removes the communication barrier between the accident declarant and the rescuer in the event of accidents to foreigners.

ALTERNATIVES

The list of applications is probably not exhaustive because the public sector is largely responsible for the development of transport infrastructure and traffic management on transport routes. GALILEO will be able to support External Complementary Systems (i.e.: GPS, GLONASS, LORAN-C, etc.) for the provision of combined services (interoperability). The GALILEO system will be connected to users and providers of additional services through service centers. These centers will provide the following functions in the relevant categories of differential positioning, precision time services and navigation services: Warranties and information on operation and data archiving; management of user accounts and access keys; insurance, guarantees in the legal field of operation; certification and licensing management; interface for commercial services; support for application development and research and development work; for the relevant services, the centers can also function to collect fees from users.

RECOMMENDATION AND IMPLEMENTATION PLAN

In particular, the public sector will support the following satellite-based applications in the field of transport: preference for public transport vehicles and rescue system vehicles when passing through a complicated traffic situation; monitoring the transport of special consignments: particularly dangerous goods, live animals, oversized consignments; supervision of transported valuable consignments as a prevention against their theft; automatic determination of the location of a serious accident and notification of this incident to the rescue services.

Although the transport infrastructure in the Czech Republic has not been completely modernized and some of its sections have yet to be completed, telematics applications are gradually being introduced (i.e.: main control panels in large cities, traffic intensity monitoring applications, weather monitoring, telematics applications to increase tunnel safety) etc.).

CONCLUSION

GNSS providers face the challenge of satisfying emerging needs, without compromising existing services. With satellite lifetimes well in excess of 10 years, the task would be almost impossible, if the original design had not ‘planned for the unpredictable. For Galileo 1st Generation, this translates into substantial reinforcements of the system’s built-in redundancies and resilience and into the introduction of new services and capabilities.

The continued diverging needs of hundreds of applications drive the customization of GNSS receivers with wide-ranging complexities, capabilities, and resource requirements. The expectations of users in different applications are often contradictory, but they do share some commonalities: the need for continuous and dependable PNT services, and the quest for ever better performance at large, e.g. in terms of accuracy, cost, or autonomy. The emerging application areas considered include the world of ‘autonomous things’ (drones, robots and cars):

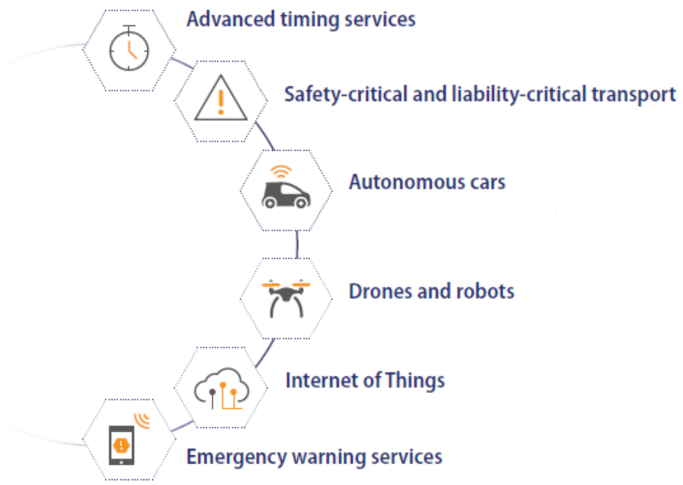

Fig. 2: Emerging applications needs are driving the evolutions of GNSS

The design of Galileo 2nd Generation is driven by overarching principles, including backward compatibility and the quality of services, but also the absolute need to meet user demands in a timely and effective manner.

With failsafe wireless connections, faster data speeds and extensive data capacity, 5G can provide the connectivity backbone required to enable cooperative positioning as well as the safe operation of driverless cars, UAVs, mobile robots and, more generally, the world of Autonomous Things. Contrary to existing radio networks where positioning has only been an add-on feature, for 5G mobile radio networks the positioning is seen as an integral part of the system design and will play a key role, enabling a huge amount of different location-based services and applications.

REFERENCES

- GNSS User Technology Report (ISSUE 3/2020)

4.1.10. Spanish Case study

Status: Currently ongoing

Author: General Sub directorate of Mobility and Technology Management (SGGMT)

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Dynamic management of information on the effects of volcanic eruptions on road traffic on the island of La Palma (Spain)

EXECUTIVE SUMMARY

The eruption of the Cumbre Vieja volcano on the Spanish Island of La Palma started on September 19th, 2021, throwing jets of lava and ash into the air. Lava from the volcano has destroyed several hundred homes and industrial buildings, and scorched hectares of farmland in the largely agricultural area. Officials evacuated more than 7,000 residents and tourists to prevent loss of life. An area of more than 8,200 hectares between the Cumbre Vieja volcano and the Atlantic Ocean has been declared off limits. Real-time information on affected roads and blocked access is essential to assist both emergency services and the users and scientists working in the area.

INTRODUCTION

The National Access Point (NAP) for traffic information is an essential web application that is created under the European mandate and collects the information provided by the traffic management entities of the national territory. The information provided, is that contained in the European Commission's delegated regulation 886/2013 which complements Directive 2010/40/EU, establishing the framework for the deployment of Intelligent Transport Systems in the road transport sector and for interfaces with other transport modes (ITS Directive), with regard to data and procedures to provide, where possible, minimum universal traffic information in relation to road safety.

The **General Traffic Directorate (DGT)**, as a governmental organization of the traffic management in Spain, has implemented exceptional measures for those affected by the eruption of the La Palma volcano, among others, within the set of information it provides to the NAP, it has included real-time information on road closed and the progress of the lava flow.

ANALYSIS

During the course of the volcanic eruption, up to 7 different roads with a length of almost 40 kilometers were affected.

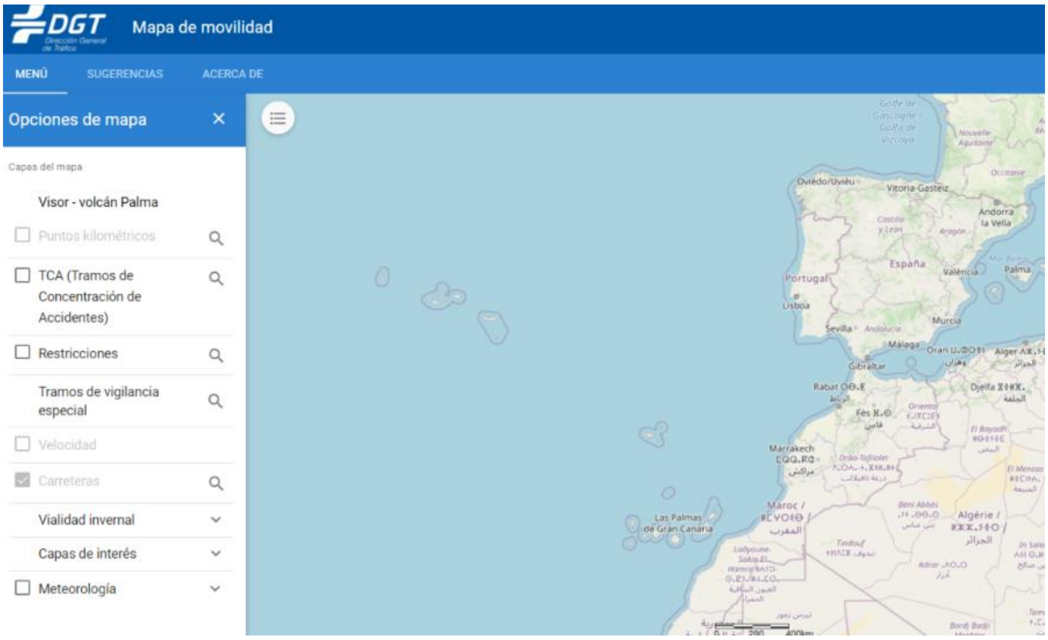

Figure 1: Access to the NAP web viewer

Copernicus is the European Union's Earth observation program that offers information services that draw from satellite Earth Observation and in-situ (non-space) data. Vast amounts of global data from satellites and ground-based, airborne, and seaborne measurement systems provide information to help service providers, public authorities, and other international organizations improve European citizens quality of life and beyond. The information services provided are free and openly accessible to users.

Figure 2. Radar image of lava flow provided by Copernicus (Emergency Management Service)

ALTERNATIVES

The inclusion of the information on the NAP website, developed by the DGT, is carried out through the integration of BIGDATA and OPENDATA technology of the data provided by the Copernicus satellite.

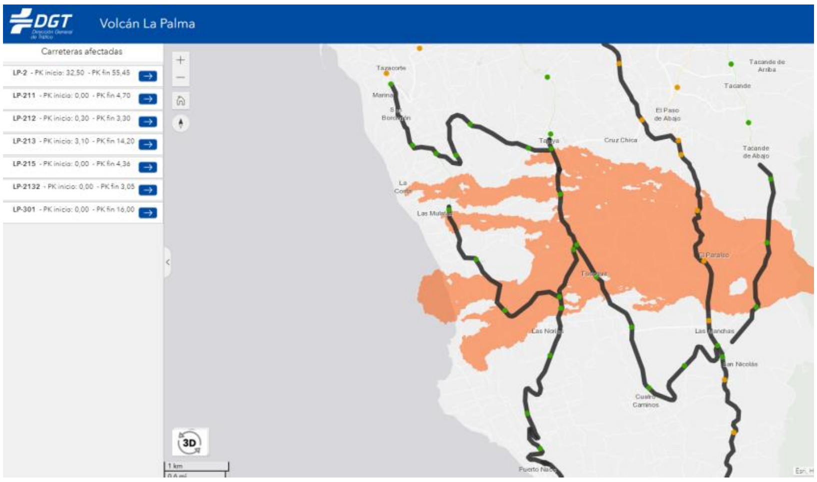

Figure 3: Affected areas and roads

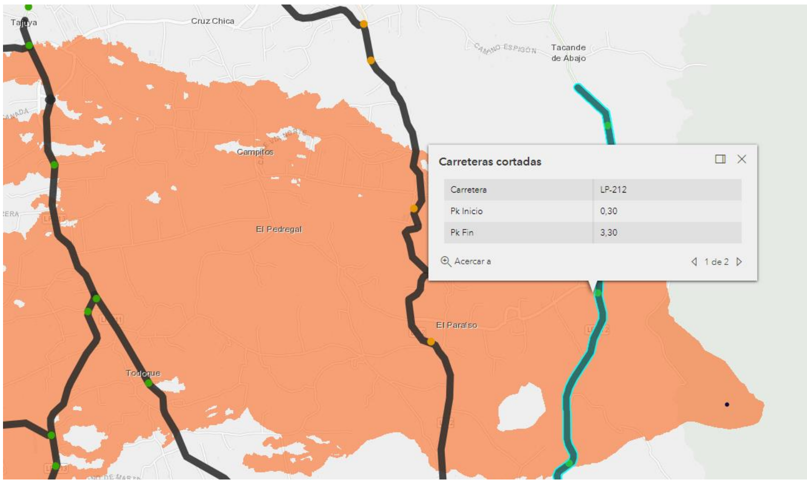

Figure 4: Information provided by the web viewer

CONCLUSION

In conclusion, the availability of a National Access Point (NAP) and its implementation is Spain (https://nap.dgt.es/), associated with rapid IT development, made it possible to activate a layer where the different emergency services, road maintainers, public administrations and users could access the evolution of the effect that the volcanic eruption was having on road traffic and roads closed to traffic, making it possible to establish access/evacuation strategies and improve land communications in a single, open and free tool.

REFERENCE

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2) https://nap.dgt.es/organization/dgt
3) DGT: http://mapamovilidad.dgt.es/home.htm
4) DGT: https://experience.arcgis.com/experience/b4af1c4450f4409b98cc7c5a50d4fd4e
5) https://emergency.copernicus.eu/

4.1.11. New Zealand Case study

Status: Ongoing Project

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Contact: neil.fisher@nzta.govt.nz

Rapid Structural Assessment of a Pavement Network Following a Major Flooding Event.

EXECUTIVE SUMMARY

The Multi Speed Deflectometer is new technology offering a solution to improve road network resilience and manage the minimization of road deterioration in the aftermath of flooding disasters. Existing survey methods are slow, expensive and/or are not feasible in wet weather, and rapid mobilization is often not possible due to the size of the equipment and availability.

INTRODUCTION

Currently post-flooding surveys are carried out with Falling Weight Deflectometer, Deflectograph or Benkelman Beam. The devices are slow to survey and coverage of a sizeable network is costly. Relatively dense testing is necessary to provide sufficient confidence in the extents of road sections designated for loading restrictions or diversions.

The Traffic Speed Deflectometer (TSD) solves the speed of testing identified in the devices above, however availability can be limited and it is less suitable for urban use. Furthermore it cannot be used on a wet road, hence there is a gap for a more versatile system. The MSD has been validated against the TSD and FWD, and reality checks have been carried out on terminal sites by consultants and roads authorities. Because a dedicated vehicle is not required, the Multi Speed Deflectometer can be rapidly mobilized at remote locations by equipping a locally sourced heavy vehicle to survey most pavements; sealed or unsealed, urban, rural, arterial, primary, secondary, residential etc., and in almost any weather condition at traffic speeds.

DATA COLLECTION AND ANALYSIS

Flood Disaster Process

1. Major flood identified with widespread impact forecasted for road network. Scale to trigger MSD response to be defined. MSD Kit is dispatched via air courier.

2. Local heavy vehicle most appropriate for the roads concerned is located or adapted to the MSD specification along with a driver.

3. Local or overseas operator commissioned to install (2 hours) and undertake MSD testing at traffic speed as roads become unsubmerged. Maintain road closures and diversions for heavy vehicles.

4. Data collected from MSD survey are uploaded at the end of each day of testing.

5. Data are downloaded and processed within hours and uploaded as csv files or to GIS web platform PaveState specifically designed to present the MSD and pavement structural data, on desktop screen or mobile phone.

6. Database is enabled for the road controlling authority to review in deciding which roads to open fully, apply specified load restrictions or remain closed with alternative route planned.

7. Repeat methodology on any newly un-submerged roads. Repeat testing on those roads with ongoing load restrictions and closures, until safe limits are reached.

Further details on the analysis and a specific case history example are contained in the Appendix.

ALTERNATIVES

At present there is no practical alternative for the rapid structural evaluation of road networks after severe flooding. Visual evaluation is ad-hoc and subjective, typically politically driven and based on limited information, requiring substantial experience and judgement. Decisions to close one road and not another, are very difficult to make as simply knowing that parts of the road may be wet and weakened needs to be backed up with substantive evidence.

5. Recommendation and Implementation plan

Where flooding potential is present, effective implementation, requires relatively minimal preparation, consisting of identifying a list of potentially available heavy vehicles for subsequent recruitment in the event of future MSD activity. In high-risk areas, road agencies could also stock a number of the MSD Kits in strategic locations, allowing for more rapid mobilization. Other funding organizations including the World Bank have been briefed on the use MSD equipment for surveying road networks for its general application to network management as well as to establish roadway resilience to flood damage. In each event or between events the agencies would need to develop a logical and practical method to enforce the restriction on proposed axle loadings.

6. Conclusion

The Multi Speed Deflectometer is a low-cost innovative tool that collects structural information for every meter of each lane at traffic speed. Because it can be readily fitted to a wide range of commonly available heavy vehicles, it can readily be mobilized to remote locations with poor access. MSD hence has all the prerequisites for supporting recovery from disasters such as flooding. It provides:

- Rapid identification of weak and hence moisture susceptible intervals of each road.
- An opportunity to significantly reduce damage and rehabilitation costs to the remaining road infrastructure by identifying when individual axle load restrictions are essential and when they may be lifted.
- A means to define the extents and the severity of softening caused by a flooding /weather event, so funding, necessary personnel, materials and equipment resources can be mobilized appropriately.
- An efficient means of providing both managers and pavement practitioners with comprehensive insight to the current structural performance and consequently the current limitations of their network.

7. REFERENCES

Masuda Sultana, Gary Chai, Tim Martin and Sanaul Chowdhury. 2015 *A Study on the Flood Affected Flexible Pavements in Australia.* 2015. ICPT.

Queensland Government. *Understanding floods: questions and answers.* [Online]

Appendix: Further Details & Case History

EXECUTIVE SUMMARY

A major flood event in Brisbane from December 2010 to January 2011 caused an estimated 5-6 billion AUD of additional pavement maintenance works. Research by Griffiths University and the Australian Road Research Board using the Falling Weight Deflectometer to assess the structural capacity of the flood affected pavements concluded that pavements structurally deteriorate more quickly than their normal baseline deterioration rate. Reductions in the subgrade CBR value up to 67% and structural number (SNP) by as much as 50% were recorded (Masuda et al, 2015). In the case of thin surfaced unbound pavements, shallow shear of the base or subbase layers where saturation exceeds 70% is the principal cause of cracking, pumping and potholing

INTRODUCTION

Roads are one of the most valuable assets damaged during a devastating flood. There is a need to be able to rapidly test and assess a pavement network as soon as possible following a major flooding event to identify which pavements have been weakened due to moisture susceptibility. At these locations heavy vehicle loading can be reduced, or traffic diverted, minimizing the amount of long-term structural damage. By determining and implementing appropriate temporary loading restrictions for various axle configurations and /or reducing tire pressures, damage to susceptible pavements can be limited until a retest demonstrates they have regained structural capacity and potentially save millions of dollars on short as well as longer term pavement maintenance costs.

ANALYSIS

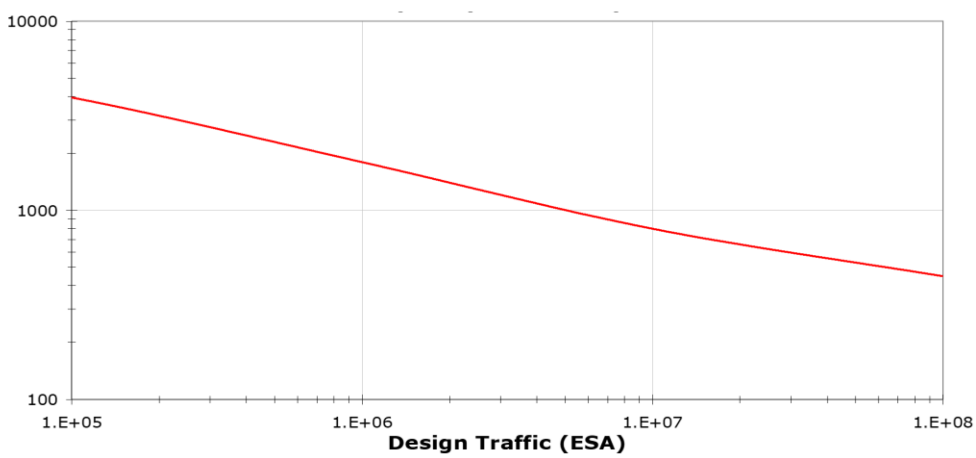
Output and Road Re-opening Criteria

MSD data output comes in various forms with detail according to application. Basic output is generated simply by correlation to the widely recognized FWD parameters, i.e., central deflection and curvature, standardized to 40kN load by default (50kN if required). Curvature for thick structural surfacing is commonly required as Surface Curvature Index, although where thin surfacing predominate, Curvature Function may be preferred i.e. for use with Austroads Design Guide. The standard for MSD hence remains locked to the principal parameters generated by the traditional "gold standard" being FWD, so that all implementation can be straightforward. However TSD, Deflectograph or Benkelman Beam can be used if FWD calibration is not possible at the time or is programmed for a later date. Typically, much less than 1% of the MSD tested km is required for calibration, but this can always be increased at a later date if desired for further assurance or project level design. Basic images of all pavements are also provided from forward facing lenses in the survey vehicle as well as automatic links to historic images using Google Streetview. Interpreted parameters for those that utilize empirical methods, commonly include the structural number (SNP). All information on each network is made accessible to the parties concerned on the complimentary PaveState Web GIS software and PaveState Mobile.

ALTERNATIVES

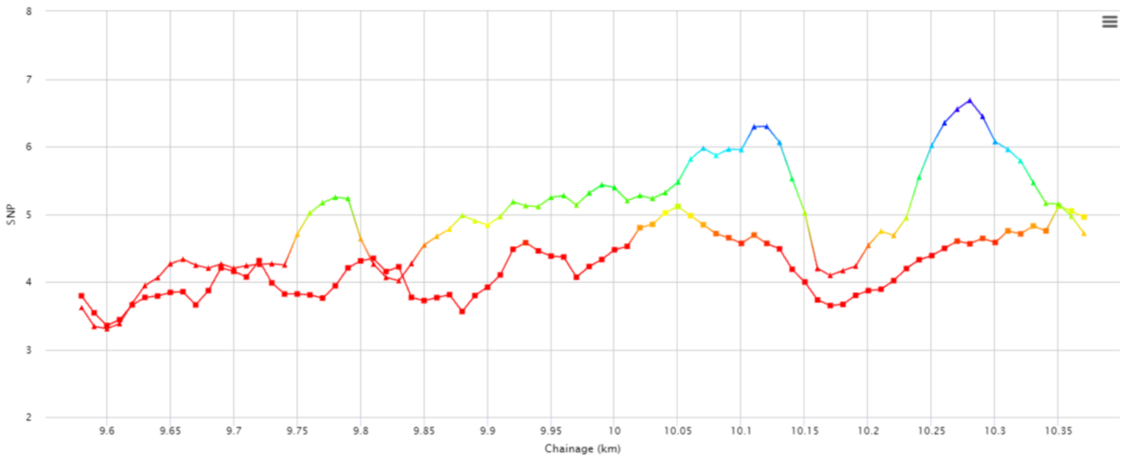
As soon as the data are collected, whatever parameter is used commonly for the region concerned can soon be established in graphical or tabular form, to set limits for allowable fatigue which can soon be calibrated to individual wheel load (single vs dual etc.). These use the familiar format of allowable fatigue versus design traffic in terms of 8 tons axles as below.

Allowable fatigue criterion



The MSD analysis takes a similar approach, preferably using local precedence to establish what is effective for design in the tested region, then develops a simple table of allowable wheel load versus the required number of repetitions per day that will be permitted during the expected period of high saturation. The hierarchy allows the road controlling authority to then set the most appropriate limits for each road tested, until effective drainage is restored as confirmed by re-test.

Where testing is carried out routinely, a baseline survey will exist and if the same road is tested in the same manner after an abnormally season or flooding event, comparison can readily demonstrate the relative state of the road. One such case history (using structural number, SNP from the respective MSD runs is shown below showing a shift between the normal and very wet years of the same interval of road.



Network Resilience - Recommended Data Collection and Analysis Process:

As well as limiting pavement deterioration after a specific flood event, MSD surveys have the more common role of determining which parts of the network would provide the greatest cost benefit from rehabilitation. For improvements to network resilience, the methodology is similar apart from the timing and scope of the testing which should be planned for when seasonal conditions are relatively adverse. Results enable identification of which important freight routes would suffer most in the event of further saturation and delineate the extents of each which require mitigation from construction of new pavements that are less moisture sensitive, as well as improvements such as flood banks, surface drainage.

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4.2. CASE STUDY ANALYSIS

Next, the analysis of the case studies collected through the international survey on the use of big data and social networks for Disaster Management is delivered. In this regard, the case studies are analyzed individually, but in groups for similar topics.

TECHNOLOGY OF INFORMATION

The following case studies refer to information technologies applied to road management during emergencies and disasters. The incorporation of software capable of detecting specific conditions on a road demonstrates the potential of these tools.

1. - Presumption of road conditions using connected cars with IoT and Big Data

This case study demonstrates that there is capability and a desire to utilize live time travel information to deliver timely road information. Utilizing a system proven during the extreme weather event of July 2020 the system enabled emergency services and roads users to make intelligence-based travel choices and route selection. There is opportunities for other jurisdictions to utilize this system but it does come with a cost in terms of both infrastructure investment, car manufacture agreement and support and investments in technology. A proposed addition to this system sees an opportunity to enhance proposed detour capability which could benefit all road users.

2. - Stuck vehicle detection system using AI image analysis

This case study has real world value and is proven in real world conditions. Utilizing existing CCTV capability an analytical overlay informs and alarm based system to identify ‘stuck´ vehicles.

This system has opportunities to be utilized in other jurisdictions with CCTV cameras in operation, with the appropriate and possibly dynamic settings. The system could be expanded for wider incidents detection. This system has the opportunity to solve the problem of remote incident identification, operations and transport center operator fatigue as the heavy lifting of the system streamlines effort. This life saving tool enables rapid response to emergency situations.

7. - Safe CAR (Cooperative Accidents Response)

This case study has a real world application and directly addresses an issue of timely incident recognition and response seen in many jurisdictions. Utilizing relationships and agreements with key stakeholders to obtain information and then assessing this information is working well in Korea. The case study identifies some challenges with stakeholders and an ambitious desire to increase stakeholders could see a dramatic increase in the number of participants sending information for analysis.

3. - Road traffic performance data system in Japan

This case study brings an opportunity to establish timely and accurate weather data to aid road users and emergency services. Essentially converting every IoT vehicle to become a mobile weather station, providing up to date information will enable road users to make good travel choices. This may be difficult to implement in some jurisdictions as it relies heavily in modern vehicles with relevant sensors being passed to the AI system. Through blending technology this system has great opportunities to feed in to other systems like detour route maps, road closure maps and other safety systems.

DATA COLLECTION

Data collection is a key stage to implement any type of system that allows disaster information management. The quality and relevance of the data must be constantly searched to generate results that can be useful for the authorities and users. Therefore, knowing various techniques for the data collection stage is a relevant issue for highway administrations.

4. - The system of providing current traffic data from the entire territory of the Czech Republic

This case study demonstrates the benefits of layers of information being collected, analyzed and presented to road users. Using both pre and post-production collection devices, this system enables information to be collected despite the vehicle age, type or design. A timely dissemination of road user's information will enable good travel choices and important information during emergency and disaster situations.

9. - Open Source for road emergency information

This case study demonstrates an ambitious future for Chilean Road users. The blending of open & closed sources of information will enable road users to make better travel choices. Overlaid with both Emergency Management and Assets Management information this tool becomes a powerful repository of information that disseminated widely could make significant difference in Chile.

5. - GALILEO system

This case study offers significant step change in the opportunities for disaster management, emergency response and overall preventative mitigations of the transport system. Precise location identification and other connectivity would give real time layers of information to wide range of users. The challenge for the system going forward is to develop, enhance and ensure that system such incidents notification, dangerous goods incidents and overall data outputs can be connected in a user friendly interface that can be easily interpreted and understood.

INFORMATION MANAGEMENT

As important as data collection is the management of information, which due to its magnitude and quantity must necessarily be managed through a computer system. The case studies show examples of systems used.

8. - Information management in GDDKiA

This case study is an excellent demonstration of meeting the challenges of modern transport changes and demands. After identifying new road challenges the Road Administrator clearly identified system requirements that would make a wide impact to both customer service and road availability and information and for subsequent emergency responses. The utilization of layers of information from different sources and the dissemination to road users is significant.

10. - Dynamic management of information on the effects of volcanic eruptions on road traffic on the island of La Palma (Spain)

This case study demonstrates the benefits of layers of information being collected, analyzed and shared to road users. This system enables information to activate a layer where the different jurisdictions and users are able to follow the evolution of the volcanic eruption and road network status, making possible to establish access/evacuation strategies and improve communications with an open and free tool. A timely dissemination of road user's information will enable good travel choices and important information during emergency and disaster situations.

DATA ANALYSIS

Analyzing collected data makes sense as it is analyzed, studied and conclusions are drawn. The following case studies reveal a good example of data analysis to generate information for the Preparedness, Mitigation or Recovery stages of a disaster.

11. - Rapid Structural Assessment of a Pavement Network Following a Major Flooding Event

This case study exemplifies how data collection and subsequent analysis can enable better management of assets and overall transport system. The interesting point of view of this case study is the recognition of pavement status after a flooding, in order to establish rehabilitation programs during Recovery phase. Collecting data is a relevant task that improves countermeasures for mitigation or recovery purposes.

6. - Investigation of Highway Frost Disaster in High latitude Frozen Soil Regions in China

This case study exemplifies how data collection and subsequent analysis can enable better management of assets and overall transport system. The exciting factor to this case study is the recognition that the infrastructure, system and tools can and may be adapted to be utilized in broader emergency and disaster management uses. The capture of live time weather data in isolated locations can have a large impact in travel choices, road closure information and emergency response.

4.3. SUMMARY OF CASE STUDIES

According to the general themes, the case studies deal with applied technologies for data collection, generation of "passable" maps, risks and hazards, as well as the improvement of collaborative information, to share it with users.

Regarding the way of disseminating information, most of the analyzed case studies use data centers and websites for that purposes.

On the other hand, the type of data referred to in the case studies tends to solve mainly the traffic situation, followed by the situation of the infrastructure and weather conditions applied to roads, which is consistent with the results obtained in the international survey, where the largest number of respondents indicated that their organizations collect information related to the traffic situation, infrastructure situation, weather conditions and disaster information.

It is important to indicate that 50% of the study cases have the objective of generating collaborative information, that it can be shared and complemented to achieve a better product for users and managers. The other half refers to more efficient ways to collect data from site. The use of GPS and ITS technology for the Czech Republic, Poland Spain and South Korea case studies are interesting, as well as AI image analysis and Big Data for the Japanese examples.

When observing the results of the survey, the search for new technologies that allow a more efficient collection and analysis of information is an important issue, because almost 70% of the responses indicated that the organizations did not have systems or processes for these tasks.

Likewise, and considering that the results of the survey related to the significant challenges encountered by organizations in the use of information from different sources, indicate that the accuracy of the data is the most important factor, it is highly recommended to permanently seek more efficient ways to collection of information.

The examples are mainly related to Response phase of the disaster cycle, however, it should be noted that three of the analyzed case studies refer to the Preparation phase, as is the case of Presumption of road conditions using cars connected by IoT and Big Data, Mitigation phase, related to the Investigation of the road frost disaster in high latitude regions of frost soil in China, and Recovery, FWD flooding, which allows covering the entire emergency cycle.

The foregoing is very consistent with the results of the international survey, referring to whether the organization has achieved any benefit with the use of information technologies during disaster cycle, where 54.8% responded that their benefits have been in the Response phase.

5. RECOMMENDATIONS

5.1. RECOMMENDATION TO THE DECISION MAKERS

- The analysis of this case studies reveals the importance of information as the baseline to support any technology or investigation, in order to improve communication with users and other organizations. Therefore, it is advisable to permanently seek high levels of quality and accuracy in the information collected.
- With quality information it is possible to maintain a resilient road network, to keep the operation of the distribution chains permanently or for as long as possible, in the case of Response phase of a disasters, as well as in the other phases of the emergency cycle.
- The more information is obtained from vehicles or other devices as well as location information, the more helpful it is for disaster management. Disaster managers need to indicate how to use the information for disaster management to promote developing the new technologies.
- In general, government efforts are needed to find ways to cooperate with the private sector to strengthen disaster and information management.
- It is important to go further in the Preparation, Mitigation and Recovery phases of a disaster, due to a good functioning in all phases allows building resilience.

5.2. RECOMMENDATION FOR PIARC

- It is necessary to generate more meeting instances, in order to encourage knowledge exchange towards LMICs countries. The participation of LMICs countries was not enough to generate worldwide conclusions in this technical report.
- Relevant factors in the participation of the LMICs countries is the language, so all efforts must be made to translate all the information into Spanish and French. Notwithstanding the fact that translation is very laborious task and requires exclusive dedication, it cannot be addressed to members of the Technical Committees within the same work cycle. It would be an interesting idea to address product translation to the next cycle activities.
- In addition to the LMICs countries, digital connections are unstable and low-bandwidth, therefore, in addition to language difficulties, there are technological issues. This is a fact that cannot be managed, however, it must be taken into consideration for future planning.
- Seminars, webinars and workshops are an excellent way to disseminate and share information and knowledge, however, it is difficult to organize this activities when the committee has not LMICs countries or their participation is too low. It could be an idea to generate more online webinars and workshops, instead of seminars, with specific topics, and deliver information at least in two languages, if possible.
- Data collection was carried out with MS Forms, which has applications to facilitate information management. It is an excellent way to obtain information, as long as the questions asked have an objective and can be focused on the topics to be analyzed. It was a useful tool to develop our report and briefing note.
- Generation of deliverable documents requires coordination efforts of working groups, and the challenge is to encourage coordination and collaboration among committee members.

6. CONCLUSIONS

Selection of case studies provided within this technical report, identifies some thematic areas:

Firstly, '**knowledge is power, but knowledge shared is powerful**'. A number of jurisdictions are working hard to share information that is useful, easy to understand and getting these activities right is very important for successful results.

Secondly, a number of case studies recognize the importance of getting live weather information. As the effects of climate change are felt, this will be more important than ever as new extremes could be identified in some areas which to date have a limited weather service. A case study recognizing IoT interconnectivity to weather identification could directly contribute to incident reduction.

A third and interesting challenge that the case studies brought up the need for enhanced detour and route selection information. Linked to weather data, incidents data and either layers of information the impacts of adverse events could be manages better enabling emergency responders to attend events quicker and safer and for road users to be kept safe by timely diversions away from danger.

Finally, the case studies highlight the need for blending information. The one source of information can greatly enhance an overall picture of the transport system and in particular events. Some areas are looking at how this information can be brought together and express a desire and vision to do so.

7. GLOSSARY

Term	Definition
Big Data	Big data refers to the large, diverse sets of information that grow at ever-increasing rates. It encompasses the volume of information, the velocity or speed at which it is created and collected, and the variety or scope of the data points being covered.
Social Networks	Social networking is the use of Internet-based social media sites to stay connected with friends, family, colleagues, customers, or clients. Social networking can have a social purpose, a business purpose, or both, through sites like Facebook, Twitter, LinkedIn, WeChat, HI5, WhatsApp, and Instagram.
Opened Source of information	The term "open source" refers specifically to information that is available for public consumption.
Closed Source of information	Refers to information that is not available for general public. It is a software owned by the organization that it is available to a limited group of individuals.
Lifecycle of disaster	Refers to Reduction (Mitigation), Readiness (Preparedness), and Response and Recovery phases.

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