RAIN – Risk Analysis of Infrastructure Networks in Response to Extreme Weather

Project Reference: 608166

FP7-SEC-2013-1 Impact of extreme weather on critical infrastructure

Project Duration: 1 May 2014 – 30 April 2017

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- **The content is not related to general project management**
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D3.3 Scenarios and case studies

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1. Executive Summary

This report presents two case studies having destruction impacts on critical transport infrastructure. More precisely, (i) the summer storms in 2010 and the winter storm 2011 in Finland and (ii) a hypothetical flood on road and rail critical infrastructure in North-West part of Slovakia are deeply presented and analysed.

The first part of this document, which is devoted to the Finnish case study, examines the civil security mechanism and lessons derived from the two major storms in Finland. Common factor in the two storms was their disastrous effect on national land transport infrastructures. The report emphasizes the assessment of the effectiveness of various national response measures.

The research draws attention to the fact that the Baltic Sea Region is one of the most trafficked areas in Europe. Both the freight traffic as well as the passenger traffic is in constant increase. One of the most intense traffic takes place in the Gulf of Finland, in between the shores of Finland, Estonia, Russia and Sweden where the passenger and cargo traffic has for a long time provided an easy way of transport.

This part of the document concludes that whereas the national level response was not activated and the essential Finnish authorities declared that the situational awareness had been sufficient, the local and municipal level authorities faced difficulties to obtain timely and coherent data on the situation and forecasts. Difficulties within the regional rescue departments emerged mainly from insufficient capacity for sharing the data and also because of the incoherence of data crossing their borders. Municipalities took action to improve their preparedness, as well as citizens found their role in many situations as real time first responders.

The second part of this report deals with the Slovakian case study. With the aim of providing a general picture of the current state of Slovakia, important aspects such as the status quo of transport infrastructure, the description of previous extreme meteorological events and the civil protection and public management, are initially presented.

The hypothetical scenario is described by the explanation of the meteorological situation, the status quo of transport infrastructure during and after the extreme weather event, and the activation of risk management, on the local and regional level. The event is assumed to affect the North-West part of Slovakia (Žilina region, next ZSK).

The data about extinctive storm clouds (the development of the extreme weather in the past), the identification of the elements of critical infrastructure and the creation of the scenarios for the analysis of the risks of potential elements of critical infrastructure complete the description and studio of this hypothetical case study.

The document finishes highlighting the importance of (a) developing and implementing appropriate adaptation strategies, (b) revising engineering standards for transport infrastructure systems to consider the increasingly frequent extreme weather events, and (c) improving the knowledge about interdependencies among infrastructures.

2. Shortcuts and key terms

CI	Critical infrastructure
CAPE	Convective available potential energy
D	Deliverable
DRAGADOS	DRAGADOS SA
EC	European Commission
ESSL	European Severe Storms Laboratory e.V.
ERTMS	European Rail Traffic Management System
HI	HELLENBERG INTERNATIONAL OY
INFRARISK	FP7 Project:Novel Indicators for identifying critical INFRAstructure at RISK from natural hazards
ISIG	Istituto di Sociologia Internazionale di Gorizia I.S.I.G
MS 5	Milestone 5
NASA	National Aeronautics and Space Administration
NDS	Národná dialničná spološnosť – National Motorway Company
NOOA	National Oceanic and Atmospheric Administration
RAIN	Project - Risk Analysis of Infrastructure Networks in response to extreme weather
SR	Slovak Republic
TCD	Trinity Colledge Dublin
TEM	Trans - European Motorways
TEN-T	Trans - European Transport Network
UNIZA	Zilinska univerzita v Ziline – University of Žilina
WP	Working package
ŽSK	Žilinský samosprávny kraj - Žilina Self-governing Region
ŽSR	Železnice Slovenskej republiky - Slovak Railway Company

Part A. SUMMER STORMS 2010 AND WINTER STORM 2011 IN FINLAND

3. Introduction

The Baltic Sea Region could be seen as a laboratory from the point of view of critical infrastructure protection. Besides being in the forefront of bilateral and multilateral civil protection cooperation the region has special climate conditions, long distances, in some sectors and between some countries closely integrated economies, still a variety of economic, political and administrative systems and cultures as well as institutional solutions as to international cooperation and integration, and sometimes very fragmented infrastructure networks. However, while critical infrastructures such as land transport networks were perhaps earlier understood as something very tangible and concrete, either physical or information and communication technology systems, there seems to be a trend towards a broad, holistic understanding of critical infrastructure, where it is understood as networks or systems of vital functions of the society as a whole, or the infrastructures embedded in, or supporting, these functions. This trend is especially visible in the Baltic Sea Region among the Nordic countries.[1]

The report describes first characteristics of the Finnish crisis management and civil protection systems. The special emphasis is laid on the recent developments and reforms undertaken in the *land and transport infrastructure protection*. The case reports are divided into three main areas of analysis: early warning, response and consequence management. Additionally, the report describes the material and socio-economic losses and damages caused by those cases. Finally, it highlights the cascading effects of these two described hazards on critical infrastructures and presents conclusions for the development of emergency management systems.[2]

Conclusions are drawn especially concerning situational awareness and communications in civil protection.

The central definitions regarding the field of civil security/protection are as follows:

- “Civil security” means that the citizens are protected from threats which can affect their living conditions and well-being. It is generally used in the societal context and in a sense which limits the responsibility area to be “below open military conflicts” as follows: “Civil security is the state of protection of a society’s normal functioning and citizens’ living conditions from all threats other than military ones”.
- “Societal security” is part of comprehensive civil security but emphasizes more the protection of society’s normal life-sustaining functions.

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[1] *Towards a Baltic Sea Region Strategy in Critical Infrastructure Protection*, Christer Pursiainen (ed.) with the assistance of Patrick Lindblom and Per Francke, NORDREGIO, 2007

[2] The impact of a natural event on a technological system may cause a cascading event resulting in severe technological accident. See: Valerio Cozzani, University of Bologna, Italy, 25.10.2013 on “Domino Effects and Cascading Events: Natech, security-related and external hazard factors affecting the process and energy industry”. Presentation at the “Future Safety and Security Research in Europe”.

- "Civil protection" refers to activities which protect civil populations against natural, technological and man-made disasters and accidents.[3]

The Council of the European Union has confirmed the two sides of emergency management: "The overall aim of disaster prevention within the EU is to, where possible prevent natural and man-made disasters from happening but if they do occur, aim at reducing their adverse consequences and minimising their social, economic and environmental impact".[4]

[3] The definitions are derived from Carl-Einar Stålvant and Pekka Visuri, Implementing and Institutionalising Civil Protection in the Baltic Sea Region – Based on the European Union Strategy for the Baltic Sea Region. Feasibility Study and Report for the Council of the Baltic Sea States 2013.

[4] 2979th JUSTICE and HOME AFFAIRS Council meeting Brussels, 30 November 2009. Conclusions See also 'A Community approach on the prevention of natural and man-made disasters' (COM(2009) 82 final) and EU Strategy on supporting disaster risk reduction in developing countries (COM(2009) 84 final).

4. Analysis of contemporary statue of the Finnish Crisis Management System

Finland is a Nordic country with 5,4 million people of which the majority is living in the southern regions. The native language for the large majority of the population is Finnish (92 %). The second official language is Swedish which is spoken by a 5,5 per cent of the people, and they are living mostly on the southern and western coasts. The number of minority nationalities in Finland has been relatively small and they have caused no significant ethnical problems.[5]

From the total area of 338 144 km^2 circa 10 per cent are lakes and rivers. There are some 190 000 lakes, and also 180 000 islands which are both in lakes and in vast Finnish archipelagos of the Baltic Sea. In terms of area Finland is eighth largest country in Europe and the most sparsely populated country in the European Union. The distance from the south to the northernmost point in Finland is 1 160 kilometres.

The landscape is mostly flat with small hills and few mountains. The highest point is in northern Lapland, 1 324 metres above the sea level. Forests are large, especially in eastern and northern parts of country. There are also wide marshes. In the southern coast areas as well as in the lake regions the terrain is generally difficult for moving outside roads. However, because of the relatively dense network of small forest and agricultural roads also the forest areas are rather well to get through.

The Finnish soil is almost totally of solid rock, and earthquakes are very exceptional phenomena. The main natural problems for civil protection are caused by extreme weather conditions, especially in winter from cold and storms. Also flooding on coastlands and northern riverbanks cause regular challenges for the municipal and regional civil security authorities.

A specialty for Finland is the long coast line by the Baltic Sea. For the civil security measures it means that maritime safety issues are essential. There are many harbours, and many rocky sea areas and routes are rather difficult to navigate.

Finland is a democratic, parliamentary republic with one-chamber parliament (in Finnish Eduskunta) for which 200 representatives shall be elected for four years mandate periods. In accordance with the principle of parliamentarianism, the Government must enjoy Parliament's confidence. The Parliament has generally powers to accept the Government's actions or dismiss ministers.

The President of Republic has been directly elected by the people for six years, and leads foreign policy in accordance with the Government. The President is also supreme commander of the Defence Forces.

The Government and other central administration are located in capital Helsinki, in the southern coast area. There are for local administration some 400 municipalities but at present no regional governments or other general administration. In the neighbourhood of Helsinki are also two big

[5] FINNFACTS 2015. Available from: http://www.finnfacts.fi/eng/for-press/facts-about-finland/

cities Espoo and Vantaa so that the metropolitan area of Helsinki has almost one million inhabitants. Other major cities are Tampere, Turku and Oulu.

Finland is a member of the European Union from 1995 and part of the euro-zone as well as Schengen area.

The neighbour countries are in the west Sweden, in north Norway, in east the Russian Federation, and in south Estonia, behind the Gulf of Finland.

4.1 General framework for land transport infrastructure

The nationwide land transport system is controlled by the Finnish Transport Agency. It is responsible for the traffic management on roads, waterways and railways as well as for the passenger information on the railway stations. The regional development work is carried out in cooperation with the provinces and municipalities. The provinces are responsible for the planning of the transport system in their own regions.

The Centres for Economic Development, Transport and the Environment (ELY Centres) are in charge of the condition of the road network and the development in their own regions. The condition and development of railways on the other hand is the responsibility of the Finnish Transport Agency. Planning, maintenance and building are procured from service providers such as VR. Infrastructure management (maintenance, financing of public transport, traffic management and small-scale investments) are funded from the state budget. The Parliament decides on large investments (new connections and extension of old ones) separately in connection with the budget process. The Finnish Transport Agency operates under the jurisdiction of the Ministry of Transport and Communications. The Finnish Transport Agency is responsible for the operations control in the traffic and infrastructure sector of the ELY Centres. One third of the transport funds is used by the ELY Centres (road management, public transport, subsidies for private roads, commuter ferry traffic). The Finnish Transport Agency monitors the use of the funding by means of operational performance agreements. [6]

4.1.1 Land transport networks

The Finnish transport network is built on principle of efficient transport which is seen as a fundamental prerequisite for sustainable growth and development to enhance the social and national competitiveness. Traffic routes include highways, streets, private roads, railways, waterways, subways and trams. The Finnish Transport Agency is in charge of the state-owned roads and railways, as well as the waterways it manages. It determines the service levels of Finnish traffic lanes. Routes with heavy traffic and commercially significant routes are kept open to traffic at almost all times. Management and maintenance services are outsourced to specialised service providers.

The Finnish road network consists of roads, municipal street networks and private roads. The Finnish Transport Agency is responsible for the maintenance and development of the state of the road

[6] Liikennevirasto. 10.08.2011. Available from: http://portal.liikennevirasto.fi/sivu/www/e/transport_network/responsibility

network in conjunction with regional Centres for Economic Development, Transport and the Environment with. This mission is carried out in all weather conditions.

Figure 1: Land transport infrastructure management
Source: Liikennevirasto, 2011. http://portal.liikennevirasto.fi/sivu/www/e/transport_network/responsibility

Railways

Finland has 5,944 kilometres of railways in use, of which 3,067 kilometres are electrified lines. About EUR 135 million a year is spent on track maintenance. The railway network's maximum axle weight is 25 tonnes. The speed limit for passenger trains is 220 km/h and 120 km/h for freight trains.

At level crossings, the railway line is crossed, at the same level, by a road or pedestrian/bicycle route. Finland's railway network has more than 3,000 level crossings. At a minimum, these are marked by a warning sign.

Good visibility is the most important characteristic of a safe level crossing. The road keeper is responsible for the visibility and condition of the level crossing area; the road keeper is either a private road management body or the Finnish Transport Agency.

The Finnish Transport Agency is removing level crossings on the railway sections where the aim is to increase line speed. Level crossings are not allowed on railway lines with a line speed exceeding 140 km/h.[7]

[7] Liikennevirasto. 2013. Available from: http://portal.liikennevirasto.fi/sivu/www/e/transport_network/railways

Figure 2: Overall map of main transport networks in Finland
Source: Liikennevirasto, 2012. http://portal.liikennevirasto.fi/sivu/www/e/transport_network

Roads

The Finnish road network comprises highways, municipal street networks and private roads. Together with local agencies such as the regional Centre´s for Economic Development, Transport and the Environment, the Finnish Transport Agency is in charge of maintenance and development of the state-owned road network. The Finnish road network is approximately 454,000 kilometres long in total. It includes around 350,000 kilometres of private and forest roads and 26,000 kilometres of municipal streets. In total, the Finnish Transport Agency is responsible for approximately 78,000 kilometres of highway.

Highways and main roads comprise more than 13,000 kilometres, 700 kilometres of which are motorways. Most of the total road length of 64,900 kilometres consists of local and connecting roads. However, these represent just over a third of all traffic. Approximately 65 % of roads, or some 50,000 kilometres, are paved.

With respect to the low-volume road network, approximately 41,000 kilometres of road are in the lowest maintenance category. This totals more than half of the total road network. It is impossible to

maintain all roads in such condition that, during the most challenging weather conditions, no problems will occur anywhere in the road network.[8]

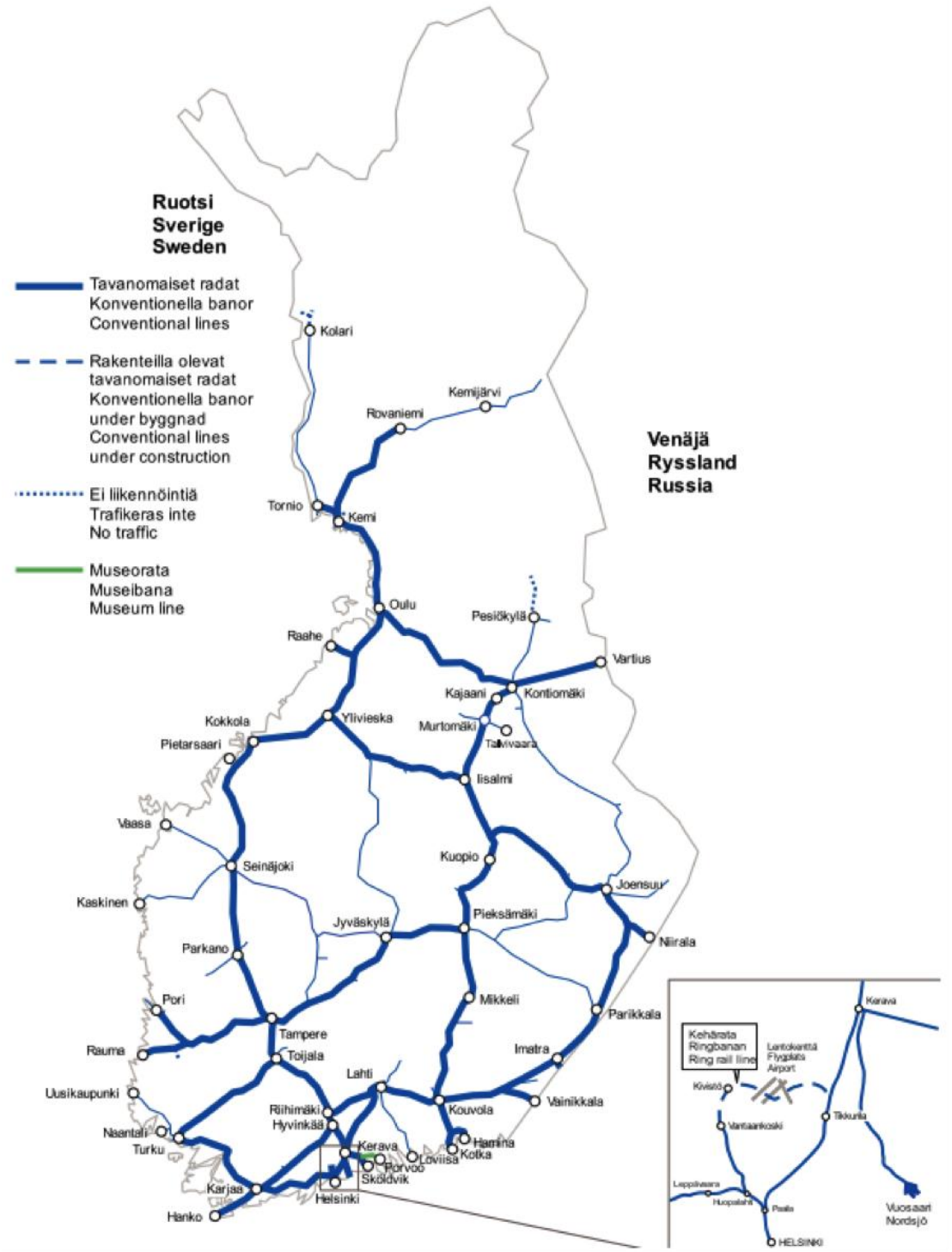

Figure 3: Finnish Road network based on functional descriptions
Source: Liikennevirasto, Verkkoselostus 2013, 2012. http://www.logistiikanmaailma.fi/wiki/Rataverkko

[8] Liikennevirasto. 2012. Available from: http://portal.liikennevirasto.fi/sivu/www/e/transport_network/roads

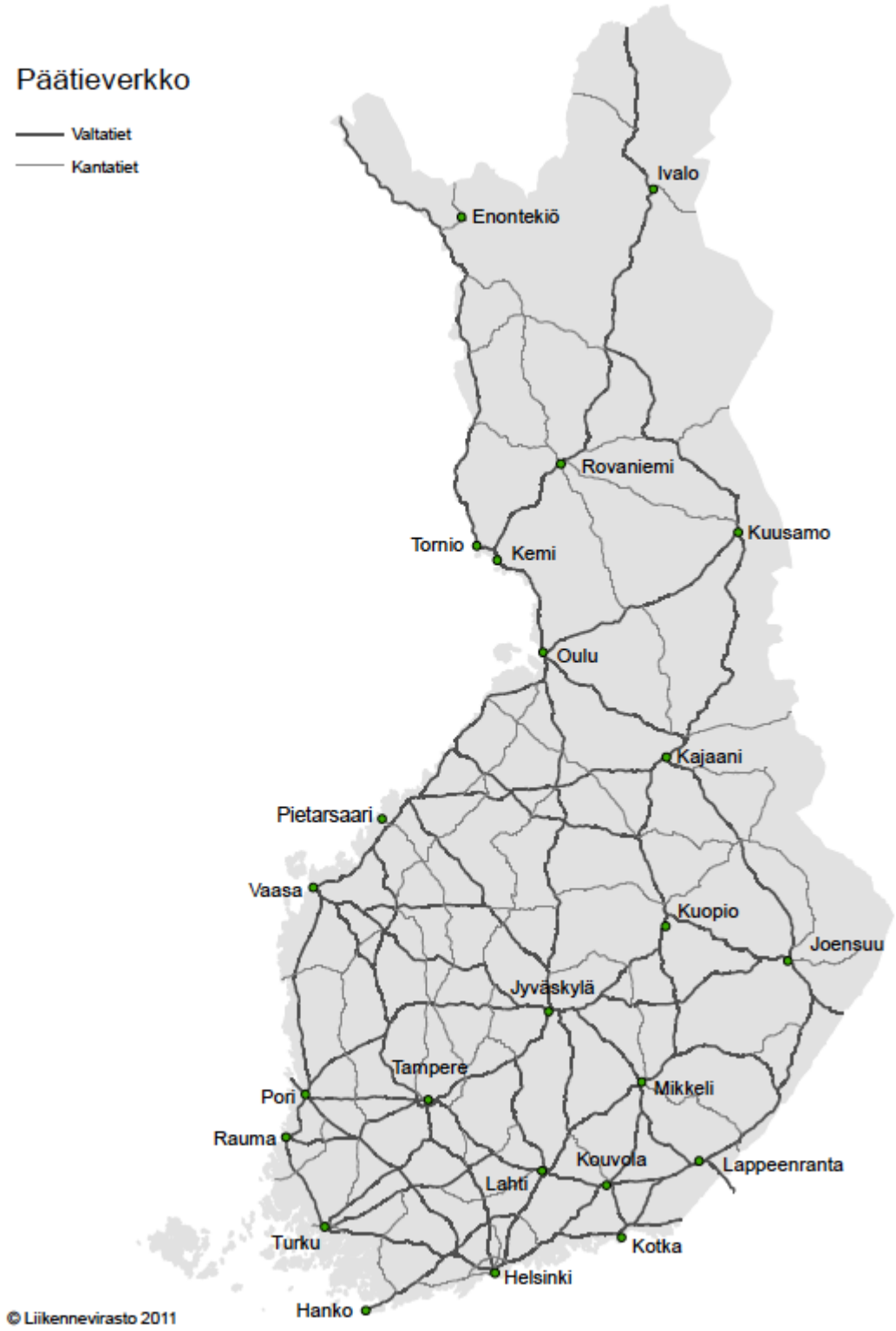

Figure 4: Finnish main road network
Source: Liikennevirasto, 2013. http://www.logistiikanmaailma.fi/wiki/Tieverkko

4.2 Historical, societal and legal aspects of the civil protection system

Finland has been located between western and eastern power spheres, i.e. between the western roman catholic/protestant and eastern orthodox churches as well as between West-European and Russian cultural-political areas. A long time, from the 13th century to the year 1809, Finland was a part of the Swedish kingdom. During 1809-1917 Finland was an autonomous grand duchy in the Russian Empire, still with Swedish-originated legislation and culture. The independence of Finland was gained in 1917 and defended by costly fighting against the Soviet Union during the Second World War 1939-1944. After the war during the Cold War Finland followed a policy of neutrality, however, with an agreement with the Soviet Union, according which Finland was obligated to defend its territory against a possible offensive from the side of Germany or an alliance against the Soviet Union.

The experience taken from the Second World War and Cold War has strongly affected the development of the Finnish crisis management and civil security systems. Security and defence policy has been based on the doctrine of "total defence" which includes both military and civil elements. After the Cold War the national security doctrine has been developed more on the basis of the idea of "comprehensive security" with more emphasis on civil security and broader crisis management issues.

The decision making in the crisis situations during the Cold War was regulated with the instructions by the National Defence Council and legal provisions by the Parliament. In the legislation a strict dichotomy was between the normal situation and the state of war. The war-time conditions were well defined and regulated. The problem was that the decision-making procedures in all kind of disturbances and crises underneath the level of a war situation were rather vaguely defined and legislated. The basic idea was: "If we have a good preparedness for a total war we can well handle all the less dangerous situations, too, possibly with some improvisation according to the special demands of the actual crisis." By the time the need to develop procedures for the "grey zone" between peace and war became urgent, but it lasted until the end of the Cold War as the new legislation was completed.[9]

The present crisis management system and its objectives concerning civil security have been developed after the Cold War from the preparedness to overcome extreme situations, a total war included, towards a more peace-time oriented crisis management which is based on the comprehensive security concept. There are still some features in the Finnish concept of maintaining civil protection/security following from that history.

The other long-lasting tradition from the past is the principle of strict legality in the administration. Horizontally, every sector has rather independent powers in decision making, and also vertically the possibilities of upper administrative levels to lead directly over the lower levels are restricted by law.

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[9] Pekka Visuri & Timo Hellenberg, "The Finnish Crisis Management" in *Securing the Air Traffic, Case CBRN Terrorism*. Ed. Timo Hellenberg and Pekka Visuri, Aleksanteri Institute, University of Helsinki, 2011, p. 131.

This culture of legality in the administration is deep-rooted, and it is rather difficult to change for a flexible and more concentrated or integrated system of civil security arrangements.

The need to have a general emergency powers act was widely recognized during the 1980s. After a lengthy political and juridical process in 1991 the Parliament passed the *Emergency Powers Act* (1080/1991) simultaneously with the *State of Defence Act* (1083/1991) which replaced the old State of War Act. They specified the conditions which could lead to enhanced authorization of powers in crisis situations, as well as they set respectively frames for the decision making.

The Emergency Powers Act (1991) aimed to secure the livelihood of the population and economy, to maintain legal order as well as constitutional and human rights, and to safeguard the territorial integrity and independence of Finland in emergency conditions. It could be applied before or beside the State of Defence Act which gives additional powers for the Government in the defence against an armed aggression.

The emergency conditions defined in 1991 were: An armed attack against Finland, as well as war and the aftermath of war; a serious violation of the territorial integrity of Finland and a threat of war against the country; war or a threat of war between foreign countries; a serious threat to the livelihood of the population or the foundations of the national economy; a catastrophe.

A new strategy from the viewpoint of functions vital to guarantee the security of the population and society as well as the freedom of action for the state leadership was created and published in 2003 under the title *Government Resolution on Securing the Functions Vital to Society*. It was revised 2006 taking into account the increasing internationalization as well as changes in the security environment and societal structures. Special attention was paid to the consequences of Finland's membership in the European Union.[10]

Ministries have been obliged to include all of the measures required by that Resolution in their standard operating and financial plans. Each ministry directs its respective administrative sector's preparedness as well as relevant legislative improvements. The resolution mentioned activities of the business community and non-governmental organizations (NGOs), too, but they have not been exactly articulated or defined, nor have the private entities given a clear role and mandate in the national exercises or planning, despite all the strategies and political declarations. Public-private partnership takes place but it is still kept mainly within multiple working groups and committees, and not well practiced through joint exercises or included in development projects.

The emergency categories as well as threats and risks for the society are described in the Security Strategy for Society. The threats can be disturbances in normal time or emergency conditions that can endanger severely the security of the society or population. On the basis of the described scenarios, the competent authorities compile more detailed threat estimates for their own fields of responsibility. These estimates specify the origin of the threat, the target, the form it takes, its

[10] *The Strategy for Securing the Functions Vital to Society*. Government Resolution, Helsinki 23.11.2006.

probability, the way it affects the authorities' capability to carry out their tasks as well as response options.[11]

According to the Constitution the **Parliament** has powers to prescribe laws and supervise the Government's policy activities. The most important laws concerning crisis management and civil security duties are the C*onstitution* and the *Preparedness Act 2011*[12].

The Preparedness Act 2011 aims to secure the livelihood of the population and economy, to maintain legal order and constitutional and human rights, and to safeguard the territorial integrity and independence of Finland **in emergency conditions**. It can be applied before or beside the *State of Defence Act* (1991) which gives additional powers for the Government in the defence against an armed aggression.

According to the *Preparedness Act* the defined emergency conditions are:

- An armed attack against Finland.
- A serious threat of armed aggression against Finland.
- A serious threat to the livelihood of the population or the foundations of the national economy.
- A catastrophic disaster.
- A widespread dangerous disease.

Those cases will be defined as emergency conditions if the authorities cannot control the situation with regular powers.

The decision making in emergency conditions occurs as follows: The Government may be authorised by decree, in concert with the President of Republic, to use the emergency powers. The Decree shall be issued for a special, defined purpose, with limited powers and for maximal six months' period. The Decree shall be immediately submitted to the Parliament.

The present **law on rescue services** (in Finnish Pelastuslaki)[13] is from 2011. It stipulates responsibilities for rescue services concerning fire-fighting and response in different accident cases, preparedness and mitigation as well as duties for civil protection in emergency situations war conditions included.

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[11] See the *Security Strategy for Society*, annexes 2 (Threat models) and 3 (Possible disturbance and emergency situations), the *Government Resolution* 16.12.2010. They list situations of different categories of threat scenarios, and the ministries which are responsible for the management of the actual cases (i.e. a competent ministry and supporting ministries). Internet:
http://www.defmin.fi/en/publications/strategy_documents/the_security_strategy_for_society

[12] Valmiuslaki 29.12.2011/1552 (Preparedness Act 2011).

[13] Pelastuslaki 29.4.2011/379. See Finlex databank: http://www.finlex.fi/fi/laki/ajantasa/2011/20110379

The law on rescue services gives the rescue leaders vast powers for measures needed in a disaster or accident response situation, e.g. forced evacuations from a dangerous place or areas. It is also obligation of every citizen to assist in rescue duties if the leader on the site estimates it inevitable.

In general, the civil security system of Finland is decentralised with a rather strict independence of administrative and functional sectors.

4.3 Cases which have influenced on developing of the civil protection arrangements

Some cases that have occurred in the Baltic Sea Region, especially those concerning Finland after the Cold War, have remarkably effected in the development of civil security:

Nuclear power plant accident in Chernobyl that occurred on 26th April 1986 dispersed its affects to wide areas. It had many features which have been taken into account in developing civil security/civil Protection also in Finland. The most remarkable still to observe is the importance of human factors as a cause of the disaster.[14]

The sinking of M/S Estonia on 28th September 1994. The ship with 989 people was en route from Tallinn to Stockholm over-night. It sunk in 50 minutes after getting water from the opened bow door. Estonia was in the international waters but near the Finnish territory, and therefore Finland was responsible for the international rescue operation. Totally 852 persons died.[15]

Tsunami, on 26th December 2004, was actually a distant catastrophe in the Indian Ocean, near by the Indonesian coast, but it surprisingly involved many thousands of European citizens. For example 571 Swedish, 552 German and 179 Finnish citizens died. It revealed faults in the Finnish crisis management system, particularly in rapid rescue response and situational awareness across the administrative boundaries. The lessons learned were a reason enough to modernize the governmental decision-making system towards more effective and towards more peace-time accidents oriented civil security mechanism, published as Government resolution 2006.[16]

Flooding in the Northern Baltic Sea 7-10th January 2005. The weather indicators notified that the sea level will rise on 7th January. Sea water flooding occurred in the coastal areas in Finland, Estonia and Russia. In Finland critical moments were in Helsinki and nearby, in the Loviisa nuclear power plant, but the situation was managed quite well. At the same time the Estonian government was struggling with response in Haapsalu, Saaremaa and Viimsi. Situational awareness as a whole and communications between the states were rather vague and incoherent. The flood affected also the Russian coast and the city of St Petersburg. It resulted in more systemic response, planning and streamlined crisis management systems in Finland and Estonia.

Nokia water crisis 2007 caused sicknesses to 8 000 people. An accidental leakage of dirty water to the drinking-water supply system began in the city of Nokia on 28th November 2007. There were

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[14] See Forsberg, Tuomas – Pursiainen, Christer – Lintonen, Raimo – Visuri, Pekka (eds), *Suomi ja kriisit. Vaaran vuosista terrori-iskuihin* (Gaudeamus, Helsinki 2003), pp. 207-220.
[15] Ibid. pp. 221-240.
[16] The description of the cases in Timo Hellenberg – Heikki Talvitie – Pekka Visuri, *Myrskyn silmässä – Suomi ja uudet kriisit* (WSOYpro 2011).

both political and administrative difficulties to find out the level of seriousness of this situation. Total 400 000 litres only roughly purified waste water poured into the drinking-water system during those three days. It caused one fatal casualty and sicknesses to 8 000 people from which many have long-lasting health problems. The risks were very high for more casualties. The crisis situation lasted over three weeks. The Finnish Defence Force took over the supply of clean water for a week.

School shootings in Finland on 7th November 2007 in Jokela and on 23rd September 2008 in Kauhajoki. These two incidents caused severe shocking experiences for the Finnish society. In Jokela a gymnasium student shot 8 persons and finally himself. Likewise, in Kauhajoki a student shot 9 persons and then himself. Both cases have been studied and investigated. It became clear that from Jokela incident in 2007 the Finnish response system learned a lot and was developed towards a comprehensive response mechanism. This was soon tested in Kauhajoki and it turned out to be an effective way of avoiding timeline gaps and misunderstandings based on versatile early warning information.

Hijacking of M/S Arctic Sea 2009. A mysterious hijacking in the Baltic Sea began during the night to 24th July 2009. The Russian-Finnish owned but in Malta registered ship was en route from Pietarsaari, Finland, towards Bejaija, Algeria. Before arriving to Finland, the ship had been taken for service repair to Kaliningrad, Russia. When the ship was in the Swedish territorial waters between Gotland and Öland, it became “hijacked”. Then it took several days’ time before the hijacking was exposed by media. The ship sailed hijacked through EU waters via Danish straits and English Channel to the Atlantic where the Russian Navy at last intercepted it. The case revealed weaknesses in the surveillance and communication arrangements in the Baltic Sea Region and the European Union as a whole. It also turned out to be a very controversial case study which has not yet been fully investigated, mainly as a result of bad communications between EU and Russian officials.

Summer storms in 2010 and winter storms in 2011. The summer storms of 2010 affected particularly the Eastern Finland. The storms tested the newly formed regionalization system of rescue services. The strong winds destroyed critical infrastructures such as electricity lines, road networks and telecommunication towers. Several weeks lasted in mitigating the consequences. The situation occurred at the same time when the neighbouring Russia was struggling with the all-time high forest fires. This created more stress but was not clearly identified by the Finnish authorities in terms of cross border cooperation. The winter storms of 2011 affected especially Southern Finland. The electricity grid was in many areas disabled for several days. It resulted to communication problems, especially with cell-phones. There were simultaneously floods but not bad frost.

4.4 Responsibilities and functions in civil protection

Political leadership and administration sectors

The actors and their responsibilities in the field of civil security are as follows:[17]

[17] See: *Preparedness and comprehensive security*. Committee report 28. November 2011: http://vnk.fi/julkaisut/julkaisusarja/julkaisu/en.jsp?oid=344062

Pursuant to the Constitution (93 art) the **President of the Republic** conducts Finland's foreign policy in cooperation with the *Government* (i.e. more accurately named *State Council*), and acts also as supreme commander of the Defence Forces.

The Government is responsible for leading and maintaining domestic civil security arrangements as well as for national preparation of decisions to be made in the European Union, and decides on concomitant Finnish measures, unless the decision requires the approval of Parliament. The *Cabinet Committee on Foreign and Security Policy* prepares decisions for the Government meetings if they include important aspects of security and foreign policy.

The **Prime Minister** leads the Government and oversees the coordination of the preparation and consideration of matters falling within the Government's mandate. Each ministry is responsible for the preparation of matters within the Government's mandate and the appropriate functioning of administration in its own administrative sector. The responsibility for ensuring that each administration functions appropriately covers also the steering and monitoring of administration under the ministry.

The Government directs, supervises and coordinates the **securing of functions vital to society**. Each *competent ministry* does the same within its respective administrative sector. In order to facilitate preparedness and to instigate activities, all **competent authorities** employ their statutory powers, which are already quite exhaustive in normal conditions.

In the defined emergency conditions the Government may be authorized to use the additional powers provided in the *Preparedness Act* (2011).

Government decisions are made either at plenary sessions or within the ministry concerned. The ministries cooperate with each other as necessary, under the leadership of the competent ministry.

In addition, ministries direct the state provincial offices and other subordinate sectors of administration within their respective mandates.

The **Prime Minister's Office** assists the Prime Minister in the overall management of the Government and in coordinating the work of the Government and Parliament. The Office coordinates the dissemination of Government information and organizes the general conditions and services for the proper functioning of the Government. The Prime Minister's Office is responsible for the Government's collective preparedness for emergency conditions. The Office has the Situation Centre which seeks and provides situational picture and information about domestic and international emergency situations.

The **Permanent State Secretaries** have the task of directing and supervising the activities of their respective ministries. They are responsible for preparing the administrative sector's objectives, monitoring their implementation and ensuring the preparedness and security of the sector. The *Meeting of Permanent State Secretaries* and the *Meeting of Heads of Preparedness* are permanent cooperation bodies. They coordinate the administrative sectors' crisis management activities and assist the Prime Minister's Office with regard to the Government's common preparedness for emergency conditions.

The Ministry of the Interior has main **responsibility for internal security** including police affairs, border management (Border Guard), maritime search and rescue, and rescue services. The *Emergency Response Centre Administration* provides emergency response centre services throughout Finland, except for the Åland Islands. Emergency response centres receive emergency calls for the rescue, police and social and health services; handle communications relating to the safety of people, property and the environment; and relay the information they receive to the appropriate assisting authorities. The Ministry maintains also the *Internal Security Programme* and cooperates with other ministries in the field of civil security.[18]

The Ministry of Defence is responsible for coordination of the **comprehensive national defence** activities. The *Security Committee* is established by the Government and located at the Ministry of Defence. The Defence Forces are prepared to assist civil sector with personnel and material needed, for example, in rescue service duties.[19]

4.5 Civil security duties of regional and local administration

Appropriate ministries direct the various fields of activity for which regional and local administrations are responsible. The **regional administration** in Finland has been going through a profound change which affects also the organisation of local rescue services, especially the arrangements of the alarm service. At present, there are no more general regional administration between local and central (government) administration levels. The *regional state administrative agencies* have some *sectoral duties* and training tasks for emergency situations, but they have no general powers for administration.

The **municipalities** play a key role in local preparedness, as it is their specific duty to organize basic services and to safeguard society's vital functions under normal conditions. The municipal managers, together with the municipal boards, direct preparedness in accordance to the law.

Municipalities are jointly responsible for rescue services within regions designated by the Government. The country is divided into 22 rescue departments (regions). Regional rescue services manage operations in their respective regions. Voluntary, institutional and industrial fire brigades also participate in the provision of rescue services as agreed between the brigades and the regional rescue services.

[18] See the *Ministry of the Interior* websites: http://www.intermin.fi/en/ministry/mandate_of_the_ministry
[19] http://www.turvallisuuskomitea.fi/index.php/en/

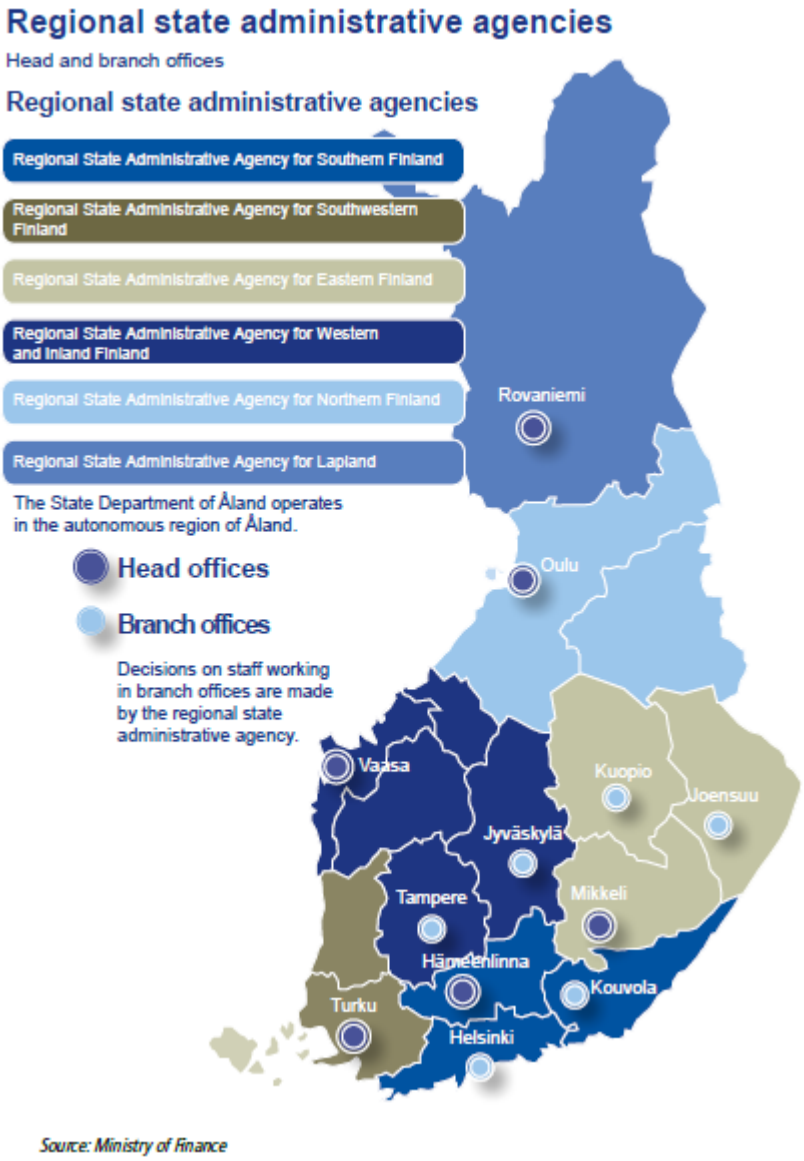

Figure 5: Regional administration has mostly functional-sector duties, for instance concerning rescue services, civil protection or economic administration. Source: *Preparedness and comprehensive security*. Committee report 28, November 2011: http://vnk.fi/julkaisut/julkaisusarja/julkaisu/en.jsp?oid=344062, p. 52.

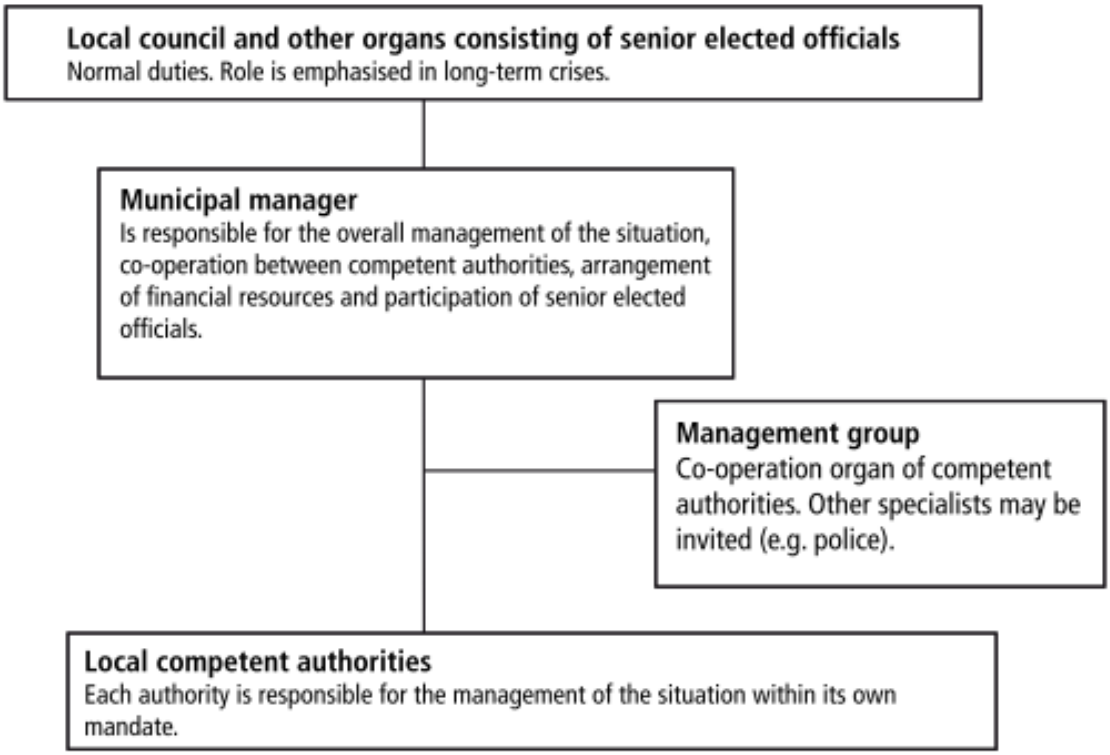

Figure 6: Duties of local government (municipalities) in crisis and emergency management. Source: *Preparedness and comprehensive security*. Committee report 28, November 2011: http://vnk.fi/julkaisut/julkaisusarja/julkaisu/en.jsp?oid=344062, p. 57.

Rescue services

Regional rescue services have both full-time and part-time personnel. Voluntary, institutional and industrial fire brigades participate in the provision of rescue services as agreed between the brigades and the rescue service region. In total, regional rescue services have approximately 4 000 full-time employees and approximately 20 000 part-time employees and voluntary fire brigade members.[20]

The full-time rescue service personnel are in charge of the rescue-service-related duties of the authorities, such as fire inspections and civil defence plans. Contract fire brigades' duties are determined in accordance with local needs. Fire brigades can carry out all duties conventionally handled by fire brigades or specialise in certain areas on the basis of the risks and special characteristics of the region.

[20] *The Ministry of the Interior, Department for Rescue Services*: http://www.pelastustoimi.fi/pelastustoimi/pelastustoiminta

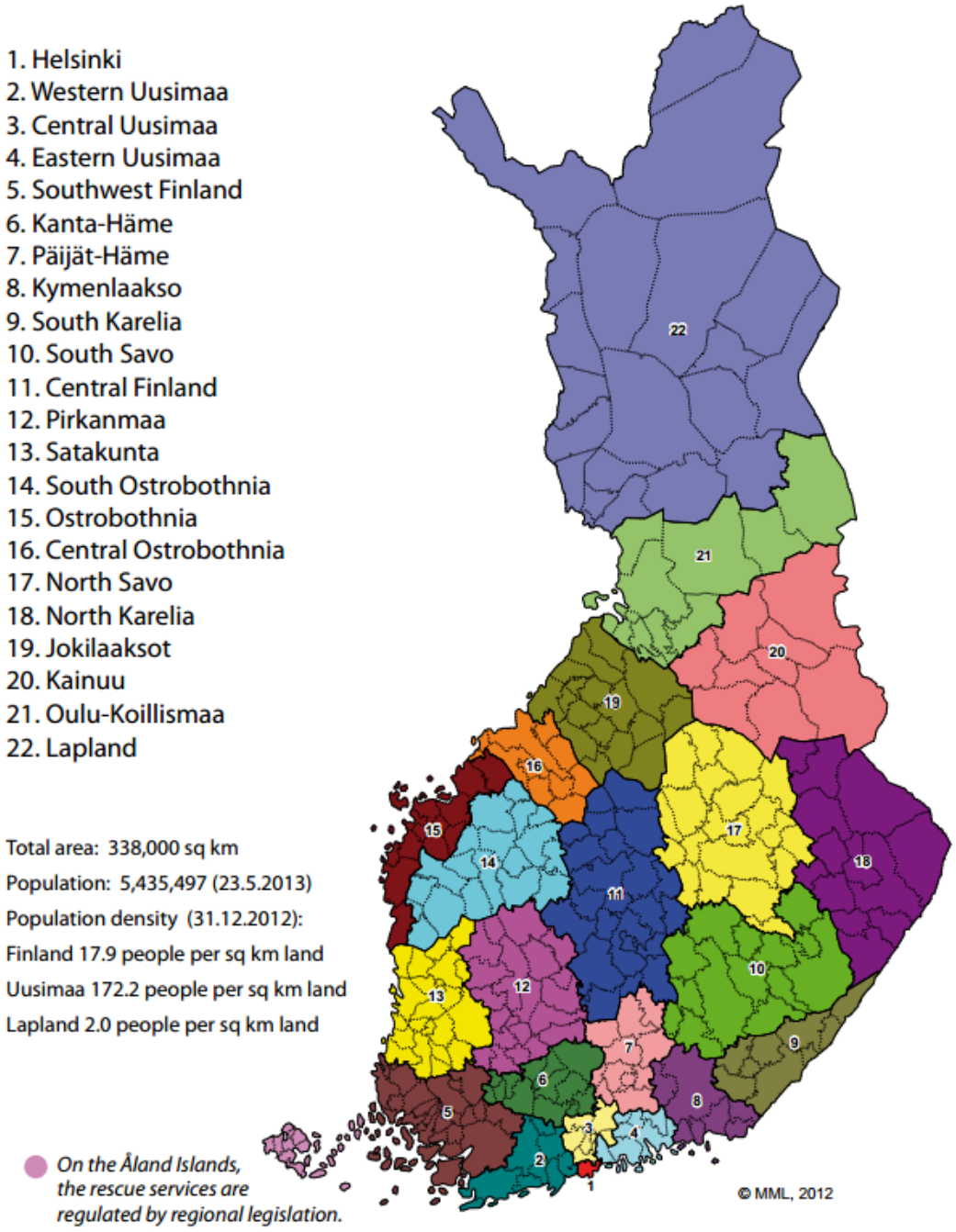

Figure 7: Rescue departments (regions). Source: The Ministry of the Interior, Department for Rescue Services: http://www.pelastustoimi.fi/download/47047_Rescue-services-in-Finland-web.pdf?aae889499bb4d088

Defence forces as regards peace-time civil security

The Finnish Defence Force employs some 14 000 soldiers and civilians, and trains a further 25 000 conscripts and 18 000 reservists annually. Finland's maximum wartime capacity is 240 000, including the Army, Navy and Air Force.

The Defence Force's task of supporting other authorities is prescribed by law. Under normal conditions, executive assistance of the Defence Forces is usually related to maintaining law and

order or to rescue operations. Executive assistance can also be given to another country in connection with a terrorist attack, natural disaster, catastrophe or other similar event.

4.6 Procedures in decision making

According to the *State's Crisis Management Model*, the *competent authority* (officials from on-site leader to the ministry level) initiates measures as per its regulations and informs the preparedness organization of its administrative sector. *The Prime Minister's Office* runs the *Government Situation Centre*, which builds on cooperation among ministries and supports Government-level management.

Respecting the actual situation the *ministry* empowered by the law to do so leads activities and coordination among ministries, when required. The Prime Minister's Office makes certain that a competent ministry has been designated.

The *permanent secretary* bears primary responsibility for the preparedness of his/her administrative sector as well as for managing the emergency situation. The measures of different administrative sectors and, when necessary, the business community and NGOs, are coordinated by the *permanent secretaries' meeting*.

The *meeting of the heads of preparedness* supports permanent secretaries with regard to operational activities. The *Security Chief of the Government* (Head of the Government Situation Centre) chairs the meetings of the heads of preparedness or they can be chaired by the head of preparedness of the competent ministry, depending on the case in question.

The *Security Committee* assists the Government and ministries in matters pertaining to comprehensive security. The committee also coordinates proactive preparedness which is related to comprehensive security.[21]

In the *Security strategy for society* (Government Resolution 2010)[22] the model of decision making has been described as in the picture. This scheme emphasizes the normal preparation procedures of decisions with several supporting elements.

[21] Turvallisuuskomitea. 2014. http://www.turvallisuuskomitea.fi/index.php/en/

[22] Ministry of Defence, *Security strategy for society.* Government resolution 16.12.2010. Available from: http://www.defmin.fi/en/publications/strategy_documents/the_security_strategy_for_society

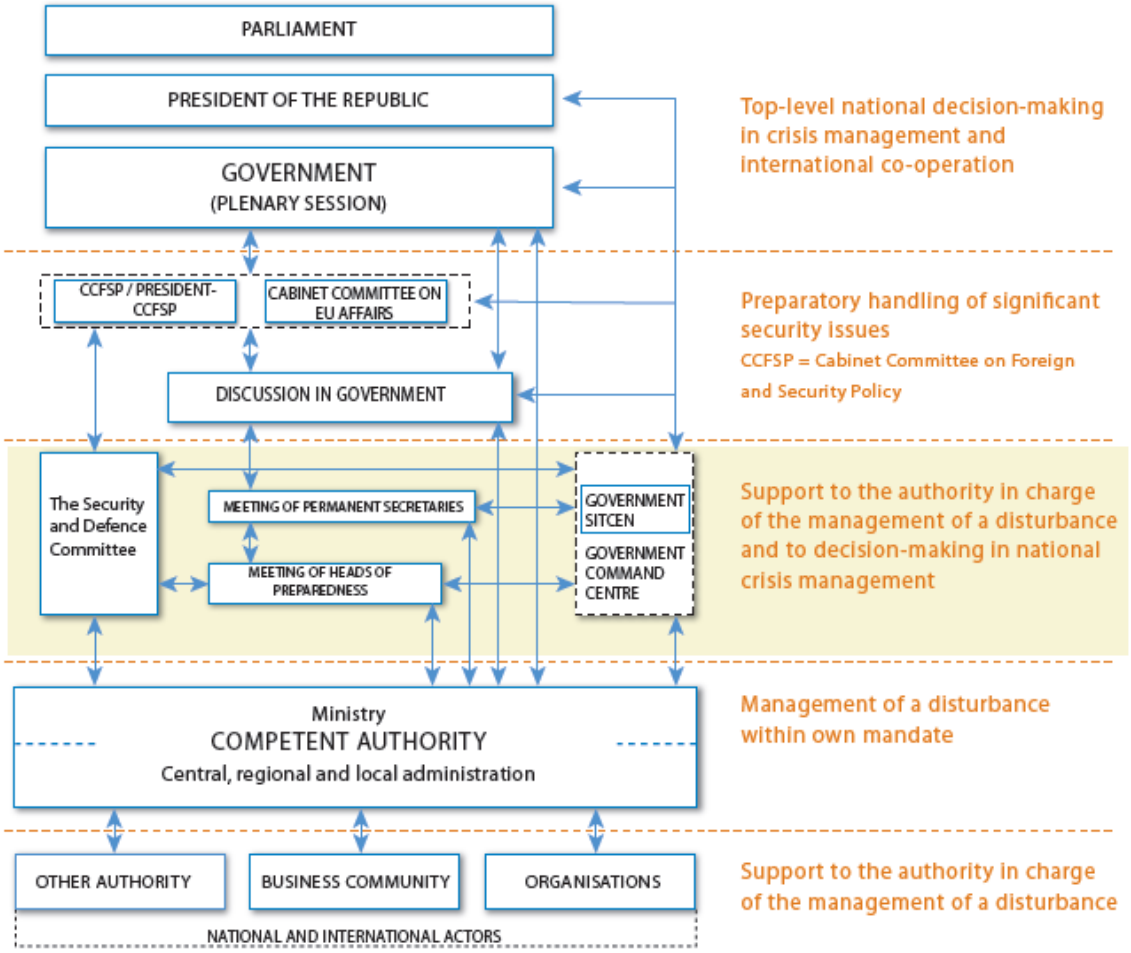

Figure 8: Model for management of crises and emergency situations, according to the *Security strategy for Society 2010*.

We can point out from the general model the main levels of decision making by the responsible authorities as follows:

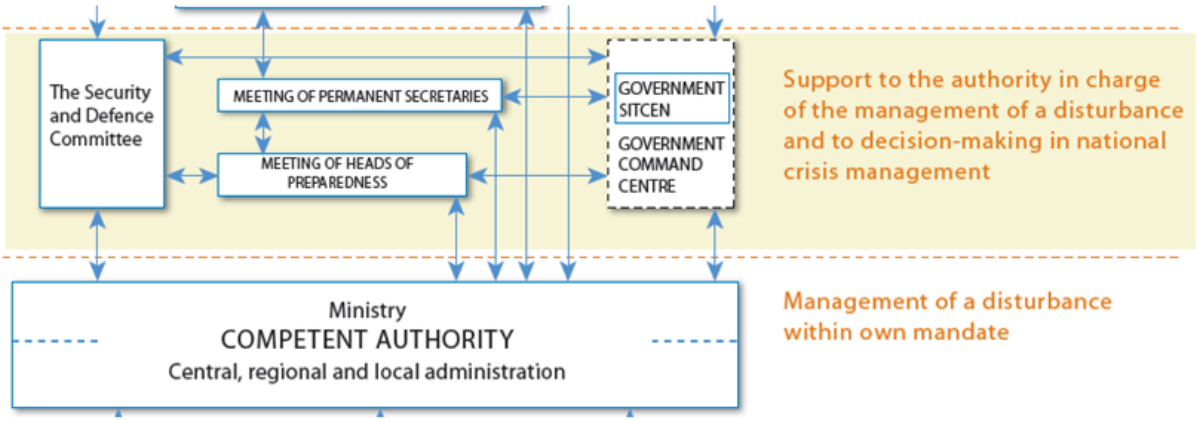

Figure 9: An extract from the larger picture shows the main levels of decision making according to the *Security strategy for Society 2010*.

1. Operational/strategic responsibility: competent authority. 2. Support and strategic planning: government level institutions.

The present crisis management model as such is clear in theory, and it meets the demands for legality and administrative efficiency, but we have not much experience of its functioning in new types of crises. Some lessons learned from the latest emergency situations and exercises signal that serious difficulties can emerge in surprising, complicated and multidimensional crisis situations, for example in a case of terrorist attacks. The cooperation of the first responders and leaders at the operational-strategic level are seen crucial prerequisites for the successful crisis management in Finland.

Therefore, it is useful to ask how the Finnish decision-making procedures in crises could be clarified and made as simple as possible. The system containing many alternative ways for assessment of the situation and procedures of decision making as well as all normal-time administration routines can be too much time-consuming and complicated in a severe crisis situation.

4.7 Situational awareness and communications in civil protection

A prognostic and real-time situation picture shall be compiled to support Government decision-making and communications. The shaping of a more comprehensive situation picture will be achieved by taking into account and utilizing effectively the authorities' pre-existing or future information technology environments. Cooperation and planning that serves the compilation of the situation picture has been improved among the different sectors of administration. Cooperation between the gathering of information, the compiling of the situation picture and communications has also been intensified and tested. The range of instruments for gathering information is widened by, for instance, developing the monitoring of open information sources. There are still many practical difficulties to overcome.

National structures tap into the cooperation with the EU's situation centres, in the first place the *Monitoring and Information Centre* (MIC), and sector officials, e.g. FRONTEX concerning situation on the external borders of the EU.

The Government Situation Centre, which relies on cooperation among ministries and is run by the Prime Minister's Office, is organized and shall be reinforced according to the actual needs so that it can support Government-level civilian crisis management (Government, Cabinet Committee on Foreign and Security Policy, meeting of permanent secretaries, meeting of heads of preparedness) in all security situations.

The situation centre is working continually (in 24/7 principle) with security police professionals and keeps contact to other situation centres in Finland (e.g. Foreign, Interior and Defence Ministries) as well as to EU authorities in Brussels. The situation centre follows also other information sources,

international news services, TV and internet news etc. According to the Government resolution on comprehensive security 2012 the capability of the situation centre should be improved remarkably.[23]

The ministries' situation centres are operative even in normal conditions and their staff must regularly participate in exercises. As premises are being developed, particular attention is paid to rapidly emerging situations which may demand enlarging the situation centres without delay to command centres.

Contacts to the European Union's crisis management organisation are maintained by sector authorities and the Government Situation Centre. The latter has direct communication line to the EU Council's situation centres (EU Situation Room and EU Intelligence Analysis Centre) and Commission's *Monitoring and Information Centre* (MIC) which can alert the EU crisis coordination arrangements and the Community mechanism for facilitating reinforced cooperation in civil protection via ARGUS communication system.

The Finnish **sectoral surveillance system** is based on the principle where each sector authority will remain in conducting their normal tasks and responsibilities during special situations or crises. The sectoral data and intelligence information is produced and disseminated through several parallel and partly overlapping channels.

New requirements are to be covered especially in the fields of cyber security. The *Finland´s Cyber security Strategy 2013* presents a programme for improving the cyber security.[24] There is included a goal to improve comprehensive **cyber situation awareness** of different actors by furnishing them with real-time, shared and analysed information regarding vulnerabilities, disturbances and their effects. The situation picture will include threat assessments emerging from the cyber world. Cyber threat prediction requires the analysis of the political, military, social, cultural, technical and technological as well as economic situation. The Cyber Security Centre will collect information on cyber incidents and disseminate it to different actors which then estimate the effects of the disturbance on the activity they are responsible for.

The general rule is that those running the activities are also responsible for the content of the **communications**. Other authorities provide support. Each authority is responsible for disseminating information about their activities. However, coordination, contacts and cooperation are of particular significance. *The Government Communications Unit* is responsible for the Government's and the Prime Minister's communications, as well as for coordination of the dissemination of official information.[25]

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[23] Prime Minister's Office Press release 5. December 2012: *Government resolution clarifies organisation and responsibilities with respect to comprehensive security*: http://vnk.fi/ajankohtaista/tiedotteet/tiedote/en.jsp?oid=371437

[24] *Finland´s Cyber security Strategy 2013*. Government resolution 24, January 2013.

[25] *Government Communications in Crisis Situations and Emergencies*, Prime Minister's Office Publications 20/2008.

Finland has only one **emergency number** — 112. The same number works in all EU countries. Calling 112 is free of charge from any phone and with no need for an area code. [26]

The **Emergency Response Centre Administration** under the Ministry of the Interior provides emergency response centre services throughout Finland, except for the Åland Islands. The duty of the Emergency Response Centre Administration is to receive emergency calls from all over the country for the rescue, police as well as for social and health services; handle communications relating to the safety of people, property and the environment; and relay the information they receive to the appropriate assisting authorities or partners.

As the crisis escalates, communications shall be further intensified and the communications control may be centralized in the Prime Minister's Office. If necessary, a **Government Information Centre** is established. The Centre can issue orders to state authorities as regards the content of information. The authorities and the media shall work in close cooperation, but the proper functioning and independence of the media should be guaranteed.

According to the Government strategy the information service has a role in maintaining overall psychological crisis resiliency. Communications maintain the psychological and social fabric of society and help strengthen confidence in the authorities. Communications should also serve to prevent rumours, combat negative opinion making and prepare for information operations. Crisis communications and relevant responsibilities are included in the strategic tasks of the Prime Minister's Office.

4.8 Relations between state and its citizens

The participation of citizens in civil security duties occurs mostly in local and municipal level organisations. The regional state administrative agencies provide expert assistance to municipalities in matters related to preparedness and the municipality's contingency planning. In addition, the regional state administrative agencies support the competent authorities and, when necessary, coordinate their activities when the authorities are managing security situations in the region.[27]

In order to promote regional preparedness, the regional preparedness committees led by the director-generals of the regional state administrative agencies, have been established. These committees have wide representation from all key actors in the region and the regional administration. Such actors include the municipalities, the police and rescue services, the Border Guard, the Defence Forces, the hospital districts, the emergency response centres and various organisations, such as the Finnish Red Cross.

The organisation's opportunities for cooperation with the regional state administrative agencies and ELY (economic-environmental) Centres are only beginning to take shape. It is therefore hoped that

[26] Ministry of the Interior, 2014: www.intermin.fi/en/security/emergency_number_112_and_emergency_response_centres
[27] See *Preparedness and comprehensive security*. Committee report 28, November 2011: http://vnk.fi/julkaisut/julkaisusarja/julkaisu/en.jsp?oid=344062

the transitional period of regional administration reform will soon be brought to a conclusion, with good practices continuing as soon as possible.

The Red Cross has continued its cooperation, initiated when the province administration still existed, on preparedness committees and working groups. The preparedness committee provides a viable opportunity for organisations to exchange preparedness-related information with various actors. Genuine interest by the authorities in working group co-operation with the Red Cross has been viewed very positively; it is hoped that this will be strengthened despite structural changes.

The regional aspect is emphasised in contingency and security planning conducted in cooperation between NGOs and authorities. The boundaries of Red Cross districts currently encompass different municipalities to regional boundaries, for instance. As a result of the regional-level aggregation of key authorities, such as the police and rescue services, in the planning of preparedness activities the districts' operational areas do not enable efficient co-operation with the authorities.

In future, volunteers' activities in support of authorities should be made official by means of written contracts. In this way, issues such as personnel changes would not endanger the position of volunteers in preparedness activities. Under normal conditions, the preparedness committee is responsible for coordinating regional contingency planning between various authorities. Coordination of preparedness should be based on risk analyses, drawn up for each region, and threat assessments of accidents. During disturbances and emergency conditions, the preparedness committees can be convened to discuss the resolution of the crisis or disturbance. Nevertheless, the regional administrative authorities have no role in actual (operational) crisis management, with the exception of the previously mentioned co-ordination task and some other duties under their responsibility, as laid down in special legislation. Regional state administrative agencies transmit information in support of operative, political and administrative decision-making by the municipalities, regional administration, other central government functions of the ministries and competent authorities within the region.

The *private sector in civil security* area covers activities performed by businesses, bodies under public law and organisations as well as various services and expert activities provided by the private security sector.

The *private security sector* covers guarding services, security steward services, security services and security check services. The private security services must have a licence. The powers of guards are laid down in the *Private Security Services Act*. Provisions on the whole private security sector are contained in a number of Acts. This has led to ambiguity and conflicting interpretations between the different elements of law. The Ministry of the Interior is reforming legislation on the private security sector.

4.9 Conclusions

The Finnish civil security and crisis management systems have been developed after the Cold War from the preparedness to overcome extreme situations, a total war included, towards a more peace-time oriented arrangements which are based on the comprehensive security concept.

The present crisis management system is generally appreciated as adequate and has functioned rather well in exercises. The emergency legislation has been modernized so that the *Preparedness Act* is from December 2011. According to the law Finland is still prepared to cope also with extreme crisis situations with the national defence system which is organized according to the "comprehensive approach" and frequently exercised. The *Government resolution on comprehensive security* (5th December 2012) defines the strategic guidelines for civil security rather similar as the EU strategy for internal security.

An *emergency situation* can be managed with usual administrative measures without special crisis management arrangements, but the same system of alarm and decision making should be used as a basis for preparedness concerning all kinds of crisis and other emergency situations following the "all hazards" principle.

There have been problems in managing surprising emergencies or minor crisis situations, especially so called normal-time disturbances, which can emerge rapidly, have many surprise elements and need inter-sector measures. This kind of situation was also the Tsunami disaster in December 2004. It occurred in a distant country but affected many Finnish citizens and required urgent rescue and evacuation measures. It also required rapid and decisive crisis management.

The lessons-learned from the Tsunami catastrophe 2004 have been taken into account in the preparedness arrangements of the Government, Foreign Ministry and rescue services. However, some administrative and operational culture problems still exist in that kind of crisis situations. For example, it has not been easy to get good information from large and severe disasters, especially if they occur in foreign countries or in large areas. Also the responsible authority may be difficult to be defined in such circumstances. Moreover, responsibilities and cost sharing between public and private sector in conducting rescue missions have been rather unclear.

The great variety of crisis types and the need to make decisions swiftly also in "civil crises" have made it necessary to construct an effective system for maintaining situational awareness. A situation centre has been built for the permanent use of the government, and it is located at the Prime Minister´s Office at the Government Council. There are still the usual military, police and border guard command and control systems as well as air and maritime surveillance arrangements for operational tasks.

The principle of independency of administration sectors concerning crisis management in Finland is well functioning in the contingency planning and in responding to such emergency situations which can be clearly defined and managed by one sector of the state administration. Difficulties may emerge especially with crises which have inter-sector effects and must be handled without delay. The most problematic case would be a terrorist attack against some vital functions of society or critical infrastructures in Finland or in vicinity. The risk is rather low because of a small probability, but the consequences would be very fatal.

The most threatening risks for Finnish civil security are conditions in which severe weather situation - especially winter storms, flooding in shore areas and cold - combines with disturbances in the electric power-grid. Such a situation can affect also land transport infrastructures, and at worst endanger the safety of nuclear power plants.

The resources for civil security can be generally estimated as sufficient. There are still problems which should be studied. They are mostly linked with managing crises which have inter-sector effects land transport infrastructures and need to be handled rapidly. Especially challenging situation would be a combination of large scale storm with an unexpected interruption in the nuclear power plants. The risks are rather low because of a small probability, but the consequences would be very fatal. Therefore, they cannot be studied in Finland only on the basis of national experience. Those kinds of threats and risks are, however, included to the comprehensive security concept presented in Government resolution from December 2012.

5. Description of the extreme weather event – summer storm 2010

5.1 Description of the meteorological events

A phase of hazardous storms began at the end of July 2010. All storms occurring during this timeframe were linked to same weather pattern. From early July to mid-August, Finland had exceptionally warm temperatures causing these phenomena. At the end of July the Finnish Meteorological Institute reported some alarming weather conditions and record high temperatures.[28]

The storm Asta hit Finland on the night of 30th July 2010 at 02.00 am. Asta (30th July) was followed by Veera storm (4th August), Lahja storm (7th August) and Sylvi storm (8th August). These severe storms had an impact on 11 days at the same regions multiplying their costs/effects. This weather phenomenon was characterized by high winds, rain and sometimes hail as well as thunderstorms.

In this chapter the special emphasis is on Asta storm which was typical thunderstorm with downward flows. Its strength and amount of blizzards (24 415) made it exceptional. Especially its occurrence during the night hours with downward flows makes it rare – but fortunate, as it prevented human losses. Asta proceeded with 100 km wide storm front and it affected the Finnish territory during 4,5 hours. The approximate speed was 102 km/h and the highest measured wind was 29 m/s. It affected five regions: South Savo, Southern Karelia, Northern Karelia, North Savo and Central Finland. The economic losses of this storm surge was biggest for the forestry (30 000 km2) and in financial terms 50,4 million euro (refunded by insurers). The electricity network was badly damaged affecting 1/3 of electricity providers in Finland (480 000 clients and leaving 100 000 of them longer than 12 hours without electricity). The longest interruptions experienced in permanent residences in rural areas were up to a month and even longer in holiday houses.

This chapter is focusing on effects of Asta storm to South Savo Region which has 155 000 inhabitants and the administrative centre is Mikkeli. The regional structure is heterogeneous and built on three major cities Mikkeli, Savonlinna and Pieksämäki. A special characteristic is large amount of lakes – one quarter of the territory is water (almost 40% of the territory in some municipalities).[29] Agriculture and forestry are largest employers and economic sectors in this region.

[28] Onnettomuustutkintakeskus. Heinä-elokuun 2010 rajuilmat. S2/2010Y. 7. Available from: http://www.onnettomuustutkinta.fi/en/index/tutkintaselostukset/muutonnettomuudet/tutkintaselostuksetvuosittain/muutonnettomuudet2010/s22010yheina-elokuun2010rajuilmat.html

[29] SPEK, Rajuilman vaikutukset paikallisten yritysten liiketoimintaan 2012, p. 7.

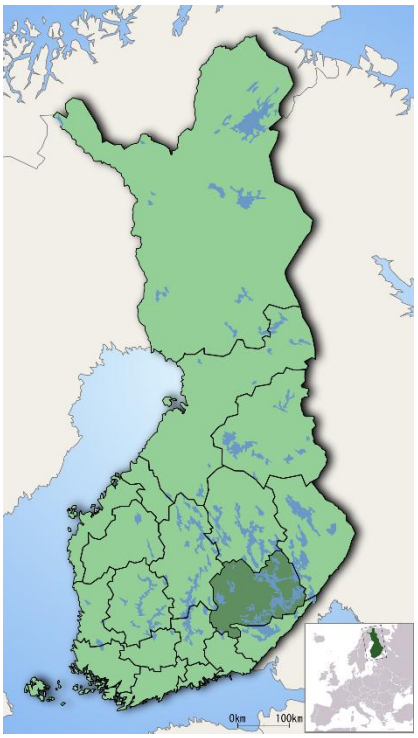

Figure 10: South Savo Region in Finland.

5.2 Situational awareness

The first symptoms arrived on 29th July 2010 when the storm arrived from Karelia towards Finland. Right before the midnight the storm reached the Finnish eastern border. It was proceeding with 100 km wide range and its first implications were felt at 00.20 am at Sulkava municipality. The storm destroyed vast amount of forests in Sulkava, Rantasalmi, Kitee and Joroinen. In Sulkava only, there were tens of thousands trees destroyed. These blocked roads, caused material damage to houses and vehicles, disrupted the water and sanitation systems and scaled down the electricity grid.

The first responder was the South Savo Rescue Region (Department) which also served as a central command unit in the Asta storm. It received 210 emergency missions.

The storm arrived so quickly that only a few dozen seconds were available to react or seek cover. Based on Accident Prevent Authority report, on the basis of weather alerts, both citizens and the first responders had difficulties in formulating what these storms meant in practise. It is not possible to forecast the precise areas affected by such downbursts.[30] During the storms the rescue departments were unable to maintain a situational picture which could serve various authorities and other actors.

[30] Onnettomuustutkintakeskus, Heinä-elokuun 2010 rajuilmat. S2/2010Y. 7. Available: http://www.onnettomuustutkinta.fi/fi/index/tutkintaselostukset/muutonnettomuudet/tutkintaselostuksetvuosittain/muutonnettomuudet2010/s22010yheina-elokuun2010rajuilmat.html

In order to maintain the situational awareness the Savonlinna rescue station served as a basis for the TOJE (Sectoral command centre). From the South Savo Rescue Department the information was sent to Regional Administrative Agency of Eastern Finland (AVI Eastern Finland). From AVI Eastern Finland the information was channelled to the Situation Centre of the Ministry of the Interior. From the Ministry it was further sent to Government Council Situation Centre.

It is notable that South Savo Rescue Department has later noted that they did not receive any kind of coherent and centralized situational picture of the national level. However, the Finnish Meteorological Agency (FMI) did send early warning signals. The South Savo Rescue Department was able to map the risk area only after the exact radar picture was received.

First warning of the weather conditions was sent to authorities 30 hours in advance before Asta storm. The Finnish Meteorological Institute gave an early warning on 29th July about “very strong thunderstorms” in four separate announcements. The warning included special remark about heavy rains in those areas where the rain water will exceed 30 mm in an hour. The FMI weather forecast warning included elements of thunderstorms and heavy winds.

The South-Savo Rescue Service in Savonlinna noted 396 rescue missions only during 30th July. On next day the amount had decreased to 34. All together there were 692 dispatch calls to South-Savo during the 10 days period of time.

Building up situational awareness was difficult as most the helicopters were booked to Jyväskylä Neste Oil Rally. The first flight was done on 30 July at 06.00 am.

The regional rescue departments feel that there should have been more systematic mechanism to provide situational data to field units and regional rescue operators. This should include both the national level data and the weather data from the FMI. The situational awareness should be two-way proceeding and comprehensive. The sectoral thinking should be abandoned in order to achieve better inter-sector and inter-agency cooperation.

Municipalities

Whereas the national level response was not needed and the essential authorities declared that the situational awareness had been sufficient, the local and municipal level authorities faced difficulties to obtain timely and coherent data. Challenges emerged of sharing capacities and data cross the borders of the regional rescue services. Also there was no request of mobilizing the Finnish Rescue Force (highly equipped Finnish rescue commando battalion) or the first assistance units of rescue services (*Pelastuslaitosten virka-apukomppania*) to provide assistance to worst hit regions.

Referring to the Safety Investigation Authority the municipalities´ management groups convened only in rare cases even in the worst storm damage areas. This demonstrated better-than-average readiness for the management of storm disturbances in those municipalities which had agreed to collaborate with the rescue department in alerting their management groups. Such municipalities

were also better prepared with their management capabilities of key people and other management support activities during disruptions.[31]

Municipalities have highlighted the need for information from electricity companies and rescue departments in particular. They also emphasized the need for continuous cooperation with the private sector (such as nursing facilities).

Citizens

The role of citizens in this particular storm case should be further evaluated in terms of producing situational data for the authorities. This is particularly needed in rural areas with long distances. The latest IT and mobile applications should be, and the focus should be on mobile phone applications producing live and photo data.

5.3 Management of emergency

Finland has only rarely been affected by severe weather phenomena. Referring to the Accident Prevention Authority report (S2/2010Y) on storms of July-August 2010 this largely explains why essential emergency response actors did not have operating models in place enabling them to fully react to early warning signals. It also explains why measures were only taken in the wake of the damage caused by the Asta storm.[32]

The first response was conducted by the South Savo Rescue Department. Decision was concerning what kind of land transport networks will be prioritized in work to secure the logistics and vital functions of society. Destia is a Finnish infrastructure and construction service company which used to be publicly owned operator. During the Asta storm Destia was providing information about the damages to land transport network. The emphasis was to secure those roads which had asphalt pavement coverage.

The amount of emergency calls was so high that the South Savo Rescue Department was forced to encourage the citizens to take some measures on their own.

The response measures lasted weeks. Several trains were replaced by busses. Many roads were cut off with falling trees and other interruptions.

[31] Onnettomuustutkintakeskus. Heinä-elokuun 2010 rajuilmat. S2/2010Y, p. 8. Available: http://www.onnettomuustutkinta.fi/fi/index/tutkintaselostukset/muutonnettomuudet/tutkintaselostuksetvuosittain/muutonnettomuudet2010/s22010yheina-elokuun2010rajuilmat.html

[32] Onnettomuustutkintakeskus. Heinä-elokuun 2010 rajuilmat. S2/2010Y, p. 7. Available: http://www.onnettomuustutkinta.fi/fi/index/tutkintaselostukset/muutonnettomuudet/tutkintaselostuksetvuosittain/muutonnettomuudet2010/s22010yheina-elokuun2010rajuilmat.html

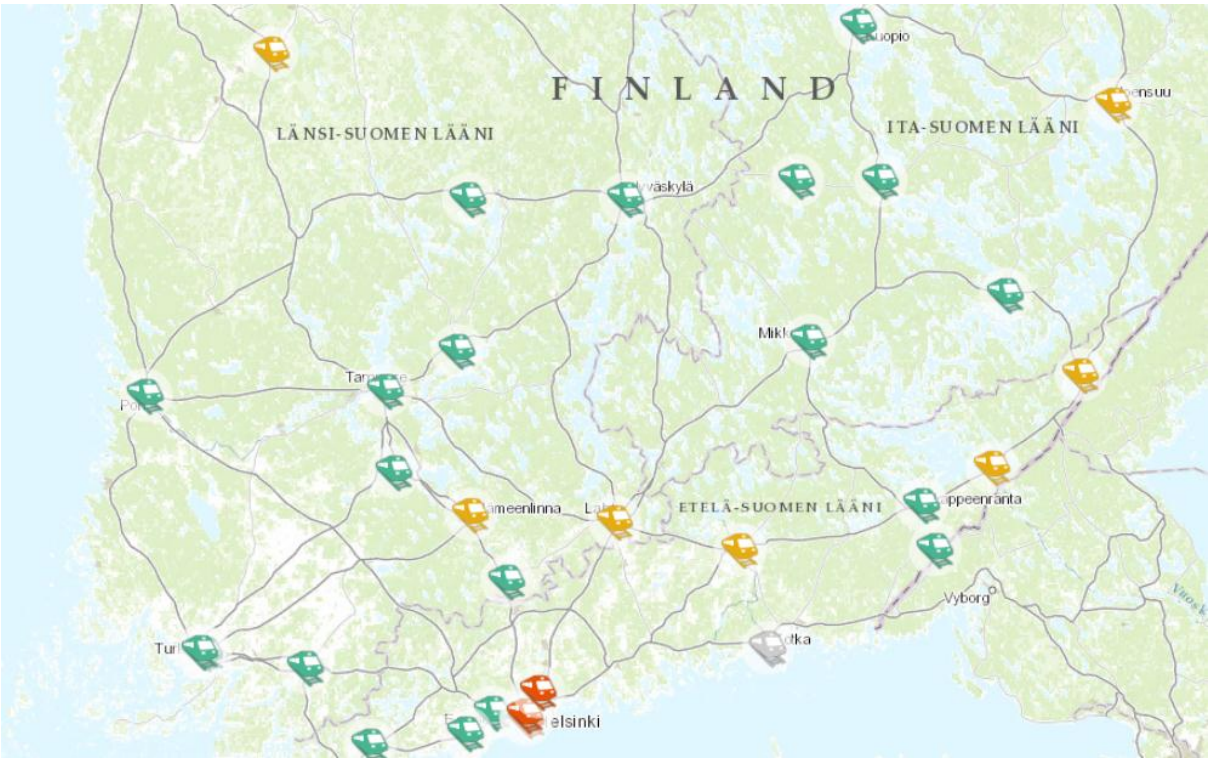

Figure 11: Finnish land transport networks affected by Asta storm in 2010
Source: Liikennevirasto, 2015. http://liikennetilanne.liikennevirasto.fi/

5.3.1 Local and municipal level

The geographical area where the Asta storm took place is wide and demanding due large lake areas. The time frame of July-August is most active holiday season and results to multiply the population in Eastern Finland. Most of the holidaymakers were used to rapid reaction by emergency authorities due living in metropolitan area. However, in remote areas of Eastern Finland the first responders might arrive after one hour or so. Difficulties emerged as the electricity was down which resulted to bad communications between citizens and the rescue authorities.

In Finland the rescue services have gone through wide transformation process “Regionalization of Finnish Rescue Services”. In the regionalization process the previous system of rescue services run by individual municipalities (there were over 400) was changed into a regional system comprising 22 regional organizations. The reform aimed to make more effective use of the resources and improve quality and availability of the services. The previous rescue services system had several weaknesses, which were mainly due to the fact that many municipalities were so small and there were too few civil servants. The financial limitations of small rescue service units were severe, e.g. purchase of a fire-engine could only be done once every 20 years. There was duplication of work in administrative affairs. There were no possibilities for staff to specialize. Furthermore, there was not enough cooperation in administrative level; and limited personnel resources. Cooperation between the

municipalities did take place mainly in operations, not really in administrative level. In addition, the level of rescue services varied a lot between municipalities.[33]

Although there were already clear cost benefits of the regionalisation of the rescue services, there are still essential differences in the "materialization" of the benefits of the new system. For instance, the current situation seems to vary when comparing the situation in the large urban centres of the Southern Finland to the Northern Finland where distances are longer and rescue capacities weaker. It comes as no surprise that the "winners" of the regionalisation have been described by the interviewed experts as being smaller municipalities and cities. The "losers" have been described to be larger urban centres and cities which are obligated to allocate their resources to wider areas. Also the various interests of the municipalities included to the same rescue regions might diversify and complicate the allocation of resources and long term planning within a single rescue region.

As indicated in the Eurobaltic case study report *"Regionalization of Finnish Rescue Services"* by Anna Halonen and Timo Hellenberg (Eurobaltic Project, 2006), the rescue leaders among the new rescue regions tend to underline that there should be comprehensive and up-to-date situation analysis at the level of the government. The RAIN project interviews at the Helsinki City Rescue Department and at the East Uusimaa Rescue Region have enhanced this prevailing hypothesis. This could be a joint situation and monitoring system based on multi-agency cooperation instead of the central role of the Ministry of the Interior. The indicators could be distributed among the country in order to get comprehensive situation analysis. The rescue regions should be able to receive risk information from the government council and to provide information seen necessary.

Referring to the Safety Investigation Authority´s report on the storms July-August 2010 the rescue service operations showed insufficient practical readiness for the management of situations with far-reaching effects. The report also highlights that rescue departments and their contract fire brigades carried out plenty of tree clearance work which is not included in rescue operations defined under the Rescue Act.[34]

5.3.2 National and governmental level

The Ministry of the Interior soon announced that there is no need for national rescue measures and the Ministry does not see necessary to take national coordination role due the storm. The Ministry noted that the regional rescue services had informed about the developments and they had performed well. Director-General Pentti Partanen noted that the Finnish Meteorological Institute has provided timely and concrete weather forecasting which helped the authorities to prepare for the rescue measures. He noted that also the electric power companies and rescue service regions were

[33] See: A. Halonen & T. Hellenberg. 2006. Eurobaltic case study report: *"Regionalization of the Finnish Rescue Services".* Available from: http://www.helsinki.fi/aleksanteri/civpro/publications/eurobaltic_case_study_regionalisation_of_finnish_rescue_services.pdf

[34] Onnettomuustutkintakeskus, Heinä-elokuun 2010 rajuilmat. S2/2010Y. p. 8. Available: http://www.onnettomuustutkinta.fi/fi/index/tutkintaselostukset/muutonnettomuudet/tutkintaselostuksetvuosittain/muutonnettomuudet2010/s22010yheina-elokuun2010rajuilmat.html

able to respond more timely based on this weather forecasting. Critical comments soon emerged from several Rescue Departments due the incoherent situational picture.

5.4 Consequence management

5.4.1 Administration

The power utility companies expressed their wish that the risk resilience of the current electricity network should be improved which would mean increasing electricity power stations and automatic system of network service. Moreover, there was issued a wish for the underground cabling of the distribution network.

Whereas the regional rescue services were more reserved and rather critical about the support received from other regions and the national level, the Regional State Administrative Agencies (AVI) were positive about their assessment. For instance the AVI Eastern Finland expressed their gratitude to multiple spheres of society for their cooperation.

Most critical comments came from municipal level authorities. Their point was focusing on weak preparedness, incoherent situational awareness and poor reactivity which were laid on shoulders of few persons and authorities. Improvisation was essential for success instead that the consequence management would had been conducted basing on system approach.

5.4.2 Material damage

The total costs have been estimated to be over 32 million euros (standard compensations 10 million, operational costs 18 million and investments 4 million).

The biggest economic losses occurred **in forestry** during summer of 2010. According to the Finnish Forest Research Institute Metla, a total of 8.1 million m3 of standing timber fell or was destroyed.[35] This is same amount than 15 percent of the annual cutting amount. The direct losses to forestry resulted by July-August storm season have been estimated to 240 000 hectares of land. One tenth (24 000) was totally destroyed. The most severe material damage was caused by exceptionally strong downbursts. These occurred mainly during night time.

Referring to the Accident Prevention Authority, as a result of forest damage, **electric power networks** (including distribution networks) were destroyed in the storm impact areas.[36] The electric grid and distribution networks were largely affected in Eastern and Central Finland. A total of 35 000 kilometres of electric power network were destroyed or damaged. As a result, some 9 000 distribution sub-networks were left without electricity. Power cuts and their consequences were more widespread than in the immediate storm areas.

They affected one third of the service providers and about 480 000 electricity customers. Almost 100 000 of them were longer than 12 hours without electricity. The Asta storm caused interruptions

[35] Onnettomuustutkintakeskus, Heinä-elokuun 2010 rajuilmat. S2/2010Y, p. 7. Available: http://www.onnettomuustutkinta.fi/fi/index/tutkintaselostukset/muutonnettomuudet/tutkintaselostuksetvuosittain/muutonnettomuudet2010/s22010yheina-elokuun2010rajuilmat.html
[36] Ibid.

to electricity distribution due the falling trees on main electric network. In South Savo electrics were down from 23 000 households and in Eastern Finland approximately 40 000 households were without electricity.

The wide extent of damage and repair needs led to rather long power cuts. Electric power failures hit also archipelago in big lakes like the Saimaa Lake. The longest period of time being without electricity was six weeks.

The long power cuts led to significant disturbance to other functions vital to society, such as communications networks, water supply and transport infrastructure.[37]

Mobile phone networks were cut off in large areas. The mobile link stations went down as reserve power units were used. There were 1050 GSM and UMTS mobile phone support units down. The mobile phone operators tried to provide extra power for support units by using aggregates. Elisa mobile phone operator stated that the phone connections were down on 100 km wide range. Most of the Elisa clients suffered were in the north of the Imatra, Mikkeli, Jyväskylä and Karstula. The other tele-operator Sonera reported that most of the interruptions were in the area between Savonlinna, Varkaus and Viitasaari. The third tele-operator DNA reported that largest disruptions were measures in the Savonlinna region. Most crucial support units were placed with portable aggregates. Elisa operator reported that 30 000 clients were suffering of bad connections only in the South Savo region.

Soon after the pumps in water towers stopped working and authorities gave order to avoid using water in Joroinen, Sulkava, Rantasalmi, Kerimäki, Enonkoski and Juva.

5.4.3 Social and human losses

The storms of July-August 2010 caused directly one death and several dozens injured persons. Most of the human injuries were caused by flying objects, falling trees and slippery conditions. Some persons were hurt while piling wood from roads and pushing through blocked roads.

5.4.4 Cascading effects

Major cascading effects were caused by falling trees and destroyed forestry. When strong winds were cutting trees they took electricity cables with them. This caused wide black outs in multiple regions. Another challenge was caused by roads which were cut down by flying trees and other materials such as roofs. Rail roads were mostly working normally.

[37] Ibid.

6. Description of the extreme weather event - winter storm 2011

6.1 Description of meteorological event

The whole December 2011 had been warm and windy in Finland. The mean temperature was 5—9 degrees Celsius warmer than in a usual December weather, and there were 11 stormy days as the average is three.[38]

The storm was born on Northern Atlantic near Iceland on 25th December, and it arrived to the coast of Norway later that day. There were cyclone-strong winds of over 45 meters per second measured on Norwegian coasts. Most violent gust wind speeds were over 60 meters per second. The storm was named Dagmar in Scandinavia.[39] Also coastal areas of Estonia and Russia were later influenced.

Depression moved across Finland from the Northern Ostrobothnia towards Kainuu area, and it caused strong western winds on southern edge of depression, meaning Western and Southern Finland.[40] There are major cities like capital Helsinki and its metropolitan area as well as Turku and Tampere but also large sparsely populated areas.

The storm called Tapani in Finland hit the west coast of Finland after midnight on 26th December and moved across the country lasting 16 hours. Stormy winds were blowing 285 degrees from the West.[41] The gust wind speed was over 30 meters per second in many places in South-Western Finland. Some observation centres were left without electricity and could not measure wind speeds during the most violent moments of the Tapani storm[42]. The strongest 10 minute average wind speed was measured in coastal town Kaskinen: 28.5 meters per second. The strongest gust wind speed, 31,5 meters per second, was measured in Espoo, Sepänkylä.[43] Around 10 o'clock some regional rescue departments advised people to stay indoors due to dangerously strong wind.[44]

In the afternoon the wind calmed down but the next day, 27th December, also saw some strong winds. This Hannu storm was not as violent as Tapani. There were some gust wind speeds of over 30 meters per second on sea areas in the Bothnian Bay and some over 25 meters per second for example in Northern Savo, Northern Karjala and Northern Ostrobothnia regions. Still, the Hannu

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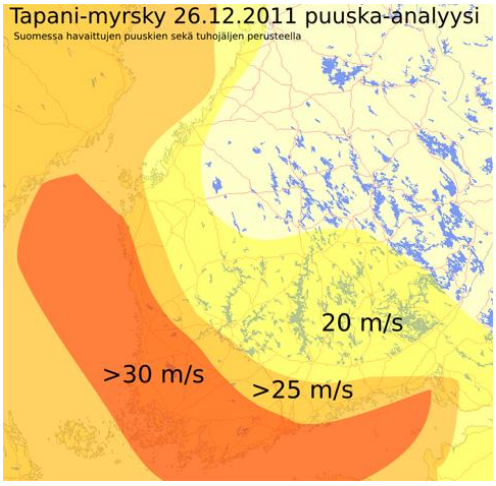
38 Finnish Meteorological Institute press release 9.1.2012: http://en.ilmatieteenlaitos.fi/press-release/465179
39 Swedish Meteorological and Hydrological Institute article 15.2.2013: http://www.smhi.se/kunskapsbanken/meteorologi/dagmar-annandag-jul-2011-1.28718. See also Norwegian Meteorological Institute news story 26.12.2011: http://met.no/Forel%C3%B8pige+m%C3%A5linger+under+Dagmar.b7C_w7DY1R.ips
40 Finnish Meteorological Institute press release 28.12.2011: http://en.ilmatieteenlaitos.fi/press-release/462710
41 Gaia Consulting & FMI research Äärevien sää- ja avaruussääilmiöiden vaikutus kriittisiin infrastruktuureihin (Extreme weather and space weather phenomena's influence on critical infrastructure) 5.6.2013, p. 23. Available from http://www.huoltovarmuus.fi/static/pdf/637.pdf
42 Meteorologist Pauli Jokinen blog 2.1.2012: http://saabriefing.com/2012/01/02/outoa-saata-joulukuussa/
43 Finnish Meteorological Institute press release 28.12.2011: http://en.ilmatieteenlaitos.fi/press-release/462710
44 See Finnish Broadcasting Company YLE 26.12.2011: http://yle.fi/uutiset/viranomaistiedote_varsinais-suomeen_ja_pirkanmaalle/3129261

storm caused again faults on electricity lines and complicated repair efforts, which continued at full-speed for many days.



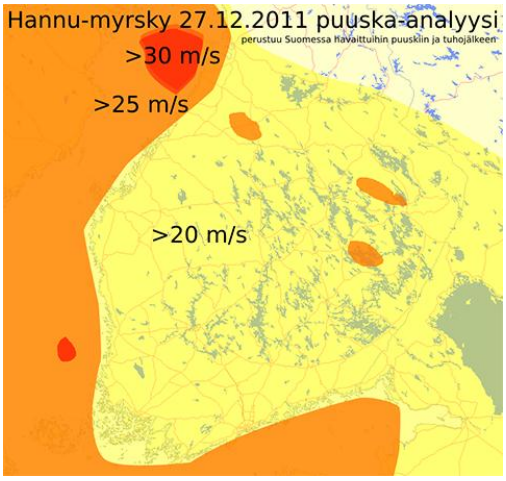


Figure 12. Wind speed in gusts 26th December 2011 was strongest in South-Western Finland, over 30 meters per second in Tapani storm. Source: Finnish Meteorological Institute. Monthly statistics: December. http://ilmatieteenlaitos.fi/aiemmat-joulukuut
Figure 13. Hannu storm 27th December 2011 was not as violent on land areas but caused power cuts and complicated repair efforts. Source: Finnish Meteorological Institute. Monthly statistics: December. http://ilmatieteenlaitos.fi/aiemmat-joulukuut

According to the Finnish Meteorological Institute (FMI), the Tapani storm was "rare but not unexceptional". There are similar winds measured a few times every decade on Finnish sea areas.[45] Still, it is often referred to be a storm of a "heavy league" and has been later categorised to level 1 storm. A research made by Gaia Consulting and FMI argues that damage would have been even greater if the storm took more northern course, moving from southwest to northeast. In such a case there could have occurred gust wind speeds of over 40 meters per second, and the storm would have swept down even more trees in Central Finland where forests are dominated by spruces.[46]

Tapani caused wide-spread damage on critical infrastructure: Faults of electricity lines left at the worst 300 000 houses and telecommunication base stations without electricity. The electricity cuts lasted long, some remote places being without electricity for more than two weeks. Also large areas of forest were destroyed.

The record-mild weather contributed to increasing damage. According to statistics it was the warmest Christmas in 50 years in Finland, and temperature was many degrees Celsius above zero.

45 FMI press release 28.12.2011: http://en.ilmatieteenlaitos.fi/press-release/462710
46 Gaia Consulting & FMI research Äärevien sää- ja avaruussääilmiöiden vaikutus kriittisiin infrastruktuureihin (Extreme weather and space weather phenomena's influence on critical infrastructure) 5.6.2013, p. 23. Available from http://www.huoltovarmuus.fi/static/pdf/637.pdf

Like mentioned, whole month had been mild. Land wasn't frozen, and so gusts ripped trees off the ground easily.[47]

The sea level rose, especially in the Bothnian Bay near by the city of Oulu, where the sea level rose at least 170 above the average. Fields flooded, roads were cut and some summerhouses were surrounded by water.[48]

There was also heavy rain, wet snow or snow, and the rains were believed to further complicate traffic. The 26th December is a public holiday and traditionally a day when many Finns travel home after spending Christmas with relatives. The Tapani storm caused problems to road and railway traffic by cutting down trees. Trains were replaced by busses between the cities of Helsinki and Turku, Turku and Tampere as well as Tampere and Pori. On 27th there were also problems in Savo region on railroads between Mikkeli and Pieksämäki and Pieksämäki and Jyväskylä.

In the biggest airport of the country, Helsinki-Vantaa, there was measured wind speed of over 30 meters per second in gusts, but the airport was operating normally. A big passenger ferry (Silja Serenade en route from Stockholm to Helsinki) arrived five hours delayed.[49]

6.2 Situational awareness

The Finnish Meteorological Institute informed officials of approaching storm first time on 23th December at 14 o'clock. Storm was forecasted to hit primarily Northern Finland and the Bothnia Bay area, where city of Oulu is. On 24th there was given an update, and the area potentially affected by storm became more accurate. FMI forecasted now that the storm would take a more southern route and affect southern and central parts of the country. On 25th at 14 o'clock FMI forecasted that the storm would be dangerous in Western Finland and have gust wind speeds of over 30 meters per second on sea and coastal areas. About 12 hours later, in an update given at 2 o'clock on 26th, the storm had already made some damage, and the area that would be affected was forecasted to be all Southern Finland.[50]

Next day, a new storm Hannu was forecasted to have gust wind speeds of 20 meters per second, and in Eastern Finland in some places 20—25 meters per second. Stormy winds were forecasted to blow from noon till the midnight.[51]

FMI used a semi-structured notice format that was called “VAARA” in 2011 (“LUOVA” from 2013 onwards). The notice is used for informing officials of all kinds of hazardous weather conditions.

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47 FMI press release 28.12.2011: http://en.ilmatieteenlaitos.fi/press-release/462710
48 Regional newspaper Kaleva 27.12.2011: http://www.kaleva.fi/uutiset/pohjois-suomi/myrsky-nosti-merivedenennatyslukemiin/560271/
49 Newspaper Helsingin Sanomat 27.12.2011: http://www.hs.fi/kotimaa/a1305552094623 and YLE 27.12.2011: http://yle.fi/uutiset/junaliikenteessa_yha_poikkeusjarjestelyja/5473735
50 Report of Ministry of the Interior 14.3.2012, p. 5: http://www.poliisi.fi/intermin/images.nsf/files/E19BA5BD6F160568C22579C200351C24/$file/myrskyselvitys_15032012.pdf; see also meteorologist Kerttu Kotakorpi lecture slides 8.4.2013: http://www.sppl.fi/files/1916/LuentoKotakorpi.pdf
51 Rescue Department for Western Uusimaa: Evaluation of Rescue Operations during 25.–28.11.2011, p. 7, 9. Not available online.

These notices are sent to officials including various ministries, regional rescue departments, Emergency Response Centres and Finnish Transport Agency, to inform and help to build situational awareness.[52] For example, Helsinki City Rescue Commander described relationship between FMI and the department well-functioning, as the "line is open 24/7".[53]

A representative of FMI later argued in an interview that all extreme weather conditions in 2011 were well forecasted.[54] Ministry of the Interior communicated right after the storm that rescue officials were well prepared for the storm, thanks to FMI's accurate forecasts.[55] There was criticism that officials were poorly prepared, but not for the sake of FMI. The head of Rescue Services at Regional State Administrative Agency (AVI) for South-Western Finland said in an interview that the officials reacted to forecasts "incomprehensibly slowly, especially regarding as the storm was forecasted well in time".[56]

Officials

Rescue officials started to prepare for storm on 25th December, as it was very probable that storm would increase their work load. Regional rescue departments got prepared to establish situation centres and informed contract fire brigade workers. Rescue officials also informed representatives of municipalities.57 In Helsinki, the rescue workers checked that all special equipment, for example chain saws, should be functioning normally.[58]

For example, Rescue Department for Western Uusimaa started the preparation at 18.00 on 25th December. A command centre was established before 23.00, and there were four people on duty (rescue chief as well as operations, situation and information chiefs). There was also one extra worker called in into situation centre. The command centre informed the Rescue Commander for Western Uusimaa that command centre was being established as well as all 12 municipalities of the area that a hazard scenario would be occurring. They also communicated with the regional

52 Report of Ministry of the Interior 14.3.2013, p. 5.
http://www.poliisi.fi/intermin/images.nsf/files/E19BA5BD6F160568C22579C200351C24/$file/myrskyselvitys_15; See also meteorologist Kerttu Kotakorpi lecture slides 8.4.2013:
http://www.sppl.fi/files/1916/LuentoKotakorpi.pdf
53 Interview with the Helsinki City Rescue Commander Mr. Simo Weckstén. 13.1.2015.
54 Ilta-Sanomat 25.5.2012: http://www.iltasanomat.fi/kotimaa/art-1288472066580.html
55 Finnish Broadcasting Company YLE 27.12.2011:
http://yle.fi/uutiset/pelastuslaitoksilla_oli_6_700_tehtavaa/3131519
56 Kimmo Holopainen: Tapanin opetukset. Red Cross magazine Avun Maailma – Hjälpens Värld 4/2012.
https://www.punainenristi.fi/sites/frc2011.mearra.com/files/tiedostolataukset/avun_maailma_4_2012_sydantalvi.pdf
57 Report of the Ministry of the Interior, 14.3.2012, p. 5.
http://www.poliisi.fi/intermin/images.nsf/files/E19BA5BD6F160568C22579C200351C24/$file/myrskyselvitys_15032012.pdf. See also Regional State Administrative Agency for South-Western Finland: Report 2:2012.
https://www.avi.fi/documents/10191/56990/Myrskyraportti+8.6.2012+LSAVI.pdf/5feb9ee3-426c-4806-99f7-220c2dd59955
58 Interview with the Helsinki City Rescue Commander Mr. Simo Weckstén. 13.1.2015.

Emergency Response Centre. During the next three days, the command centre was working (except between the storms, from 22.55 on 26th December to 8.00 on 27th December).[59]

Situation centres were established in 19 regional rescue departments. For example, Rescue Department for South-Western Finland established one command centre and five sectoral command centres.[60]

Regional rescue departments co-operated with emergency response centres. In South-Western Finland a rescue professional was placed to the Emergency Response Centre, where he helped to evaluate tasks and determine response. He also communicated with rescue officials and helped them to build situational picture. In Satakunta, the head of Rescue Department sat at the office of the Emergency Response Centre. However, the representatives of the Regional Rescue Departments were leading operations in Emergency Response Centres in some cases. A report by State Administrative Agency (AVI) for South-Western Finland argues, that this cannot be the case in future. The emergency response centres cannot expect that the rescue departments would send a leading officer to take control in risk evaluation. Also, there was a problem with sharing situational picture between the situation centre of Rescue Department and Emergency Response Centre in South-Western Finland.[61]

The Ministry and the state administrative agencies faced problems in organizing themselves during the storm and the immediate repair efforts. Regional State Administrative Agency (AVI) for South-Western Finland also established a situation centre that was working for four days, starting on 27th December 2011. The AVI situation centre provided situational reports to the Ministry of the Interior and to the Ministry of Social Affairs and Health, but could not get information from other officials as well as from local or regional levels. Also the Government Council Situation Centre did not share its information with the agency. A report by AVI argues that AVI itself couldn't maintain situational picture, and that the command centre of Rescue Department of South-Western Finland was the only official in country that was able to maintain a full situation picture during the storm.[62] This also means that situational reporting was made simultaneously in at least three places of administration, and those places did not communicate with each other. At the same time, a report by the Ministry of the Interior argues that the role of state administrative agencies was not clear.[63]

Citizens

The FMI first time publicly mentioned “strong winds” in a forecast made for the Christmas week. The forecast was published on 19th December and updated on the 22nd. Next release was published on

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59 Rescue Department for Western Uusimaa: Evaluation of Rescue Operations during 25.–28.11.2011, pp. 5—6. Not available online.
60 Report of the Ministry of the Interior 14.3.2012, p. 5. http://www.poliisi.fi/intermin/images.nsf/files/E19BA5BD6F160568C22579C200351C24/$file/myrskyselvitys_15032012.pdf. See also: Regional State Administrative Agency for South-Western Finland: Report 2:2012.
61 Regional State Administrative Agency for South-Western Finland: Report 2:2012, pp. 6, 11—12 and 22.
62 Regional State Administrative Agency for South-Western Finland: Report 2:2012, pp. 7 and 11.
63 Report of Ministry of the Interior 14.3.2012, p. 7. http://www.poliisi.fi/intermin/images.nsf/files/E19BA5BD6F160568C22579C200351C24/$file/myrskyselvitys_15032012.pdf

23rd, and it was updated 25th, a day before the storm hit Finland. This time the wind was forecasted to blow at least 18—23 meters per second and cause damage. In the release it was stated that these kinds of winds are probably cutting trees and causing electricity cuts. The forecast also mentioned that the sea level was expected to rise, even to dangerously high levels in Kvarken, the sea area between the Bothnian Bay and Bothnian Sea. During the storm the FMI published two official notices warning people of strong winds.

The notices on dangerously stormy weather were published on the FMI's web page and sent to all media. The publicly funded Finnish Broadcasting Company YLE is obliged to publish official notices. In 2011 they were read on the most listened and nation-widely operating radio network Radio Suomi and published on teletext[64]. In 2013, updated Act on official notices came into force, and previously existed categories or types of notice were united into one (named emergency warning). These warnings are read in all radio stations and if necessary, showed on television.[65] Notably, radio is still believed to be the best medium for use in case of emergency. But, how many people still have a radio that uses battery power in their houses? This question is raised in the AVI report.[66]

Some media was following the coming storm already on 25th December, when it was raging in Norway and Sweden. YLE told that all train traffic in Northern Sweden had been stopped. Many roads were blocked by toppled trees.[67] Though, these stories did not include any tips how to prepare for the storm which was approaching Finland. The Finnish officials did not instruct people for preparing against the storm. There was no advice given in the interviews in media or in press releases. This is stated also in the report of the Ministry of the Interior.[68]

On the contrary, in Sweden the officials of Västernorrland's region raised a public warning to level two, which is described to be a hazard scenario: a weather development that could pose a danger to the public as well as cause considerable material damage and major disruptions in the critical infrastructure. People were clearly advised to stay indoors and wait before starting to drive home. It was known, that many Swedes had been visiting relatives at Christmas and some traffic was expected. "If you must take the journey, the least you can do is not to hurry", the rescue officials advised in an interview for the Swedish News Agency TT.[69]

Also in Estonia, officials advised people how to prepare for the storm. A rescue official talking to the Estonian Broadcasting Company said that loose objects should be collected from yards, the cars

64 Teletext, text based index in TV, is still widely popular in Finland.
65 See also YLE FAQ page http://yle.fi/yleisradio/faq/viranomaistiedotteet/yleisradio-viranomaistiedotteiden-valittajana (visited 23.1.3015)
66 Regional State Administrative Agency for Southwestern Finland: Report 2:2012, p. 17. https://www.avi.fi/documents/10191/56990/Myrskyraportti+8.6.2012+LSAVI.pdf/5feb9ee3-426c-4806-99f7-220c2dd59955
67 YLE 25.12.2011: http://yle.fi/uutiset/myrsky_seisautti_junaliikenteen_ruotsissa/5472921; See also newspapers Ilta-Sanomat 25.12.2011: http://www.iltasanomat.fi/ulkomaat/art-1288437636816.html and Hufvudstadsbladet 25.12.2011: http://hbl.fi/nyheter/2011-12-25/pa-annandagen-kommer-stormen-0
68 Report of the Ministry of the Interior 14.3.2012, p. 6. http://www.poliisi.fi/intermin/images.nsf/files/E19BA5BD6F160568C22579C200351C24/$file/myrskyselvitys_15032012.pdf
69 Swedish News Agency TT 25.12.2011: http://www.dn.se/nyheter/sverige/dagmar-utloser-varning-i-vasternorrland/

should be parked to safe spots and the mobile phones charged. People were also advised to listen to radio. During the repair efforts rescue officials asked people to be patient and wait if damage was not causing an immediate threat. Also the state electricity company Eesti Energia advised people to leave their notices of electricity cuts on answering machine and to talk to a customer service agent only in the case they can indicate exact location of a damaged electricity line.[70]

On 26th December the Finnish media published stories about damage. There were updated numbers of households without electricity and collected picture galleries of the damage made by the storm. The first online news were published in the morning, after seven. Before noon, there were couple of official notices published: in Helsinki as well as in South-Western Finland and Pirkanmaa people were advised to stay indoors; in Eastern and Central Uusimaa region the emergency number 112 was jammed, the officials informed.[71]

During the next day media continued to follow repair efforts. Three days after the storm the newspaper Helsingin Sanomat wrote that electricity companies were facing heavy criticism. Especially the market leader Fortum was in the eye of criticism. Electricity companies' phone and internet services were jammed and people were frustrated. The paper told about a man from Espoo, who drove to the Headquarters of Fortum electricity company to deliver his notice of an electricity cut in person. He told that he had tried to call and use the internet customer service for almost two days without succeeding and described the situation as “catastrophic”.[72]

Electricity companies

But neither were the electricity companies able to build a good situational picture. Fortum used helicopters to map damage, but this happened only after the second storm, apparently on 28th December. The head of PR department of Fortum told in an interview that even though the phone calls would have been answered, company could not have been able to tell to people, when the electricity cuts will end. Fortum itself was not aware of all failures and could not maintain a full situational picture.[73]

Fortum had problems in communication with officials, too. For example, in Western Uusimaa the first signs of communication difficulties with Fortum emerged already on 26th. Rescue Department for Western Uusimaa tried to contact Fortum at 11.50, but it could not get in touch with representatives of the company. On 28th at 11.00 in the staff meeting of the heads of the rescue mission, it was stated that the Rescue Department had difficulties to communicate with the

70 Estonian Broadcasting Company ERR 25.12.2011: http://uudised.err.ee/v/eesti/7445c4d0-fa8b-4022-bcda-597639e0d447, ERR 26.12.2011 http://uudised.err.ee/v/eesti/225bc33d-a11c-44c7-8305-7da542c54493 and ERR 26.12.2011 http://uudised.err.ee/v/eesti/d21f2144-d092-4bd4-a808-ca15db978b13

71 See official notices published on YLE 26.12.2011: http://yle.fi/uutiset/viranomaistiedote_varsinais-suomeen_ja_pirkanmaalle/3129261; http://yle.fi/uutiset/viranomaistiedote_ita-_ja_keski-uudellemaalle/3129364

72 Janne Toivonen, “Sähköyhtiöille sataa kritiikkiä” 29.12.2011: http://www.hs.fi/paivanlehti/arkisto/S%C3%A4hk%C3%B6yhti%C3%B6ille+sataa+kritiikki%C3%A4/aaHS20111229SI1YO02muq?src=haku&ref=arkisto%2F

73 Finnish News Agency STT 30.12.2011: http://m.aamulehti.fi/kotimaa/fortum-tehosti-asiakaspalvelua-paivan-myohassa-emme-osanneet-varautua-nain-isoon?v=1

electricity company Fortum, and their internet pages were not functioning. In the meeting the head of the mission decided to inform Fortum on most vital places for the critical infrastructure via a liaison official. In the next meeting at 14.00, it was stated that a fire chief was already at the office of Fortum. Therefore, it took at about 48 hours to get a liaison person to the spot. During this time, the Rescue Department had no reliable line for communication with the main electricity provider.[74]

The officials, municipalities and electricity companies did not have well-functioning systems neither for communication nor for sharing the situational picture. The AVI report argued that a system that enables building and sharing of the situational picture was needed. Also the electricity companies have to be integrated to the mobile official's VIRVE-network.[75]

6.3 Management of emergency

6.3.1 Local and municipal level

Municipalities had problems in their emergency response functions. Especially in small municipalities it was difficult to find enough people for work. The Christmas and vacation time complicated efforts.[76]

The emergency response and rescue officials were loaded with work, receiving thousands of calls and assignments. Electricity cuts were the main factor in causing problems in the management of emergency. First, the electricity cuts had a direct effect on work of the health care officials and water service. Second, the cuts caused problems to communications.

In the health sector, the electronic health record systems stopped working in some health care centres. There were also problems with electronic locks. One nursing home facility suffered by a water cut, one health care centre was left without heating. In Sauvo and Paimio municipalities the health care centres and facilities of intermediate or long-term care did not have generators in 2011, which made their services vulnerable. Municipalities took action to improve their preparedness after the Tapani storm.[77]

The most water and sewage service stations did not have emergency power sources, and therefore they faced problems during electricity cuts. Therefore, during the cuts the stations could not pump water up to water towers. The sewage treatment stations used pump trucks and had to let some

74 Interview with the Rescue Commander for Western Uusimaa Mr. Veli-Pekka Ihamäki. 13.1.201. See also Rescue Department for Western Uusimaa, Evaluation of Rescue Operations during 25.–28.11.2011, pp. 5—9. Not available online.
75 Regional State Administrative Agency for South-Western Finland: Report 2:2012, p. 21. https://www.avi.fi/documents/10191/56990/Myrskyraportti+8.6.2012+LSAVI.pdf/5feb9ee3-426c-4806-99f7-220c2dd59955
76 Regional State Administrative Agency for South-Western Finland: Report 2:2012, p. 9.
77 Regional State Administrative Agency for South-Western Finland: Report 2:2012, pp. 9–10. https://www.avi.fi/documents/10191/56990/Myrskyraportti+8.6.2012+LSAVI.pdf/5feb9ee3-426c-4806-99f7-220c2dd59955

dirty water run to rivers or ground. In some municipalities, the sewage treatment stations were working in emergency mode for days.[78]

Long-lasting cuts made telecommunication base stations run out of power and this caused faults in both public mobile network and official network (VIRVE). The public mobile network had full cuts and a weak reception capability. Base stations had batteries that secured operations of stations for three hours but they run out of power. At the worst, one third of the base stations located in South-Western Finland were down. The telecommunication company Elisa fixed problems so that a day after the storm at noon there were only 6 per cent of base stations down.

The officials' network VIRVE suffered severe problems. In South-Western Finland half of the base stations of VIRVE network were down at the worst. The Defence Forces were requested for official assistance to provide generators to base stations. However, some VIRVE network base stations could not be plugged in into the generators.[79] The Helsinki City Rescue Department argued that VIRVE stations were said to be OK in paper, but the officials did not make visits to stations for checking their condition. Network safety has been improved since.[80]

Communication problems forced officials to improvise. In Kemiönsaari both public and officials' networks were down but regular landline phones worked. Paramedics who were on the road visited homes and borrowed landline phones to call to their emergency response centre for new assignments.[81] Old people living in assisted housing could not get contacted because "senior mobile phones" (that have a wrist band and emergency button) did not work. Officials had to drive and pay a visit to check if everything there was OK. In Pirkanmaa some cars run out of petrol since the petrol pumps did not work without electricity. Even generators did not help, because the pumps didn't have plug-ins. Food was not delivered, and so old people were gathered to local pizzerias and provided pizzas.[82] Report of the Ministry of the Interior says that despite of problems with official network rescue officials were able to do their job. Official network was replaced by different means of communication (like landline phones, radio phones, e-mail and fax). Management of operations was slower but did not endanger response to emergency situations.[83]

Still, Finland was not the only country where damaged telecommunications caused trouble to old people living in assisted housing.

In Sweden, over 200 000 people were left without mobile phone service, some for over 24 hours after the storm. It was also discovered that some mobile internet base stations did not have any

78 Regional State Administrative Agency for South-Western Finland: Report 2:2012, p. 8.
79 Regional State Administrative Agency for South-Western Finland: Report 2:2012, p. 14.
80 Interview with the Helsinki City Rescue Commander Mr. Simo Weckstén. 13.1.2015.
81 Kimmo Holopainen, "Tapanin opetukset", Red Cross magazine Avun Maailma – Hjälpens Värld 4/2012: https://www.punainenristi.fi/sites/frc2011.mearra.com/files/tiedostolataukset/avun_maailma_4_2012_sydantalvi.pdf
82 Ilta-Sanomat: http://www.iltasanomat.fi/kotimaa/art-1288598373944.html
83 Report by the Ministry of the Interior 14.3.2012, p. 6: http://www.poliisi.fi/intermin/images.nsf/files/E19BA5BD6F160568C22579C200351C24/$file/myrskyselvitys_15032012.pdf

spare energy sources. The Swedish Post and Telecom Authority studied the situation and found that the industry could do better and provide safer telecommunications.[84]

Rescue Officials

Regional rescue departments throughout the country had total of 6 700 assignments, mostly in South-Western Finland, Satakunta, Western and Central Uusimaa and Tampere.[85] In Helsinki, it was one of the busiest days during the last couple of decades but not an emergency situation, describes Helsinki City Rescue Department. Department had 330 assignments. The most assignments, 345, it had received during a storm in 1995. Operations were conducted orderly and no problems occurred.[86] As in Helsinki, also in the whole country the majority of assignments were management of toppled and damaged trees. Trees were toppled on roads, railroads, houses, telecommunications and electricity lines. Rescue officials prioritized assignments and had crews ready for emergencies.[87]

For example, in Rescue Department for Western Uusimaa the night passed calmly, but after 7.00 on 26th December there was an increase on assignments. Between 8—19 they received about 100 assignments per hour. In their evaluation report it is mentioned that there were more notifications of faults than rescue officials were able to handle. Hundreds of assignments were in queue and people called many times to make a notification of one fault. Rescue Department for Western Uusimaa had approximately 1200 assignments because of the storms Tapani and Hannu. 90 per cent of assignments were concerning the clearing of roads and 10 per cent the clearing of electricity lines.[88]

The regional officials responsible for roads are centres for economic development, transport and the environment. Regional rescue departments usually take responsibility for the storm damage because the toppled trees on roads are considered to be hazardous. This regards especially main roads.[89] A report by Rescue Department for Western Uusimaa argues that in 2011 taking care of land transportation network in hazard situations caused by a storm was “un-coordinated, partly un-planned, and the responsibilities were unclear”. Rescue officials are expected to begin action in all cases, also in the ones that can be regarded non-urgent. The law, however, defines the work of

84 Dagens Nyheter 30.12.2011: http://www.dn.se/nyheter/sverige/mobilnatet-kan-slas-ut-vid-storm/. See also Swedish Post and Telecom Authority report: http://www.pts.se/upload/Rapporter/Tele/2012/Stormen-Dagmar-PTS-ER-2012-21.pdf
85 YLE 27.12.2011: http://yle.fi/uutiset/pelastuslaitoksilla_oli_6_700_tehtavaa/3131519
86 Interview with the Helsinki City Rescue Commander Mr. Simo Weckstén. 13.1.2015.
87 Report by the Ministry of the Interior 14.3.2012: http://www.poliisi.fi/intermin/images.nsf/files/E19BA5BD6F160568C22579C200351C24/$file/myrskyselvitys_15032012.pdf
88 The Rescue Department for Western Uusimaa, Evaluation of Rescue Operations during 25.–28.11.2011, pp. 5—6. Not available online.
89 The Regional State Administrative Agency for South-Western Finland: Report 2:2012, p. 23: https://www.avi.fi/documents/10191/56990/Myrskyraportti+8.6.2012+LSAVI.pdf/5feb9ee3-426c-4806-99f7-220c2dd59955

rescue officials to be urgent and mitigating probability of an accident. The report proposes that responsibilities should be clarified.[90]

Modern farms are dependent on electricity. For example milking is done with robots and requires electricity. Farms are expected to take care of their preparedness. It is assessed that most farms have generators. However, during the Tapani storm it was noticed that not all generators functioned. Still, Finnish officials did not provide aid to farmers. Regional State Administrative Agency for South-Western Finland advises farmers to take care and regularly observe condition of generators.[91]

In Estonia the farms also faced problems because of electricity cuts. Estonian rescue officials provided generators to total of eight farms a day after the storm in the area east of the capital Tallinn.[92]

Emergency Response Centre

Phone lines of the Emergency Response Centres were jammed. During the busiest hour, the Emergency Response Centres received seven times more phone calls than usually. During two days of storms the centres received all together over 9 000 phone calls, a one month's worth. Not all phone calls had been answered and queues became long. The longest recorded waiting time was over 19 minutes in the Emergency Response Centre for Western Uusimaa.[93] Normally, the emergency response centres answer over 93 per cent of phone calls in less than 10 seconds[94].

For example, in South-Western Finland the Emergency Response Centre got an average of 400 phone calls per hour during the most violent hours of the Tapani storm. The centre has resources to pick up only 200—250 calls per hour. The emergency response centres were loaded down with non-emergency calls. As mentioned, customer services of electricity companies were jammed for days. People called to the emergency number 112 either in order to let the authorities know they did not have electricity or to ask when the electricity would be restored.[95]

NGOs

In Salo, the Finnish Red Cross and local rescue service volunteers organized emergency aid at a school. A temporary accommodation was provided to some people who had not electricity or

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90 Rescue Department for Western Uusimaa, Evaluation of Rescue Operations during 25.–28.11.2011, p. 13. Not available online.
91 YLE 1.8.2014: http://yle.fi/uutiset/myrskyt_opettivat__maatilat_eivat_ole_enaa_avuttomia_sahkojen_katketessa/7387532; See also Regional State Administrative Agency for South-Western Finland: Report 2:2012, p.14.
92 Estonian Broadcasting Company ERR 27.12.2011: http://uudised.err.ee/v/eesti/58485540-32f7-4070-abb1-0d977e7aa5c4
93 Report by the Ministry of the Interior 14.3.2012, p. 4: http://www.poliisi.fi/intermin/images.nsf/files/E19BA5BD6F160568C22579C200351C24/$file/myrskyselvitys_15032012.pdf
94 Emergency Response Centre Administration statistics: http://www.112.fi/hatakeskuslaitos/tilastot_ja_toiminnan_seuranta/yleiset_tunnusluvut
95 Regional State Administrative Agency for South-Western Finland: Report 2:2012, p. 12: https://www.avi.fi/documents/10191/56990/Myrskyraportti+8.6.2012+LSAVI.pdf/5feb9ee3-426c-4806-99f7-220c2dd59955

heating. There was also water service and possibility to take shower as well as to charge mobile phones.[96] The Red Cross helped officials also in other towns. According to the AVI report Red Cross resources should be better coordinated and integrated into general crisis management.[97]

6.3.2 National and governmental level

The Ministry of the Interior and the state administrative agencies (AVIs) blamed each other for a slow response on the Tapani storm. The report of AVI for South-Western Finland describes that regional rescue departments and AVI requested for official assistance from the Defence Forces on 27th December, a day after the storm. Official on duty in the Ministry of the Interior took the charge but did not pass the requests until the next day, the 28th. There should have been a clear code of conduct that these requests were coordinated by the ministry since the damage was out of regional administration borders, the report argues.[98]

On the other hand, the report by the Ministry of the Interior argues that all but one regional state administrative agency did not start to build situational picture and report on it before the ministry had asked for it.[99]

Both instances agree that the role of the state administrative agencies should be clarified. The agencies should also enhance their role in preparedness. Like described before (concerning the situational awareness) there were also problems with communication and information sharing.

6.4 Consequence management

6.4.1 Administration

A day after the storm, Minister of Interior Päivi Räsänen said in an interview, that response of rescue officials was exceptionally good, but jams in Emergency Response Service phone lines were problematic. Minister Räsänen argued that the Tapani storm showed how important the ongoing reform of the Emergency Response Centre Administration was.[100]

The reform of the Emergency Response Centre Administration started in 2010 and has been completed during 2014. It networked the emergency response centres and merged previously existed 15 centres into 6 centres. They are currently located in the cities of Kerava, Turku, Pori,

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96 Kimmo Holopainen, “Tapanin opetukset”, Red Cross magazine Avun Maailma – Hjälpens Värld 4/2012: https://www.punainenristi.fi/sites/frc2011.mearra.com/files/tiedostolataukset/avun_maailma_4_2012_sydantalvi.pdf

97 Regional State Administrative Agency for South-Western Finland: Report 2:2012, p. 18 and 20: https://www.avi.fi/documents/10191/56990/Myrskyraportti+8.6.2012+LSAVI.pdf/5feb9ee3-426c-4806-99f7-220c2dd59955

98 Regional State Administrative Agency for South-Western Finland: Report 2:2012, p. 19: https://www.avi.fi/documents/10191/56990/Myrskyraportti+8.6.2012+LSAVI.pdf/5feb9ee3-426c-4806-99f7-220c2dd59955

99 Report of Ministry of the Interior 14.3.2012, p. 6: http://www.poliisi.fi/intermin/images.nsf/files/E19BA5BD6F160568C22579C200351C24/$file/myrskyselvitys_15032012.pdf

100 YLE 27.12.2011: http://yle.fi/uutiset/rasanen_myrsky_osoitti_hatakeskusuudistuksen_tarpeellisuuden/5473175

Vaasa, Kuopio and Oulu. Before the reform (also in the time of Tapani storm), emergency phone calls could not be answered in any other Emergency Response Centre than in the one, where caller was. Nowadays, emergency calls can be answered in other parts of the country as well.[101]

The storm seems to have been a wake-up-call for officials. For example, the Rescue Department for Western Uusimaa evaluated their work after the storms. The evaluation report indicates numerous points that should be done better, and it derives an action plan to improve performance during next hazard scenario caused by storm.

–Stakeholders' (municipality, rescue and other officials) roles should be clarified. For example, rescue departments and emergency response centres should update their action plan regarding non-urgent action during storms, e.g. concerning toppled trees. Actions should be trained together.

–Situational picture should be built together with all stakeholders and shared. A system that allows this must be introduced.

–Preparedness should be improved, especially regarding water service during faults.

–Co-operation with electricity companies should be enhanced and command centres should have an access to electricity companies' situational picture on faults.

–Municipalities should improve their use of resources during an emergency. The Rescue Department can provide support. Leaders in emergency situations should be defined clearly and informed effectively of a hazard scenario.

–Citizens should be better informed during an emergency situation. Municipalities should draft guidelines for crisis communications. Media should be an active part of communication policy.

–Liaison officials should be sent to municipalities and vice versa from municipalities to command centres of the Rescue Department.

–Inside the Rescue Department the utilization of human resources should be planned better. For example, employment of contract fire brigade workers should be planned in advance. Leadership is important in hazard situations. The roles inside the command centres should be clarified and a code of conduct should be updated.[102]

6.4.2 Material damage

Energy companies

Fortum is one of the biggest electricity companies in the country, having over 600 000 customers in Finland. Fortum's representatives told that preparations were made, but later they argued that it was impossible to be prepared to the scale of damage which the Tapani storm caused. A

101 See more on the page of the Emergency Response Centre Administration: http://www.112.fi/hatakeskusuudistus

102 Rescue Department for Western Uusimaa, Evaluation of Rescue Operations during 25.–28.11.2011, pp. 10—13. Not available online.

representative of Fortum said in an interview before the storm (on 25th December) that company is preparing for storm by calling in extra electricians. Though, the Christmas holiday season complicated efforts to get extra work force.

Fortum's customer service was jammed. According to the head of PR department of Fortum there were 588 000 phone calls on 26th and 170 000 on the next day. Fortum's internet pages were down. There were at most 200 000 attempts to visit Fortum's web page. Company did not have sufficient IT support resources. Company started to inform its customers in Twitter and build a new internet page, but this took some time. The head of PR department of Fortum said that they should have had more capacity and told that actions are taken to improve communications for future.[103]

At the worst, there were 190 000 Fortum customers left without electricity. During the first day, electricity has been restored to 100 000 households. Repair work lasted long: on 5th January, 10 days after the storm, there were still 1 500 customers having no electricity. On 7th January the company informed that electricity has been restored to all regular houses, but some summer houses were still lacking electricity.[104] According to the report of the Ministry of the Interior the longest cut lasted for 18,5 days.[105]

Fortum announced that the Christmas storms of 2011 caused extra cost of 45 million euro: 35 million in Finland and 10 in Sweden, where the company operates too. Fortum paid 17 million euro of compensations to customers in Finland and 6,4 million euro in Sweden. The company had to fix electricity lines and pay extra labour costs.[106]

The energy company Vattenfall described the situation caused by Tapani and Hannu storms ”unprecedented and serious”. There were altogether almost 2 000 failures in electricity lines controlled by Vattenfall. The company got nearly 6 000 notifications, meaning that people announced same failure many times. 102 000 Vattenfall customers suffered from electricity cuts. Company paid 6 million euro of compensation (of which one million was due to company policy and five million due to law). Altogether, the Tapani and Hannu storms caused Vattenfall extra expenses of 11 million euro.[107]

According to a survey made by the industry association Finnish Energy Industries, Tapani and Hannu storms had affected on 49 energy companies in total. A few were affected only by one of the storms; most were affected by both. The extra cost of damaged energy lines rose to total of 31 million euro.

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103 Newspaper Hufvudstadsbladet 25.12.2011: http://hbl.fi/nyheter/2011-12-25/fortum-fyrdubblar-bemanningen-infor-stormen. See also Finnish News Agency STT 30.12.2011: http://m.aamulehti.fi/kotimaa/fortum-tehosti-asiakaspalvelua-paivan-myohassa-emme-osanneet-varautua-nain-isoon?v=1

104 Fortum press release 7.1.2012: https://www.fortum.fi/fi/media/pages/fortumin-asiakkaille-palautettu-sohkot-myrskun-jaljilta-.aspx

105 See Regional State Administrative Agency for South-Western Finland: Report 2:2012, p. 15. https://+8.6. www.avi.fi/documents/10191/56990/Myrskyraportti 2012+LSAVI.pdf/5feb9ee3-426c-4806-99f7-220c2dd59955

106 Fortum press release 5.1.2012: https://www.fortum.fi/fi/media/Pages/tapani-myrskyt-katkoivat-sahkot-laajoilta-alueilta-ja-aiheuttivat-fortumille-noin-45-miljoonan-euron-kustannukset.aspx

107 Vattenfall press release 5.1.2012: http://corporate.vattenfall.fi/uutiset/uutiset/tapani-ja-hannu-myrskyt-faktoina-ja-lukuina-muun-muassa-kustannukset/

Additionally, companies were to pay over 30 million euro of compensation to 120 000 customers. There were all in all 570 000 customers affected by power cuts which were caused by the storms Tapani and Hannu.

Compared with the summer storms 2010, the winter storms 2011 caused more damage and affected more people. Those summer storms caused electricity cuts to almost 420 000 customers and total compensation paid was 10 million euro to 110 000 customers.[108]

Table 1. The Electricity Market Act (art 00) obliges the companies to pay compensations in case of electricity cuts. Compensation sums rise as a cut is prolonged. Source: Law of Finland text: http://www.finlex.fi/fi/laki/alkup/2013/20130588#Pidp4989616

Duration of power cut	Compensation of annual transmission cost
12–24 hours	10 %
24–72 hours	25 %
72–120 hours	50 %
120–192 hours	100 %
192–288 hours	150 %
Over 288 hours (12 days)	200 %

The Finnish Electricity Market Act obliges electricity companies to pay compensation, if cuts last longer than 12 hours. The law has been updated in 2013. That time, in 2011, the maximum compensation sum was 700 euro, and it was reached when a cut lasted 120 hours or more. In the law of 2013 two more categories were made to compensate especially long-lasting electricity cuts. The maximum compensation sum rose to 2000 euro, and it would be reached in case of a cut lasting over 288 hours (12 days).[109]

Already in 2011 the compensation was 10 per cent of annual transmission cost if a cut lasted 12 to 24 hours. After Tapani storm, the news site Uusi Suomi counted that the compensation would make around 120 euro for an average household living in a single-family detached home.[110]

108 See Finnish Energy Industries press release 19.1.2012: http://www.mynewsdesk.com/fi/pressreleases/loppuvuoden-saehkoekatkoista-kaersi-570-000-asiakasta-725038

109 See study of Technical University of Lappeenranta 28.6.2012, pp. 15–16. http://www.lut.fi/documents/10633/138922/S%C3%A4hk%C3%B6njakelun+toimitusvarmuuden+parantamisen+sek%C3%A4%20s%C3%A4hk%C3%B6-+katkojen+vaikutusten+lievent%C3%A4miseen+t%C3%A4ht%C3%A4%C3%A4vien+toimenpiteiden+vaikutusten+arviointi/bf021a58-24fc-47bd-a893-1804ad813f08

110 News page Uusi Suomi 27.12.2011: http://www.uusisuomi.fi/raha/118960-sahkokatkon-uhri-nain-sinulle-korvataan

Number of people receiving compensation was quite similar in the cases of winter storms 2011 and summer storms 2010. The total sum of compensation was three times bigger in case of winter storms. The storms Tapani and Hannu 2011 caused longer lasting power cuts. Winter time complicated repair efforts. The damages were also not in the central system but mainly in sub-transmission and distribution lines. According to Fortum many distribution lines were to be built from scratch, which took time.

Forest

The forest owners suffered significant losses. According to the Ministry of Agriculture and Forestry, about 3,5 million cubic meters of wood, worth of 120 million euro, were lost during the winter storms. In comparison, during the summer storms 2010, there were more than 8 million cubic meters of wood damaged.[111] The wood damaged and cut by storms is usually 15 to 25 per cent less profitable to sell than regular timber. The damaged wood is more difficult to collect and some parts of tree cannot be exploited. Also, timber might lack quality.[112] There is also lots of timber available on the market, which further makes prices fall.

The Tapani storm damaged forest mainly in Western and Southern Finland, Hannu mainly in Eastern Finland in region of Savo. One of the worst hit areas were around Säkylä and Huittinen, circa 80 kilometres north from the city of Turku. The losses were studied in January by pictures taken from air. There was about 5 per cent of forest damaged.[113]

Insurance companies

The Federation of Finnish Financial Services estimated that insurance companies would have to pay compensations worth of 10 million euro for the damage caused by Tapani. Depending on type of damage there are different options to apply for compensation. For example, home insurances normally cover damage caused to houses or other structures. For cars or boats, there should be an additional vehicle insurance. After the summer storms the companies paid 50 million euro of compensation.[114]

Interestingly, in Estonia the damage caused by a storm was covered by people themselves. According to an insurance company If, 60 per cent of households have no home insurance. However, there were no serious damages. One of the worst incidents happened in Tartu, in central Estonia, where a

111 Ministry of Agriculture and Forestry press release 31.12.2011: http://www.mmm.fi/fi/index/etusivu/tiedotteet/myrskyissakaatuipuitanoin120miljoonaneuronarvosta.html
112 Ministry of Agriculture and Forestry press release 31.12.2011: http://www.mmm.fi/fi/index/etusivu/tiedotteet/myrskyissakaatuipuitanoin120miljoonaneuronarvosta.html
113 See Maanmittauslaitos press release (date unknown): http://www.maanmittauslaitos.fi/kartat/ilmakuvat/tuho-tulvailmakuvaus/metsatuhojen-ilmakuvaus

114 YLE 27.12.2011: http://yle.fi/uutiset/myrskyvahingoista_saattaa_tulla_miljoonien_vahingot/5473727

ladder fell and damaged 20 vehicles. In Riisipere, West from capital Tallinn, a piece of pavement next to a house was ripped off by the wind.[115]

6.4.3 Social and human losses

In Finland two people got killed during the repair efforts. The first one was an elderly man who died in South-Western Finland in town of Paimio. He was doing yard work, when a damaged tree fell on him.[116]

Later, the fire chief at Pirkanmaa Rescue Department said in an interview, that if weather had been cold, there could have been more victims[117.]

Thousands of people lived on emergency mode for days. Local paper in Kaarina, the city next to Turku in South-Western Finland, wrote a story about a family who lived without electricity for almost five days. Family Pyy used only flash lights and candles and stayed warm using a fireplace and a wood stove. They also bought an extra generator worth of 2000 euro. Ms. Pyy told the paper that some of their neighbours were not able stay at home and went to live in a hotel for the time of the electricity cut. They were lacking alternative heating systems, because wood stoves are not a standard equipment in modern houses. She also told that one neighbour got depressed because of electricity cut. She “did not want to get out of bed nor had appetite”.[118]

6.4.4 Cascading effects

The Energy Market Act was updated after the storms. It was drafted right after Tapani and came into effect in 2013. The new law puts emphasis on energy network safety and obliges the electricity companies to invest for example on underground cables. Like mentioned, it also raised compensation sums.

The Energy Market Act[119] stipulates that an electricity cut may last maximum 6 hours in city areas and 36 hours in other areas. According to a study by Technical University of Lappeenranta, these requirements lead to full underground cabling in city areas. Also, depending on geography and infrastructure of the electricity company's operation area and customer base, 40—75 per cent of sub-transmission lines and 40—90 per cent distribution lines have to be renovated and put underground. Electricity companies would have to invest 3,5 billion euro in the cabling by 2027. This would increase household electricity bills by 8–10 per cent, but the raise varies greatly between companies.[120]

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115 Estonian Broadcasting Company ERR 28.12.2011: http://uudised.err.ee/v/majandus/607d8d2c-9753-4bc9-8758-2e3dfce28590 and 26.12.2011: http://uudised.err.ee/v/eesti/074e6054-e6b6-4c1f-99f9-7b80c146ffb7
116 Helsingin Sanomat 26.12.2011: http://www.hs.fi/kotimaa/a1305552090736
117 Ilta-Sanomat 12.9.2013: http://www.iltasanomat.fi/kotimaa/art-1288598373944.html
118 Local newspaper Kaarina 4.1.2012: http://www.kaarina-lehti.fi/2013/12/arkiston-aarteita-tapani-myrsky-kuritti-kaarinaa-2011/#.VK5baSusX1y
119 See more: Law of Finland: http://www.finlex.fi/fi/laki/alkup/2013/20130588#Pidp4989616
120 Study of Technical University of Lappeenranta 28.6.2012, pp. 30–31 and 59–60: http://www.lut.fi/documents/10633/138922/S%C3%A4hk%C3%B6njakelun+toimitusvarmuuden+parantamisen+sek%C3%A4%20s%C3%A4hk%C3%B6-

The Finnish Energy Authority has calculated that cabling of 60—80 per cent of sub-transmission and distribution lines would cost 5—6,7 million euro. Citizen's electricity bill would rise by 4—9 per cent during 10 years.[121] In January 2015 the Energy Authority estimated that customer prices for transmission may rise 20 per cent in average in coming years. Some raise of costs may arise up to 50 per cent. The raise will be about 10 per cent of the whole electricity bill. Electricity companies have until 2028 to fulfil all requirements of the updated Electricity Market Act. Requirements ought to be met step-by-step, the first wave of cabling should be finished in 2019.[122]

Also forest insurances became more popular, but at the same time their prices went up. According to the newspaper Maaseudun Tulevaisuus, before the summer storms 2010 about a third of forest owners had insurance. In 2011 already 45 per cent had bought insurance. After Tapani storm, insurance companies had to pay 38 million euro of compensations to forest owners with forest insurance. In June 2012 the newspaper wrote that insurance companies were planning to raise forest insurance prices about 8 per cent.[123]

+katkojen+vaikutusten+lievent%C3%A4miseen+t%C3%A4ht%C3%A4%C3%A4vien+toimenpiteiden+vaikutusten+arviointi/bf021a58-24fc-47bd-a893-1804ad813f08

121 Memorandum of the Ministry of Labor and the Economy 16.3.2012, p. 5: http://www.tem.fi/files/32354/Muistio_TEMin_ehdotuksiksi_toimitusvarmuudesta_16032012_final_clean.pdf

122 Finnish News Agency STT 15.1.2015: http://www.maaseuduntulevaisuus.fi/politiikka-ja-talous/maakaapelointi-kasvattaa-s%C3%A4hk%C3%B6laskuja-1.78999. See also Helsingin Sanomat 4.1.2015: http://www.hs.fi/kotimaa/a1420340698412

123 See newspaper Maaseudun Tulevaisuus 28.12.2011: http://www.maaseuduntulevaisuus.fi/mets%C3%A4/mets%C3%A4vakuutusten-ehdoissa-on-eroja-1.8918, and 11.6.2012: http://www.maaseuduntulevaisuus.fi/politiikka-ja-talous/mets%C3%A4vakuutusten-hinnat-nousemassa-tuntuvasti-1.18355

7. What was learned, what was improved, guidelines

The storms of 2010 and 2011 studied in this report have indicated several administrative, technical and policy aspects which should be improved in order to improve the resilience of Finnish society and to enhance the risk resilience of the land transport infrastructure network. The Ministry of the Interior reviewed co-operation between officials, meaning rescue and emergency response officials. A memorandum has been published with seven **suggestions how to improve both preparedness and management of storms**.[124]

1. Electricity supplies should be secured in emergency situations. The Ministry of Employment and the Economy took measures that resulted in updating the Energy Market Act.[125]

2. Emergency Response Service should not get jammed. There should be more communication capacity and an emphasis on public awareness. People should be educated to have patience and the number 112 is not the right place to call in a case of a regular electricity cut. Another national help line should be started.

3. Civilian preparedness should be enhanced. Those in need should take an action and purchase generators (for example farms and other entrepreneurs). Civilians should have resources to survive a couple of days without electricity, especially in remote areas.

4. The officials' network VIRVE needs to be developed. The maintenance during emergency situations should be improved. The National Emergency Supply Agency gave an extra 2,8 million euro to a project, aimed at improving the reliability of the network.

5. Responsibilities of different officials should be clear. The regional rescue departments are not responsible for helping to fix electricity lines. The responsible is the service provider.

6. Preparedness should be better coordinated. Municipalities have various approaches to emergency situations. The approaches should be made similar. Role of state administrative agencies should be clarified.

7. The ways to produce situational pictures should be standardized and communication between administration levels should be improved.

It has been indicated that the Tapani storm has affected positively on preparedness and capabilities for emergency management. In 2013 the head of Security of the Government Council Mr. Timo

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124 See Ministry of the Interior press release 29.12.2011:
http://www.intermin.fi/fi/ajankohtaista/uutiset/uutisarkisto/1/0/sisaministerio_analysoi_pelastustoiminnan_ja_hatakeskustoiminnan_sujuvuuden_myrskytilanteessa_29274; See also Report of Ministry of the Interior, 14.3.2012, pp. 7–9.
http://www.poliisi.fi/intermin/images.nsf/files/E19BA5BD6F160568C22579C200351C24/$file/myrskyselvitys_15032012.pdf
125 Ministry of Employment and the Economy: Report 16.3.2012, p. 1.
http://www.tem.fi/files/32354/Muistio_TEMin_ehdotuksiksi_toimitusvarmuudesta_16032012_final_clean.pdf

Härkönen said in an interview at YLE that officials have improved their co-operation since the storms Tapani and Hannu.[126]

Both telecommunication and electricity networks safety have improved since Tapani. “Mobile networks are not so vulnerable anymore”, argued a representative of the Communication Bureau in an interview on 2014.[127]

Energy network safety has been improved and storms don't cause so wide-spread power cuts anymore. The positive development was caused by the update of the Energy Market Act. A representative of the Energy Authority said in an interview that the electricity companies have complained a bit on the new law. “On the other hand, it is not too much to ask to be taken into consideration how dependent on electricity our modern societies are”, Mr. Simo Nurmi from the Energy Authority said to the newspaper Helsingin Sanomat.[128]

Civil preparedness has also been widely discussed since these recent storms. For example the Finnish Red Cross has been campaigning for better civil preparedness. The Red Cross advises people to have at home food for a week, necessary drugs, candles, flashlights, batteries and so on. In 2013 a preparation rehearsal organized by the Red Cross gathered 10000 people.[129]

126 YLE 17.11.2013. Available from: http://yle.fi/uutiset/valtioneuvoston_turvallisuusjohtaja_aiemmista_myrskyista_on_opittu/6939058

127 Ilta-Sanomat 8.11.2014. Available from: http://www.iltasanomat.fi/digi/art-1288764222660.html

128 Helsingin Sanomat 4.1.2015. Available from: http://www.hs.fi/kotimaa/a1420340698412

129 Finnish Red Cross press release 16.3.2013. Available from: https://www.punainenristi.fi/uutiset/20130216/noin-10-000-ihmista-osallistui-punaisen-ristin-sydantalvi-harjoitukseen; See also Finnish Red Cross campaign page https://www.punainenristi.fi/sydantalvi/talvimyrskyyn-voi-varautua

8. Policy conclusions derived from this study

Crisis management requires officials to run effective *inter-operable* communications both internally and externally.

Internally, situational picture should be built among shareholders and shared. Both chief rescue officials interviewed for this paper mentioned shared situational awareness to be the main goal of future developments.

Externally, active communication is required, because it would boost civil preparedness and performance during hazard scenarios. This report has indicated how urban people are more dependent on electricity and telecommunications than those living in countryside.

Before and during Tapani storm (2011) there was not enough situational data available for the citizens on how to prepare for the storm or act during the storm and repair efforts. This should be improved and more web-based open source information should be available and constantly updated.

External communications seemed to be rather avoided by officials. For example, Regional State Administrative Agency for South-Western Finland published only two releases during the storm, the first being published on 30th December, even four days after the storm. Media was only used to disseminate official information, not as an active partner in providing situational awareness. The Rescue Commander for Western Uusimaa Rescue Region presented that journalists could be invited into command centre so that they would have immediate access to information. Public broadcasting company's reporters should at least have this role.

The winter storm of 2011 should be seen as a wake-up-call to officials. During past decades, use of electricity-based systems has increased, but there had not been sufficient emphasis put on back-up systems. Vital systems seemed to be secured already 2011, but other important features seem to have been forgotten (water services, telecommunication base stations).

The nationwide land transport system is controlled by the Finnish Transport Agency. This model should be supported and secured with more active public-private cooperation in order to guarantee sufficient resources in all weather conditions and in all parts of the country. The regional development work is a good example how the owners of critical infrastructures (i.e. private sector) are engaged to carry out disaster response and consequence management with the provinces and municipalities. This model should be further enhanced with governmental incentives and permanent working groups should be established to consider and update regional strategies for critical land transport infrastructure protection.

Part B. RIVER FLOODS ON ROAD AND RAIL CRITICAL INFRASTRUCTURE IN NORTH- WEST SLOVAKIA

9. Introduction

The purpose of the second part of this document is to elaborate the case study of destruction impacts of river floods on road and rail critical infrastructure in North-West Slovakia. The objective is to identify and review of critical land transport infrastructures failures caused by river floods following a hypothetical flooding scenario. Floods in Central Europe seem to occur more frequently. They have got different origin such as flash floods, heavy rainfall, intensive rainfall during melting of snow and the accidents or potential disturbance of the dam that accumulate a big volume of water. A special attention is paid on the mentioned floods, as they are the most dangerous with high potential of damage, priority damage of transport and energetic infrastructure.

There are also other significant threats such as landslides. These incidents are related to intensive rainfalls. In the northwest part of Slovakia there are a lot of locations with the potential landslides with the possibility of damage or the destruction of transport and energetic infrastructure because of the ruggedness of the landscape.

According to the experience of the origin of previous extreme incidents it is necessary to improve the forecast of these extreme incidents. The operators of transport and energetic infrastructure need to get the weather forecast about local occurrence of mentioned extreme incidents in advance.

An important result of the project RAIN should be a proposal of the thresholds of extreme weather events (the research of extreme influences of the weather towards transport infrastructure). Other results should be the scenarios with the possible unfavourable influences and impacts on the potential elements of critical infrastructure in the subsectors of road and railway transport.

The presented case study was evaluated by the Department of Crisis Management, District Office in Žilina and the internal system of the evaluation under the project RAIN.

10. Analysis of contemporary statue

10.1 General framework for civil protection

Slovakia, officially the Slovak Republic, is located in the central part of Europe. The capital city of Slovakia is Bratislava. The mother tongue language is the Slovak language. About 5,5 million people live there. It has been the member of the European Union and NATO since 2004.

The Slovak language belongs to the western Slavonic languages. It is very close to the Czech language and is relatively close to the Polish, Croatian and Serbian languages. Regarding the nationality, about 85% of the inhabitants are the Slovaks (western Slavs in origin), 10% of them are the Hungarians, and 3% of them are the Romanies. There are also significant smaller nationalities such as Czechs, Ukrainians, Germans, Poles and Ruthenians.

Slovakia is a republic, with a parliamentary democracy. The government represents the executive body. The head of the government is the Prime Minister, generally the leader of the largest party in the parliament. The National Council of the Slovak Republic represents the legislative body. It is one-chamber parliament. The members of the parliament are elected every four years. The formal head of state is the President who is elected every five years. Slovakia is a young country, becaming independent after the disintegration of Czechoslovakia, in 1993.

The historical framework of civil protection dates from 1899, when the first international peace conference took place in Haag. The output of the conference was the codification of the international war rules. 26 countries participated in this conference. In the second Haag conference, in 1907 with 44 states attending, the basic rules for management of sea wars were formulated. The Haag Conventions from 1899 and 1907 concluded that the war was not prohibited. Their outputs created the first rules to the regulation of détente of the war consequences.

The First World War, its progress and global dimension, definitely confirmed the importance and necessity of legal regulation of armed conflicts. Because of the development and the use of weapon systems (dynamic development of air forces and the mass use of chemical weapons) it was necessary to direct the codification conventions at other specific areas of the war regulation. Some examples are The Hague Rules of Air Warfare (1922), The Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or other Gases, and of Bacteriological Methods of Warfare (the Geneva Protocol), (1925) and the Convention Relating to the Treatment of Prisoners of War (1929).

At the end of the Second World War, qualitative new weapons and systems (racket and nuclear weapons) started to be used. The worldwide war conflict reaffirmed that the codification process had to continue towards the humanization and the détente of consequences. The prosecution and punishment of the war criminals became a new memento of the international legal regulation. The international courts in Noremberg and Tokyo (1945 to 1948) expressed a political will and willingness of the winning powers to sentence the crimes against humanity and peace.

The legal protection that was provided to the war victims, especially to people during WWII, did not correspond with the reality of the protection against new weapons. Therefore, it was necessary to specify versatile accesses to the next development of the international humanitarian law. At the

Diplomatic Conference of Geneva the conventions were revised in 1949. Subsequently four conventions were signed, namely, (1) The Convention for the Amelioration of the Condition of the Wounded and Sick in Armed Forces in the Field, (2) The Convention for the Amelioration of the Condition of Wounded, Sick and Shipwrecked Members of Armed Forces at Sea, (3) The Geneva Convention relative to the Treatment of Prisoners of War and (4) The Convention related to the Protection of Civilian Persons in Time of War.

The Additional Protocols (I. II. and III.) signed in 1977 and 2006, followed up the Geneva Conventions. These protocols extend and update new conditions of the legal standards under the international humanitarian law.

The article n. 61 of the Additional Protocol to the Geneva Conventions is very important. Its content has the following wording:

"Civil defense" is the fulfilment of some or all mentioned humanitarian tasks. Their goal is to protect the inhabitants against the danger, to help them to remove immediate effects of hostile actions or the disasters and necessary conditions for their survival. These tasks are:

- the voice services,
- the evacuation,
- the organising and the providing of shelters,
- the blackout,
- the rescue works,
- the medical services including the first aid as well as religious assistance,
- the firefighting,
- the identification and marking of dangerous areas,
- decontamination and similar protective measures,
- providing of emergency accommodation and supplies,
- immediate assistance in the renovation and the maintaining order in the affected areas
- immediate repair of necessary public facilities,
- immediate funeral services,
- the help in the protection of items that are necessary for the survival,
- the complementary activity that is needed for the achieving of mentioned tasks including planning and organisation.

10.2 Historical, societal and legal aspects of the civil protection system

After the establishment of an independent Slovak Republic on 1st January 1993 it was necessary to fill the legal vacuum in the field of the protection of inhabitants. Another requirement was to continue in the specific questions of the protection which had been prepared in the previous social system and to define new accesses, with the goal to make more efficient and to improve not only the system, but also the preparation of the inhabitants for the civil protection. After the adaptation of the Law about civil protection of the inhabitants, n. 42/1994, a basic platform was created for the construction and development of the protection of inhabitants in the condition of the Slovak Republic.

A new legal amendment came from the institutional law of the inhabitants on the protection of their health, lives and properties from extraordinary incidents. The need to respect for the institutional law came to the fore with the development of technological processes in the industry and the increase of transport density including transport of dangerous goods. The civil protection is in the law n. 42 defined as: "The system of tasks and measures which are oriented at the protection of the life, health and property lie in the analysis of possible danger and the acceptance of measures on the reduction of the risks of the danger including the solving of the procedures and activities during the removing of the consequences of extraordinary incidents."

The specific conditions of the Slovak Republic, especially the danger of a big density of primary (natural and anthropogenic) risk sources and the respecting of the conclusions of the Additional protocols to the Geneva Conventions, have created the preconditions for the next formulation of the tasks and measures of the civil protection in the presented legal norm. They are:

- the evaluation of the location of buildings and technical parametres of civil protection devices,
- the organisation, management and performing of the preparation of civil protection,
- the ensuring of evacuation,
- the organisation, ensuring of the voice information service,
- the organisation, management and performing of rescue works,
- the performing of antiradiation and chemical, biological measures,
- the provision of emergency supplies and emergency accommodation,
- the ensuring and performing of publishing, scientific, research and development activities in the civil protection.

10.3 Description of previous meteorological events

According to the information of NASA and NOAA, the global temperature increased in 2014. The World Meteorological Organisation informed about anomalies in 2014. In September in the Balkans, double volume of precipitation fell than the normal, in Turkey it was four times more, in the Moroccan town Guelmen the same volume of precipitation fell during four days as last years for a whole year. In Japan there were record rainfalls in August.

On the other hand the droughts were in the west of the USA, some parts of China and Middle and South America (News, 2015).

Under the RAIN project the research is focused on the influence of extreme weather on critical infrastructure. The different weather influences were researched in some EU research projects (EWENT, EXWE, ACCLIM, more details in D2.1). Under WP 2 the researcher of the RAIN project elaborated the Milestones 2.1.The list of definitions and thresholds. This list includes the following climatological events:

- Heavy Rainfall
- Windstorms
- Coastal Floods
- River Floods

- Landslides
- Lightning
- Tornadoes
- Hail
- Convective Windstorms
- Snowfall and Snow Storms
- Icing Snow Loading
- Forest Fires
- Freezing rain

More details in D2.1 List of Definitions and Thresholds (RAIN, 2015).

The following examples of real extreme weather events with adverse impacts on transport infrastructure in Slovakia in the last years are presented in detail:

- Žilina and Vratna rainfall event, 21 July 2014,
- Heavy rainfall in the northern part of eastern Slovakia, 3-4 June 2010
- Flash flood in Jarovnice, 20 July 1998
- Flood and landslide in northwest of Slovakia (Svrčinovec - Čadca region), July 1997.

10.3.1 Žilina Rainfall Event, 21st July 2014

Introduction

Widespread thunderstorm activity was observed on 21st July 2014 across central Europe with many reports of excessive precipitation arriving from the Czech Republic, Slovakia and Austria (Figure 14). Only the north-western region of Slovakia, which endured several flash flooding events on this particular day, will be analysed in this section.

Two of the events included a flash flood in Žilina, crippling the traffic for several hours in this city, and a flash flood with landslide in the Vrátna valley. This event completely destroyed the road inside of the narrow valley, stranding many tourists.

Synoptic situation

The synoptic situation was characterized by a slow moving cold front with a surface low centered over the Czech Republic. On its forward flank, a warm and humid airmass was advected to Slovakia from south–southeast with CAPE values between 500 and 1000 J/kg over the region. According to the sounding measurements from 12 UTC from Prostejov, Poprad, Wien and Budapest, environment featured high relative humidity up to the upper troposphere. Furthermore, prevailing mid to upper tropospheric flow was quite weak, below 10 m/s at 500 hPa (Figures 15, 16). The combination of these factors supported slow moving thunderstorms with high precipitation efficiency.

Figure 14. A plot of ESWD (European Severe Weather Database) reports from 21.7.2014 00 UTC till 22.7.2014 00 UTC. Blue circles correspond to the heavy rain reports and yellow squares to the severe wind gust reports.

Rainfall event in Žilina

The first cluster of thunderstorms formed on the border of northwestern Slovakia and the northeastern Czech Republic, due to the surface wind convergence and rich topography. The whole cluster was moving southeastwards and increasing in size. Town of Žilina was affected around 13 UTC (3 PM local time) by the southern part of the cluster. Due to the slow moving nature of the storm and rainfall intensities of 80 mm/h, flash flooding was observed in the town. Between 13 and 14 UTC, 48 mm of rain were observed in Žilina, with 24 hour sum of 69 mm (SHMI, 2014). Thunderstorm cluster continued on its way eastward, producing additional high hourly rainfalls, locally exceeding 40 mm.

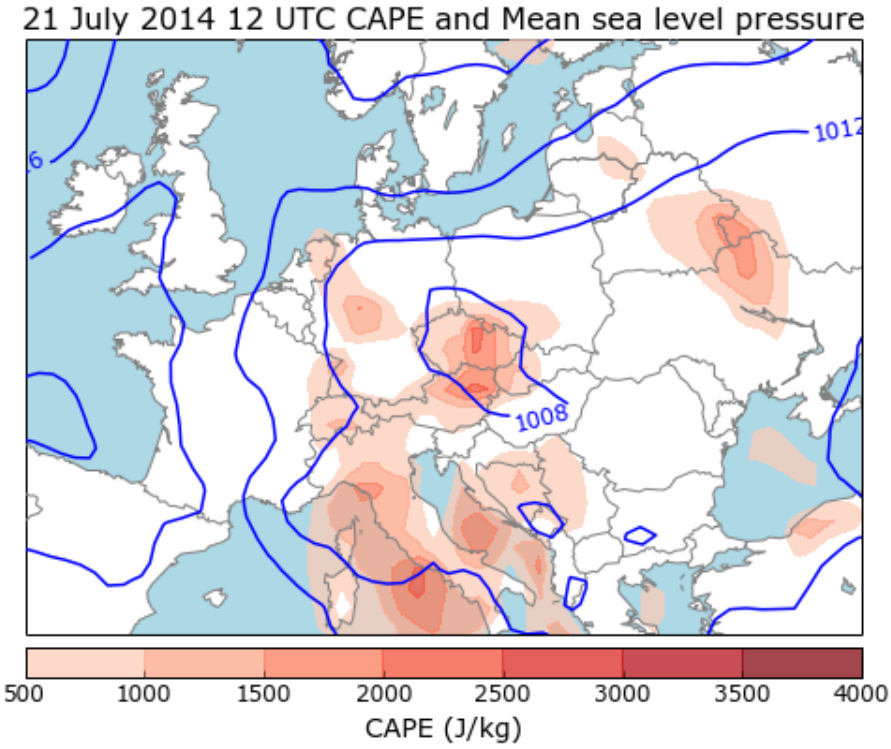


Figure 15. ERA Interim reanalysis of 21 July 2014 12 UTC Mean sea level pressure (blue isolines, in hPa) and CAPE values (red filled contours).

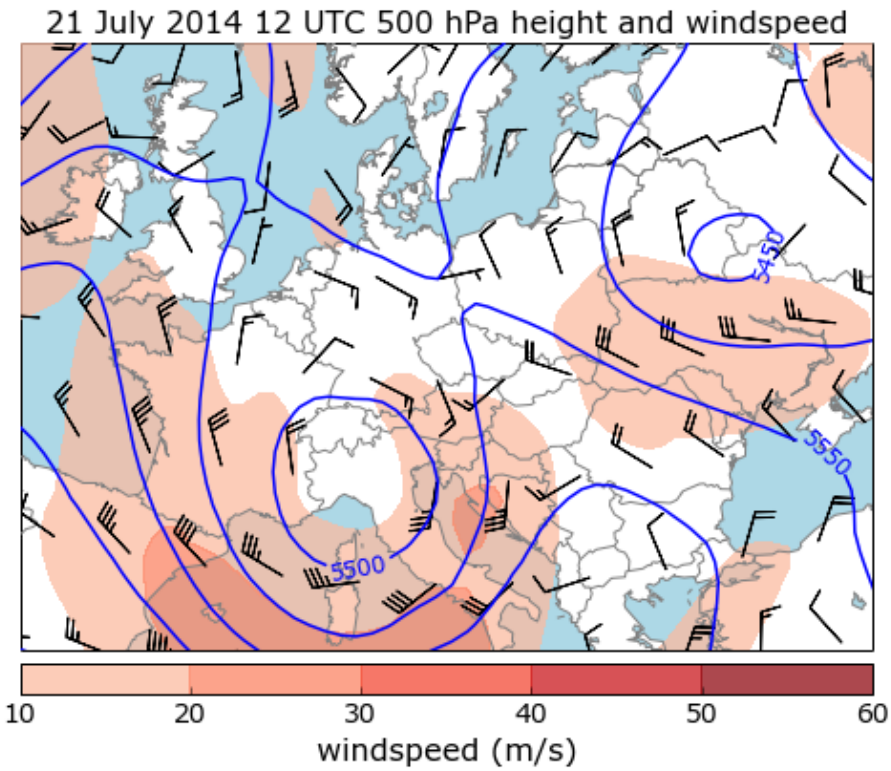


Figure 16. ERA Interim reanalysis of 21 July 2014 12 UTC 500 hPa geopotential heights(blue isolines, in m) and wind at that level.

Impacts of rainfall event in Žilina, 21st July 2014

During the rainfall event in Zilina, water flooded many streets in Zilina, destroyed and shattered roads, broke trees and caused power cuts. All subways and many cellars in some apartment buildings were flooded (Fig. 17-20). Transport in Zilina was completely congested because some roads were not rideable. Power failure stopped trams in Zilina but they were replaced by buses. Fire patrols, volunteer firefighters, police and the Slovak water supply and sewerage were in readiness. It was necessary to pump water from the roads, subways, cellars, gardens and courtyards.

Police immediately took the necessary measures to protect the life, health and property. The situation was constantly monitored. Police managed the traffic on places of fallen trees and flooded roads and where the traffic lights did not work.

During the storm 158 hotline for calling police ceased to work. The inhabitants had to use emergency number 112 until its repair.

This rainfall event also caused a delay of several trains. The train delay information was indicated on the internet page of the Slovak railways.

During the storm Mayor of Zilina called Crisis Staff and declared the flood stage number 3. Rescue operations began immediately during the actual calamity. Based on the findings priorities for rebuilding the proper functioning of the city were divided. The primary aim was to put into operation critical sections of the roads, removal of debris, cutting trees and to monitor the situation in the city. All components of the integrated rescue system participated in eliminating all the storm impacts, preventive measures to prevent enlargement of damage were accepted and security measures to manage the transport situation in the city were also accepted. Members of the Crisis Staff assessed the damages on the ground, received information from citizens by phone and informed relevant rescue services.

Crisis Staff of Zilina, together with other invited institutions such as the Slovak Water Management Enterprise, the Slovak water supply and sewerage, owners of engineering networks, deputies, municipal and state police, public welfare workers, firefighters and other volunteers, groups of sportsmen and local citizens, worked to repair damages after a storm.

After this event, the Crisis Staff of the city Zilina has paid more attention to preparing for the possible danger that can arise any time due to extreme weather event.

Figure 17. Railway station in Žilina (aktuality.sk, 2014)

Figure 18. Railway station in Žilina (Žilinak.sk, 2014)

Figure 19. Street in Žilina after rainfall event (Žilinak.sk, 2014)

Figure 20. Fallen tree (Žilinak.sk,2014)

10.3.2 Vrátna dolina heavy rainfall event

In Vrátna dolina, a flash flood combined with a landslide created major impact on the local road infrastructure. An automatic rain gauge station is situated 5 km away from the mountain ridge. One hourly precipitation max reached 36 mm between 14 and 15 UTC, with 24 hour rain sum of 66 mm. According to the radar analysis done by SHMI, more than 90 mm of rain could fall on the slopes of the mountains during the 100 minute long period. However, poor radar coverage of this region precludes very detailed analysis. Because of the large uncertainties and lack of rain gauge and river gauge stations in the most impacted region, it is virtually impossible to figure out the event rarity.

This heavy rainfall event on the evening of 21 July, 2014 caused flooding which destroyed dozens of cars and the road leading from Terchová village to the Vrátna Dolina, a valley in the Malá Fatra Mountains. Mountain rescuers had to assist around 120 tourists, including children, infants and a pregnant woman who were trapped in Vrátna. Since the road was destroyed they were forced to walk through the forest at certain points.

About 100 firemen and 30 mountain rescuers were searching the car wreckages to make sure there were no trapped or dead people inside. No injured or missing people were found.

This storm affected the whole Zilina region. Landslides on sections of the Hromové and Steny hills struck cars and trapped people in huts and houses. In the town of Považská Bystrica, the flood destroyed a 700-metre long stretch of road (see Figures 21 to 24).

The biggest damage, which reached €5 million was caused by an avalanche of rocks, mud and wood. 50 hectares (123 acres) of hillside were part of the slide.

Figure 8. Vrátna dolina 21 July 2014 (Dnes.sk, 2014)

Figure 9. Vrátna dolina 21 July 2014 (aktuality.sk, 2014)

Figure 10. Vrátna dolina 21 July 2014 (aktuality.sk, 2014)

Figure 11. Vrátna dolina 21 July 2014 (aktuality.sk, 2014)

10.3.3 Heavy rainfall in the northern part of eastern Slovakia, 3-4 June 2010

Introduction

May and June 2010 were months with persistent synoptic situation featuring slow moving low pressure systems over the central Europe, causing high rainfall sums over many countries, e.g. including Poland, Austria, Czech Republic and Slovakia. Widespread flooding with huge economic impact was the result of persistent heavy rain, which was orographically enhanced on the northern slopes of the mountains. The events occurring from 3rd to 4th June 2010, with high rainfall sums

observed in the northern part of eastern Slovakia, are explained in detail. Basin of the river Poprad was already saturated from the previous heavy rains of May and early June. The slopes of the High Tatras had already received more than 400 mm of rain during the month of May (SHMI, 2010), making it more than 400% anomaly with regards to the normal May rainfall in this area.

Synoptic situation

Synoptic setup was certainly favourable for another heavy rain period. At mid to upper troposphere, Slovakia was located on the western flank of the closed low with northerly to northeasterly flow (Figure 25). Surface low was at the same time centered over southeastern Poland, Ukraine and Belarus (Figure 26). A tongue of warm and moist airmass was wrapped around the low, stretching from the Black Sea via Belarus and Poland into the northern part of Slovakia. Rain resulted from the lifting of this warm and humid air along the warm part of the frontal boundary. As the lifted airmass was also unstable (Figure 26), embedded thunderstorms were observed within a larger scale rain shield.

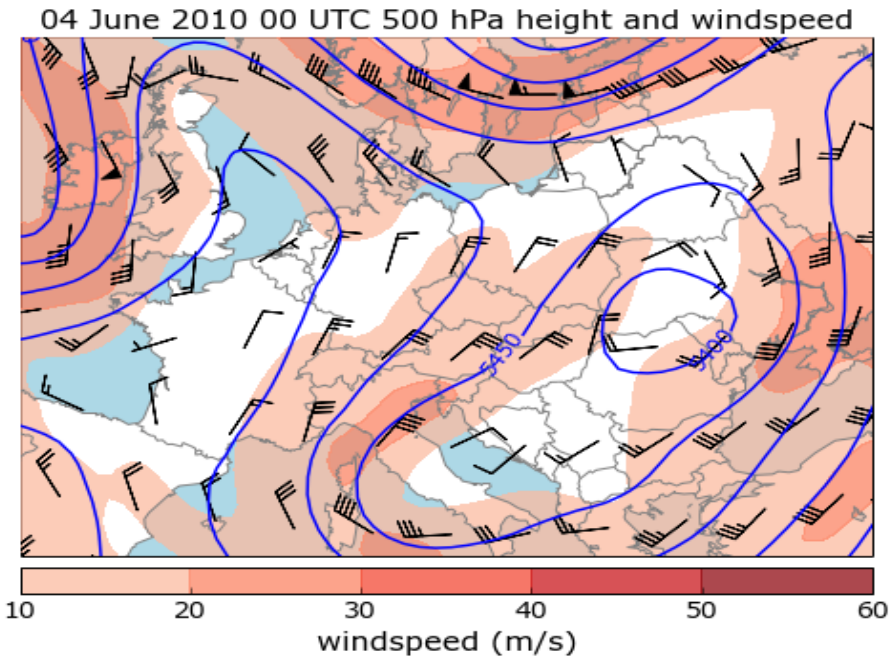


Figure 25. ERA Interim reanalysis of 04 June 2010 12 UTC 500 hPa geopotential heights (blue isolines, in m) and wind at that level.

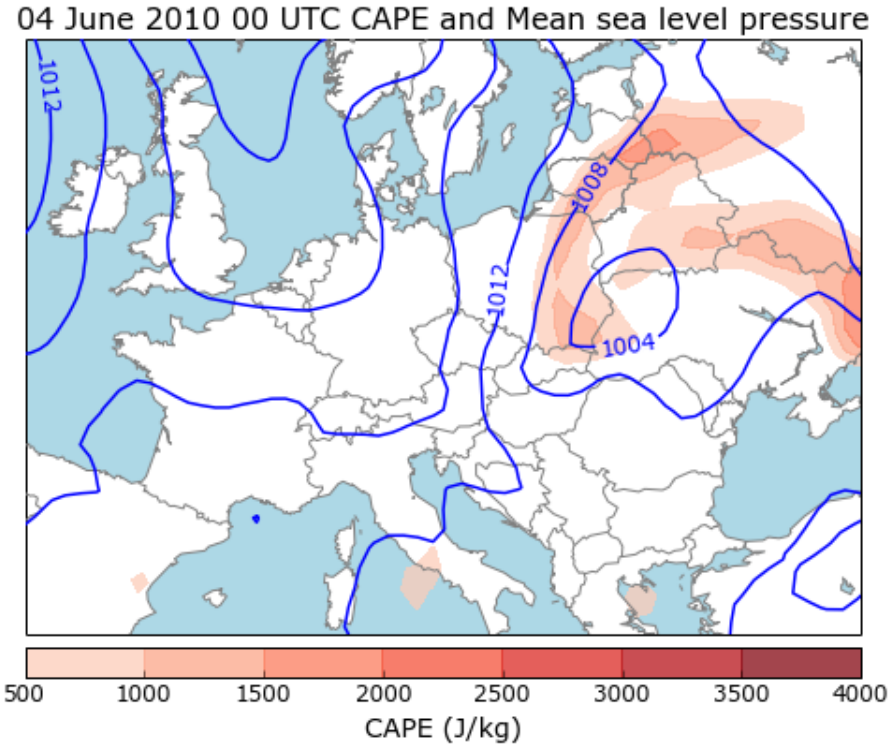


Figure 26. ERA Interim reanalysis of 04 June 2010 00 UTC Mean sea level pressure (blue isolines, in hPa) and CAPE values (red filled contours).

Rainfall sums

Combination of orographically enhanced precipitation along with embedded thunderstorms contributed to the very high rainfall sums. 24 h values ranging between 50 and 100 mm were common in the affected region (SHMI, 2010). The highest 24 h rainfall sum was observed in Chmelnica, with 92.2 mm of rain. Majority of rain fell in the night hours between 3rd and 4th June. Also, due to the basin saturation, increase in the water levels was immediate, with culminations observed on the 4th and 5th June. Several river gauge stations registered the passage of the flood wave, with discharges reaching 10 to 50 year return period in the river Poprad, 20 to 100 year return period in the river Hornad and 50 to 100 year return period on the river Torysa (SHMI, 2010).

Heavy rainfall and subsequent flooding significantly affected the transport in the region of the northern part of eastern Slovakia. The situation on the roads became muddled, there was a lot of impassable stretches, landslides on the roads, roads were undermined and several bridges were damaged (Fig.27).

Railways also suffered from serious problems. One of the rails was undermined on the main route between Kosice and Bratislava, trains passed in both directions only on one track. Damaged power line caused delays of the trains and passengers were appealed by the Slovak railways to consider their journey to the east of the country.

Figure 27. Torn off part of bridge beyond town Spišská Nová Ves (Pluska.sk, 2014)

10.3.4 Flash flood in Jarovnice, 20 July 1998

Introduction

On 20th July 1998, a local, but very severe thunderstorm with subsequent flash flood caused perhaps the greatest tragedy in the modern Slovak history with 50 fatalities, mostly in the village Jarovnice. Flash flood occurred on a small creek Malá Svinka in the Bachureň mountain range. Just two days later, a similar disaster occurred in Orlické Hory in the Czech Republic, with more than 200 mm of precipitation observed during the series of thunderstorms moving over the area and 6 fatalities during the flash flood.

Synoptic situation

Regarding the synoptic-scale situation, Slovakia was situated on the forward flank of mid to upper tropospheric ridge with westerly to northwesterly flow aloft (Figure 28). Close to the surface, warm air was advected from south with the center of the surface low over the Atlantic. According to the analysis of SHMI (1998), airmass was very unstable, with CAPE values from Poprad-Ganovce 12 UTC sounding reaching over 2000 J/kg. ERA Interim reanalysis for 12 UTC reproduced CAPE values above 1000 J/kg and moderate degree of vertical wind shear, with 0-6 km bulk values between 10 and 15 m/s.

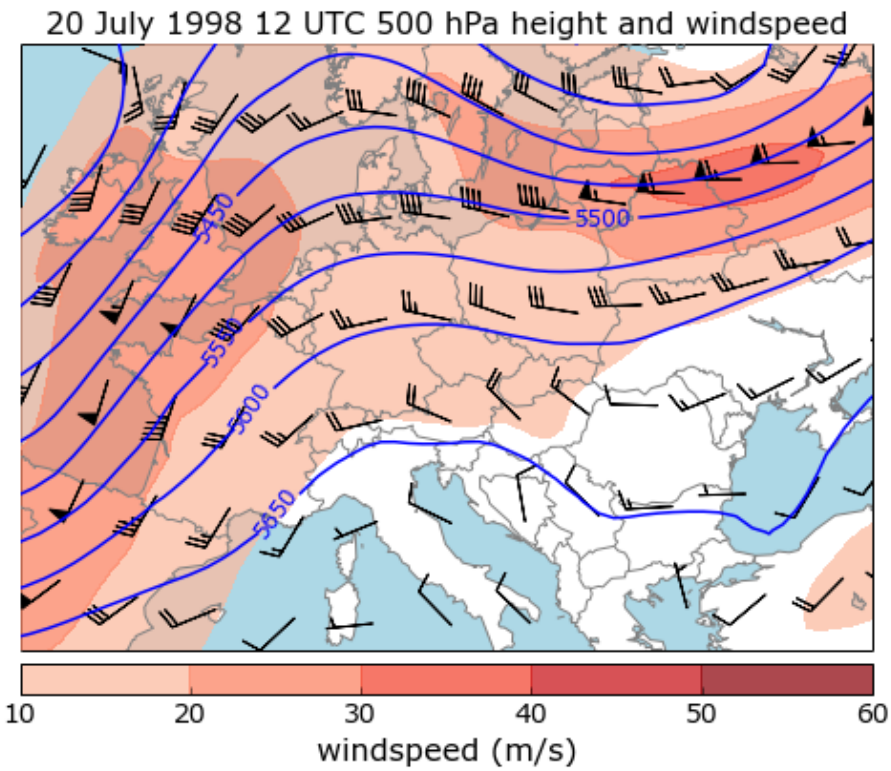


Figure 28. ERA Interim reanalysis of 20 July 1998 12 UTC 500 hPa geopotential heights (blue isolines, in m) and wind at that level.

Event analysis

Lack of high-resolution satellite and radar data from this case precludes any detailed analysis of the thunderstorm development and progression (Sokol and Sokolova, personal communication). However, it seems that thunderstorm existed in a form of a slowly moving multicellular system with signs of backbuilding (i.e. new thunderstorm cells forming against the direction of prevailing flow). Analysis of Slovak hydrometeorologic institute (1998) also mentions the supercellular nature of the thunderstorm, which could be supported by the fact that besides the flash flood, also very large hail was observed by the local inhabitants (hen egg size).

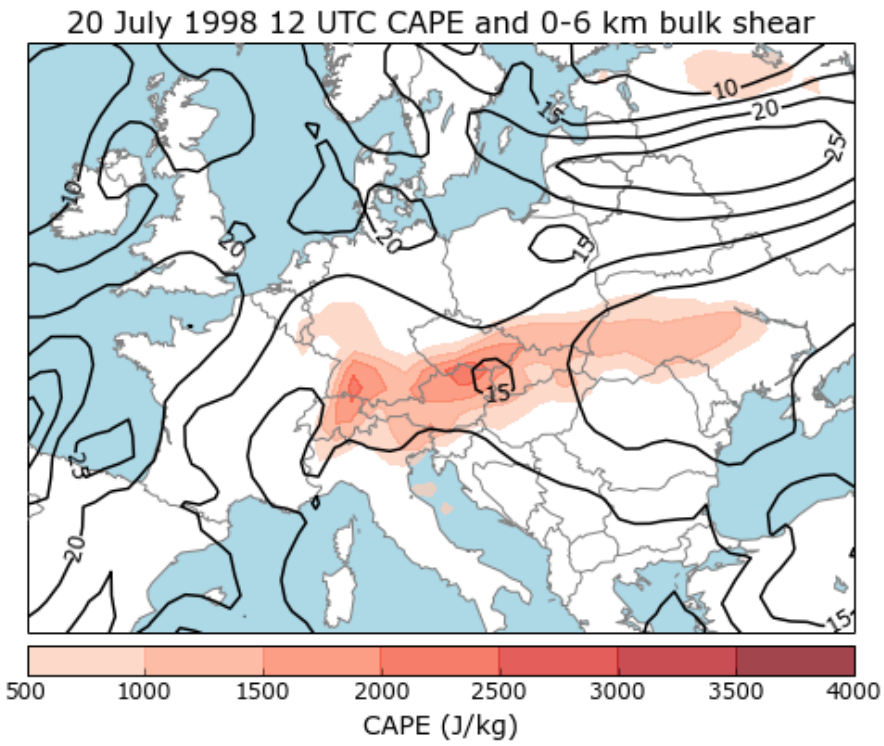


Figure 29. ERA Interim reanalysis of 20 July 1998 12 UTC CAPE values (red filled contours) and bulk wind shear between 10 m and 6 km wind (black contours).

Unfortunately, no rain gauge station was located in this small river basin and the closest rain gauge measured only 62 mm of rain during the 24 hour period. After the radar and on-site survey it was concluded that likely more than 100 mm of rain fell during the storm. A river gauge station on the Svinka river measured discharge with an approximately 200 years return period. However, this gauge station is downstream of the worst affected area. It was estimated that in the upper section of the Mala Svinka river basin, discharges could reach 1000 years return period.

Heavy rains in June 1998 brought about the worst floods in the history of Slovakia, changing otherwise quiet rivers in eastern part of the country into a lethal force. The tragic results were 63 dead, over 3000 people evacuated from their homes, and two thousand houses destroyed. Since shacks are incomparably more vulnerable to natural disasters than proper houses, this flash flood hit the Gypsy settlement near the community of Jarovnice the hardest, and the highest number of casualties occurred there. Jarovnice is one of the largest and most backward of the Romany settlements in Slovakia. Almost four thousand Romany lived in unbearable living conditions there, most of them without work and illiterate. The otherwise harmless rain-swollen Mala Svinka brook claimed at least 44 children and 16 adults. This is a real example confirming that poor and inadaptable people belong to the most vulnerable groups.

Already in the evening 20 July 1998 flood service, which in the first hours of flooding ensured voice and warning service for villages in the river basin Svinka, was established. In the flooded communities, the mayors coordinated aid and soldiers helped to clear away the damage. Romany who lost their homes lived in military tents and ate military rations.

Figure 30. Jarovnice 21 July 1998 (Ražňany, 2002)

10.3.5 Flood and landslide in northwest of Slovakia (Svrčinovec - Čadca region), July 1997.

Introduction

Flood event in the north western part of Slovakia in July 1997 was a part of a major disaster that occurred in many countries of central Europe, most severely affecting the Czech Republic and Poland, where more than 100 people perished in the floods. Rivers Oder and Morava caused the most severe floods with return periods of measured discharges exceeding 100 years at many measurement spots and even reaching 500 years on the upper sections of Morava and Odra rivers (CHMI, 1997).

Synoptic situation

Meteorological situation featured a famous V-b track of the low pressure area, notoriously known for causing heavy precipitation over the area. A low tracked on the forward flank of the deep upper tropospheric cyclone (see Figure 31) from northern Italy towards the Czech Republic and southern Poland. One of the factors contributing to the extreme precipitation amounts was the fact that the low became quasi stationary over southern Poland for two days. A belt of moist airmass was wrapped around the low towards its northwestern sector, where a band of heavy precipitation formed. This band remained over the area for a long period, while strong northerly to northwesterly flow provided for a significant orographic enhancement of the precipitation (Figure 31). Combination of these factors resulted in the precipitation sums exceeding 500 mm in 4 days over Beskydy and Jesenniky mountains between 4th and 8th July.

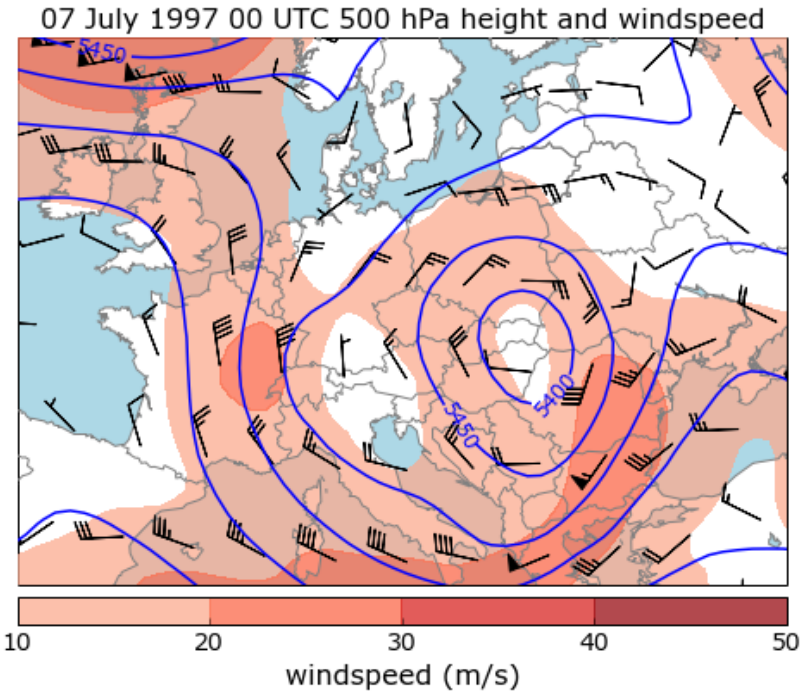


Figure 31. ERA Interim reanalysis of 07 July 1997 00 UTC 500 hPa geopotential heights (blue isolines, in m) and wind at that level.

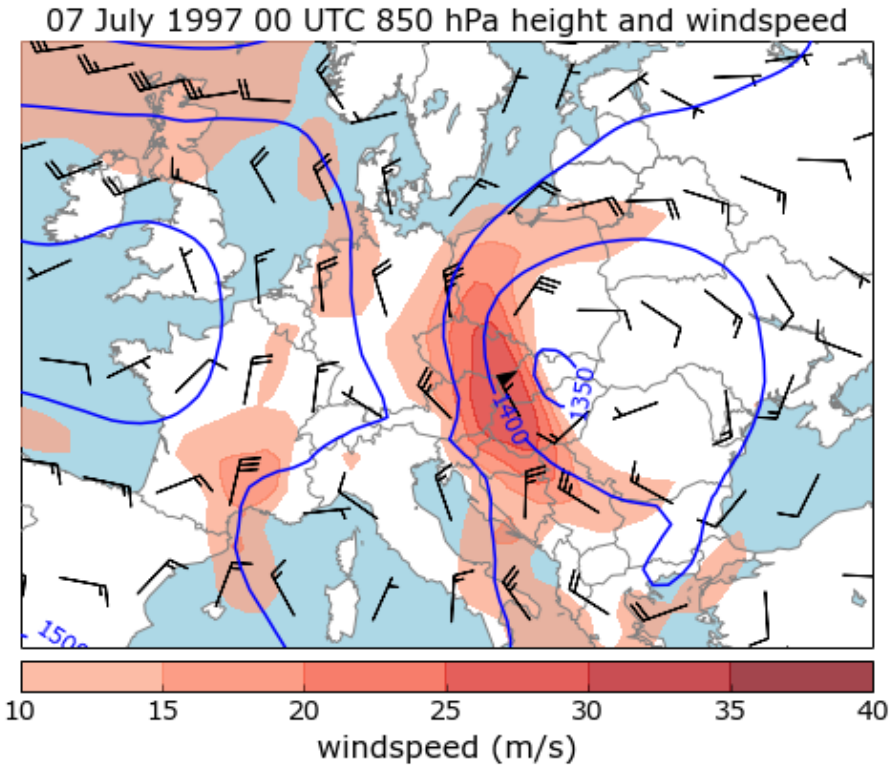


Figure 32. ERA Interim reanalysis of 07 July 1997 00 UTC 850 hPa geopotential heights (blue isolines, in m) and wind at that level. Note a belt of winds above 20 m/s stretching from SW Poland towards Hungary.

Situation over Slovakia

Precipitation was not so abundant over northwestern Slovakia when comparing with the Czech Republic, but still, more than 200 mm of rain fell during the 4-day period between 5th and 9th July (Lapin and Faško, 1997). The highest rainfall amounts were observed especially along the mountainous borders with the Czech Republic. Monthly rain sums reached 400 mm in the regions of Kysuce, Orava and in the High Tatras. Compared with the Czech Republic, return periods of observed discharges were not so extreme, but still reaching 100 year return periods.

The several days' extreme precipitation resulted in landslide in Svrčinovec on 8 July 1998. Due to this landslide the transport between the Slovak and Czech Republic was interrupted (Figure 33). Commission experts decided on July 11th how to remove the landslide but the work could not begin until July 16th after the rainy season. On July 21st transport in this section was reopened.

Figure 33. Landslide in Svrčinovec 8 July 1997 (author photo)

10.4 Description of the current transport infrastructure

The current European transport policy brings 26 billion Euros for member states transport in the period 2014 – 2020. The core network will form the backbone for transportation in Europe's Single Transportation Market. European Commission declared a new infrastructure policy in Europe: "This policy aims to close the gaps between Member States' transport networks, remove bottlenecks that still hamper the smooth functioning of the internal market and overcome technical barriers such as incompatible standards for railway traffic. It promotes and strengthens seamless transport chains for passenger and freight, while keeping up with future technological trends." (EC mobility and transport, 2015). As transport is vital to the European economy, without good transport connections Europe will not grow or prosper. Therefore the new European infrastructure policy will put in place a powerful European transport network across 28 Member States. It will connect North with South and East with West and replace today's transport infrastructures with a network which is genuinely European.

By 2030 the EU will upgrade infrastructure and simplify cross border transport operations for passengers and businesses. The new TEN-T core network will be supported by a comprehensive network of routes, feeding into the core network at regional and national level. The aim is to ensure that progressively, throughout the entire EU, the TEN-T will contribute to enhancing internal market, strengthening territorial, economic and social cohesion and reducing greenhouse gas emissions.

The basic goal of the Case study developed in this document is to analyse the sector Transport in the subsectors of road and railway transport from the point of view of the potential weather impact on transport infrastructure. Transport infrastructure networks are very important for performance and sustainability of national economy, land availability and mobility of inhabitants. Other goals are the security of a smooth motion and the filling of basic functions of the state in the economic, political, social areas. A detailed analysis of the importance of transport infrastructure of road and railway transport represents a basic precondition of fulfilling of the process of identification of potential elements of critical infrastructure in the second part of the presented material.

The selection of the typological elements of potential critical infrastructure of road and railway transport is based on the evaluation of the importance of national and international network of roads and railways. In the research it was necessary to consider the values of own indicators of sector and cross-section criteria. The objects which meet the mentioned criteria are marked as potential elements of critical infrastructure. The subsystems of railway and road transport are the most important part of the transport infrastructure of the SR including ŽSK. Road and railway transport system consist of:

- the fixed (stationary) subsystem - transport infrastructure which consists of transport ways (railway and road networks, etc.) and transport elements (equipment) – railway stations, terminals,
- movable (mobile) subsystem – transport means,
- management subsystem – information tables, light signalisation,
- the rules that regulate the activity of subsystems (laws, regulations, technical norms, procedures, directives).

Another solution for the identification of elements of critical infrastructure was narrowed on the fixed (stationary) subsystem of railway and road transport.

The transport policy of the SR by 2015, in the priority 6.2 The security protection in transport, states that the goal of the protection of transport infrastructure and means of transport is to ensure that employees, objects, equipment and information services, which are critical for the function of the society, will not stop filling their role under all scenarios like risks and threats. A critical transport infrastructure should include the systems whose failure, damage or destruction would have a serious impact on the state security, economy, health, security of inhabitants, and function of the state administration. The equipment of transport network of critical infrastructure is necessary to harmonize with the transport policy of the EU.

Multimodal corridors

After the SR became the member of the EU, it was obligated to observe the accepted rules and documents under the EU. The transport infrastructure has to be adapted to the international standards and has to be oriented at the strengthening of the north-south and the east-west connections.

Slovakia, which lies in Central Europe, is an important transit country. It is also located closed to the countries of Eastern Europe. Two out of ten Pan-European transport corridors, which were defined in Crete (in 1994) and Helsinki (in 1997), pass through the north-west part of Slovakia (Figure 34). They head towards north - south and west - east directions and the Balkan. These corridors are:

- the corridor V branch A (Trieste – Ljubljana – Budapest - Bratislava –Žilina - Uzhhorod – Lviv),
- the corridor VI (Gdansk – Warsaw – Žilina).

Figure 34 The European multimodal corridors (Pan-European Corridors, 2015.)

The network TEN – T consists of two parts: the basic and supplementary networks. The basic network, which should be completed by 2030, will have a function as a supporting axis under the unit transport market of Europe. The supplementary network should be completed by 2050 and will link with the basic network. Under the basic network the most important connections and junctions

of TEN-T were to be determined. The railway station Zilina and road junctions Zilina and Martin are the most important transport objects in Zilina region. They should be fully operational by 2030. Both parts include all modes of transport like road, railway, air, inland water and sea transport, as well as intermodal platforms. The basic goal is to ensure that most European citizens and businesses will not be located more than 30 minutes from the qualitative transport network by 2050.

The basic principle is that each country has the benefits from the access to a strong basic European transport network which enables a free movement of cargo and passengers. All European countries will be linked to this network.

The projects, which are financed under the basic network, have to fill two important requirements:

- technical requirements which are necessary to assert include interoperable requirements under the whole network. For example, in road transport there are some norms of safe road traffic (the requirements for the safety of tunnels and technologies of intelligent transport systems), in railway transport it is system ERTMS,
- new legal requirements for the finishing of the projects by 2030 (the deadline for the finalisation of the basic network).

10.4.1 Railway infrastructure; function and capacity

The concept "conventional railways" includes the railway infrastructure associated to speeds up to 200 km per hour.

1. In the structural area there are:

a) railway infrastructure,
b) provision of energy,
c) security management and signalling of track equipment,
d) security management and signalling of vehicle equipment,
e) railway carriages.

2. In the functional area there are:

a) operation and management of transport,
b) maintenance,
c) telematics application in passenger and cargo transport.

The railway transport network in Slovak Republic was built as the supporting element of transport infrastructure which enables transport of bulk cargo in freight and passenger transport on shorter and longer distances. The density of railway network, which is 73,4 km/1000 km2, is higher than in other EU countries. According to the data of ŽSR, the length of tracks was 3 895 km in 2012. Other indicators, which reflect the status quo of railway infrastructure, is the portion of single tracks. In Slovakia, this portion is 72,6%. The portion of electrified railway lines is 44%. In the network of ŽSR there is 95,9% of tracks, which gauge is 1 435 mm. The number of bridges is relatively high (6,5 bridges per 10 km) but they are not very long. On the tracks there are 76 tunnels with the length of 45 km (0,12 tunnels per 10 km).

In 2012 the number of the level crossings was 2 160 in the network of ŽSR, the majority of them were gated level crossings (50,4%). There are 6 level crossings per 10 km of the track, which is a high proportion of level crossings with roads. A more detailed explanation of these figures can be found in Table 2.

Table 2. Technical parameters of railway transport in the Slovak Republic in 2012 (Slovak Railway Company, 2015)

Parameter	quantity
Construction length of tracks, total in km	6895
- of which main tracks	4650
- other and railway tracks	2245
Total length of main TEN-T tracks in km	701
- TEN-T track Va in ŽSK, direction: Vrútky to Žilina (km)	20,9
- TEN-T track Va in ŽSK, direction: Žilina to Púchov (km)	44,2
- TEN-T track Va in ŽSK, direction: Žilina to Teplička (km)	5,8
- TEN-T track VI in ŽSK, direction: Žilina to Čadca (km)	30,5
- TEN-T track VI in ŽSK, direction: Čadca – Skalité (km)	13,5
Important railway stations in ŽSK	Čadca, Žilina a Žilina Teplička
The number of railway switches	8477
The total length of bridges (km)	50,6
The number of bridges	2324
- of which they are solid	1870
- of which they are steel	454
The total length of tunnels (km)	45,0
The number of tunnels	76
- of which they are one-tracks	68
- of which they are double tracks	8

It is necessary to mention that, in northwest part of Slovakia, TEN-T corridors are being modernised at the present time (Figure 35). The modernisation of the European TEN-T network includes:

- The corridor Va (Baltic – Adriatic) - Bratislava - Nové Mesto nad Váhom- Žilina - Čadca – Skalité,
- The corridor VI (Rhine – Danube) - Ostrava/Přerov- Žilina – Košice

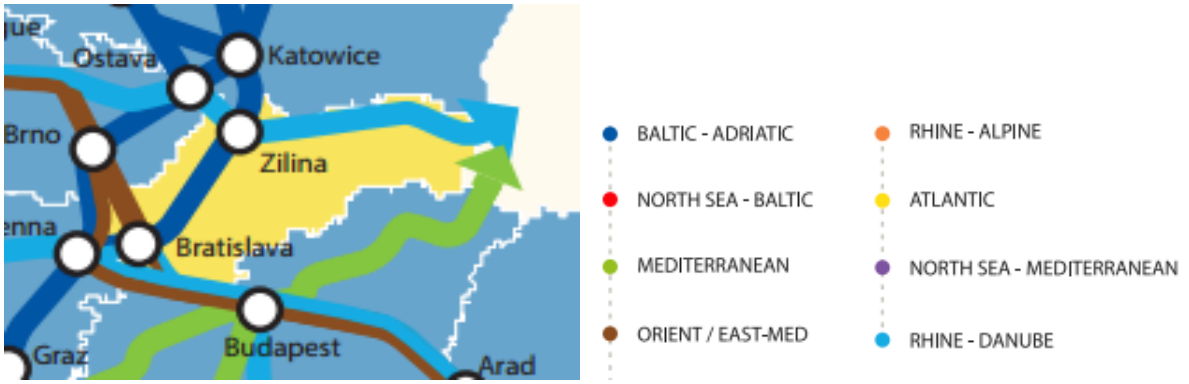


Figure 35. TEN-T corridors that pass through Slovakia (Vlaky.net, 2015)

Under the process of roadway modernisation, the railway junction Žilina will be significantly modernised.

Northwest Slovakia is relatively a highland country. This region has an area of 6808,7 km2, 690 121 inhabitants, and a population density of 101,4 inhabitants per square kilometre. On the other hand, the region of Žilina has 11 regions, 18 towns, and 297 villages. The Žilina region is divided into the following subregions Horné Považie, Kysuce, Liptov, Orava and Turiec.

The mountains stretch from the north to the south. They are divided by the rivers and deep valleys. The most complicated part of TEN-T network is Domašínsky meander that is located on the bank of the Váh River between Zilina and Vrutky.

The railway infrastructure often has to follow the landscape. The original railway was built and put in the operation in 1871 and 1872.

Figure 36. The tracing of original railway track Ostrava –Žilina – Košice (Vlaky.net, 2015)

In Figure 36 the track from Žilina to Košice is shown. Two railway one-track bridges were built (see the Figure 37, object B). To present the importance of these bridges, Figure 38 shows the damaged railway bridges over the Váh River in summer 1945. As a result, the railway transport was blocked for several months.

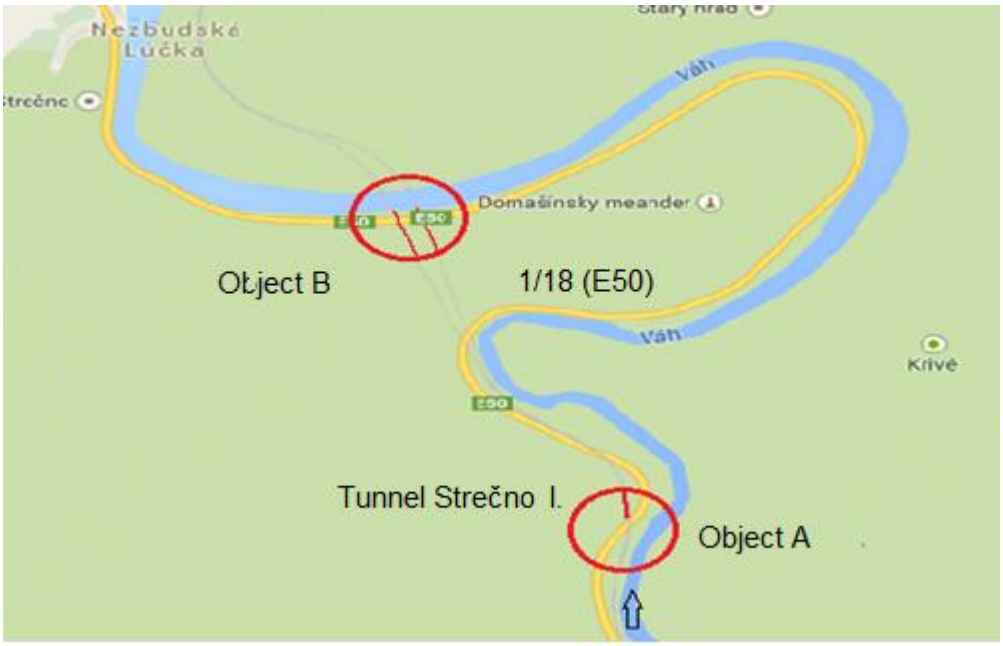


Figure 37. Vah meander near Strečno and objects A and B (Google Maps, 2015)

Figure 38. Damaged bridges in Strečno, summer 1945 (vlaky.net, 2015)

The double track tunnel Strečno I (Figure 37, object A and Figure 39) is the most important object of this case study. It arises as one of the potential elements of the critical infrastructure considering the defined sectoral and cross-cutting criteria in D 3.1 Annex 1, Annex 2.

Figure 39. Strečno railway double track tunnel – object A

The railway tunnel Strečno I, including the adjacent tracks were reconstructed in 2014. The importance of this tunnel is highlighted by the road bridge located close to it (see Figure 37 and Figure 40). This road bridge is part of the international road network E50.

Figure 40. Strečno railway double-track tunnel and road bridge E50 – object A

The examined railway track is an electrified, double-track, with a throughput of 100 pairs of trains per 24 h. In the case it were damaged the total economic damage would be over 10.000 EUR for 24 hours.

10.4.2 Road infrastructure; function and capacity

The status quo of road transport is characterized by a relatively dense road network. The existing capacity is exceeded in the main international road connections. On 1st January 2013 the density of road network was 0,368 km/km2, the density of the motorways and expressways was only 0,014 km/km2 (see Figure 41).

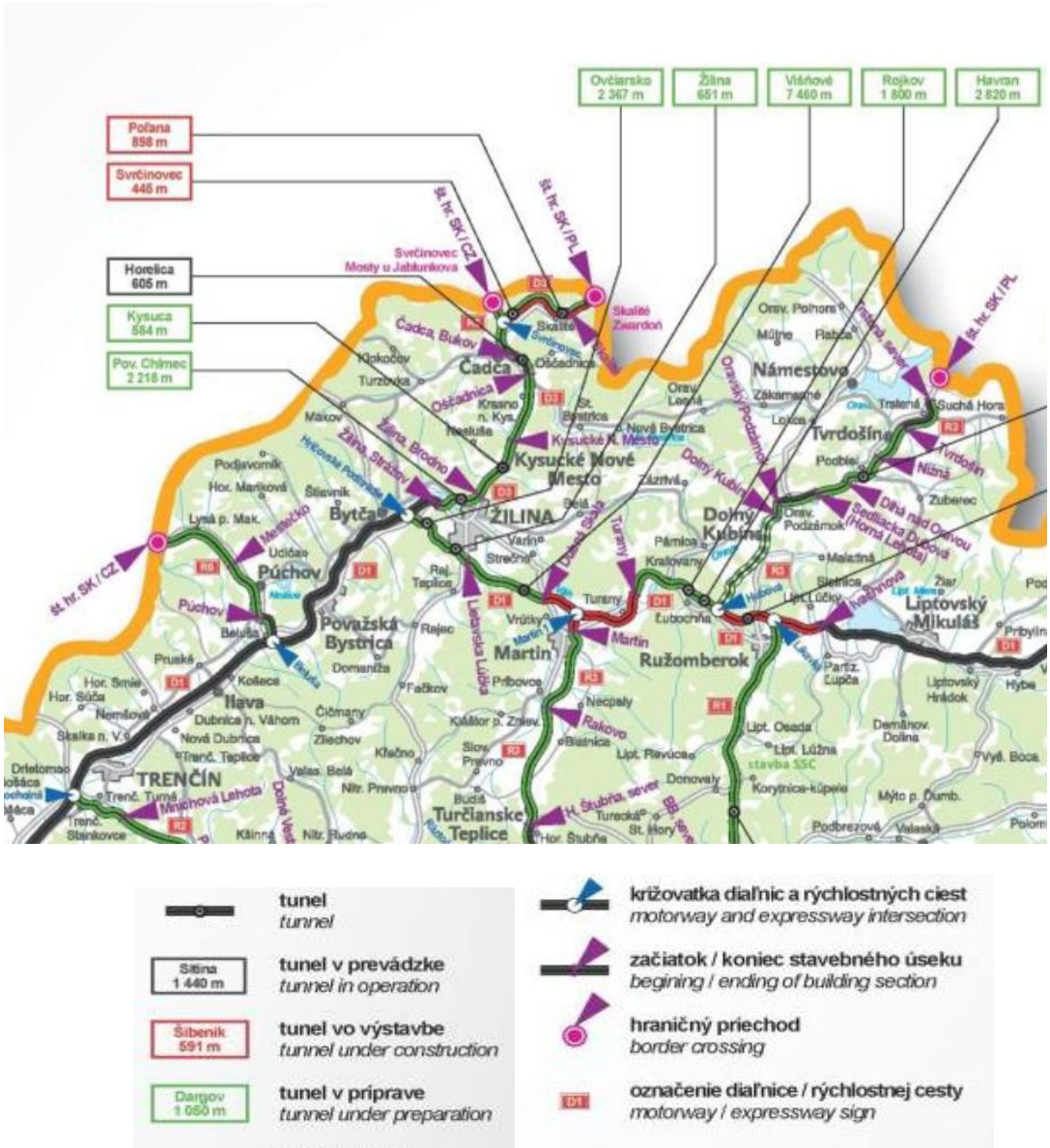


Figure 41. Map of road network in northwest part of Slovakia (SSC, 2015)

The network of the Slovak motorways, whose planned length is 705 km in 2030, consists of the routes D1, D2, D3 and D4. At the end of 2012, 59% of the projected motorways were in the operation, with 416 km long. The expressway network consists of the routes R1, R2, R3, R4, R5, R6, R7, and R8. The total length of these ways should be 1 263 km long in 2030. At the end of 2012 19,7% of these ways were completed, with 248 km long.

In northwest part of the Slovak Republic the TEN-T network of roads consists of:

- the motorway route D1: Trenčín – Žilina – Poprad, with a full profile of 312 km, and non full profile of 8 km.
- the motorway route D3: Žilina- Čadca- Skalité – the state border Slovakia / Poland, with a full profile of 8 km and anon full profile of 4 km.
- the express route R6 – state border Slovakia / the Czech Republic (Lysá pod Makytou-Púchov) with a non full profile of 3 km.

To evaluate the potential elements of critical infrastructure in the subsector of road transport it is important to identify the involved objects (bridges, tunnels). For example the motorway route D1 links eight out of ten biggest towns in the Slovak Republic, from the West through North to the East. This motorway has 3 tunnels in operation, such as Branisko, Lučivná and Bôrik. Moreover, it has the longest road bridges in Slovakia, namely, Považská Bystrica (1 444 m long) and Hričovský kanál (1 695 m long).

Bridges and tunnels

From the point of view of critical infrastructure bridges and tunnels on motorways represent important elements which should be taken in consideration during the analysis of the potential risks, and should be subjugated to the criterial evaluation. For example the tunnel Horelica, 605 m long, non full profile on the motorway D3. In a near future the most important objects will be ten motorway tunnels in ŽSK (see Table 3).

This fact will imply more efficient road traffic; nevertheless it will involve a bigger risk.

Table 3. The planned road tunnels in ŽSK according to their length (SSC, 2015)

name	length (m)	stretch
Višňové	7520	D1 Višňové - Dubná Skala
Korbeľka	5700	D1 Turany – Hubová
Havran	2702	D1 Turany – Hubová
Ovčiarsko	2609	D1 Hričovské Podhradie – Lietavská Lúčka
Považský Chlmec	2218	D3 Žilina, Strážov – Brodno
Poľana	898	D3 Svrčinovec –Skalité
Žilina	655	D1 Hričovské Podhradie – Lietavská Lúčka
Kysuca	584	D3 Brodno – Kysucké Nové Mesto
Svrčinovec	464	D3 Svrčinovec – Skalité

In the Slovak motorway network there are also 95 small bridges (less than 2 m long) and 205 underpasses excepting bridges and tunnels. In the network of roads for motor vehicles there are 244 small bridges and 102 underpasses. In the entire network (motorways and roads for motor vehicles) there are 137 meteorological stations, 374 camera systems and 1009 traffic changeable message signs for smooth traffic flow. There are also other devices such as automatic traffic counters, devices for measuring oversize transport, devices for weighing vehicles, devices for other type of measures, technological nodes and transmission equipment (telecommunication and power equipment), equipment for the management of technologies in the tunnels, management system of vehicle fleet (management and monitoring of maintenance vehicles) and truck scales.

The international road network "E" in ZSK

In Slovakia 11 main routes with 1 536 km length are classified as European roads "E" in accordance with AGR (European Agreement on main international traffic arteries). The following E routs pass through Žilina region:

- E 50 (direction: west – east) the Czech Republic – Trenčín – Žilina – Prešov – Košice – the Ukraine
- E 75 (direction: north – south) the Czech Republic – Čadca – Žilina – Trenčín – Bratislava – Hungary (see Figure 42).

Figure 42. Fragment of a network of national roads "E" in Žilina region (SSC, 2015)

International road network TEM

The project TEM (Trans European North-South Motorway Project) has existed in Europe since 1975. In the TEM network, 60,7% of the international roads of the class "E" are in the SR. The length of these roads is 932 km. Within this network the north-south road E75 Gdansk – Katowice – Žilina – Bratislava – Vienna / Budapest is the most important part of transport infrastructure in conditions of the ŽSK.

The following TEM routes pass throughout ŽSK:

- TEM 2 – the state border PL/SK, the border crossing Skalité (district: Čadca) – Žilina – Bratislava – the state border SK/A, the border crossing Berg,
- TEM 4 – the intersection I/11, I/18 Žilina – Ružomberok – Liptovský Mikuláš – Poprad – Prešov – Košice – Michalovce – Sobrance – the state border SK/U, the border crossing Vyšné Nemecké,
- TEM 5 – the intersection I/18, I/59 Ružomberok – Banská Bystrica – Zvolen – Levice – the state border SK/H, the border crossing Šahy.

The quality and density of the road infrastructure in the countries of Central and Eastern Europe does not correspond with the current needs. A big part of the main routes is valuated by EuroRap as unsafe (EuroRap, 2009).

10.4.3 Resilience of Land Transport Infrastructure

The present European research project is needed to identify the extreme weather risk in the European transport network. It is imperative to identify the appropriate adaptation measures, and to develop multi-modal implementation strategies that optimise over cost performance-risk. Firstly, common methods for risk assessment based on the state-of-the-art are being carried out. This will define the data base level required for building a comprehensive risk map for the core TEN-T network (e.g. ÖBB - Austrian Federal Railways). The risk map needs to be developed in close cooperation with the network's operators, on the basis of a harmonised risk assessment method for the impact of extreme weather events on the management and functioning of the core network. These maps should identify the vulnerable locations in the network and the impact of eventual disturbance from weather extremes.

The focus is on the assessment of the impact of extreme weather events on the important objects of transport infrastructure. Therefore, the first stage is the assessment of climate change scenarios and its determination of the effects on the transport infrastructure. This includes the integration of terrestrial and satellite systems for the structural health monitoring of key infrastructures located in a natural risk (rainfalls, snowstorms, landslides and floods) in the examined area (ERTRAC, 2013).

In Slovakia road and railway transport belongs to the most important modes of transport because of insufficient preconditions for the development of other mode of transport (for example navigable rivers, the area of the state with the respect to airports). The advantages and disadvantages of road and railway transport are summarized into Table 3.

Table 3 Advantages and disadvantages of road and railway transport in the relation to extreme weather

Mode of transport	Advantages	Disadvantages
railway	resistant to negative impact of the weather	demanding for the renewal
	green transport	depended on the rail infrastructure and electricity
road	dense network of the road	accident rate
	speed, availability, operability	negative impact on the environment

10.5 Description of Slovak public management; phase planning

As the climate in the Slovak republic is continental, the road and railway transport is usually operated without significant disturbances. Some parts of transit routes are congested in rush hours. In the case of accidents the volume of traffic is strongly reduced. The crisis management of road and railway transport is only activated in extreme weather events. In this case the principle of local and regional responsibilities is applied. The mayors activate the emergency committees. On the regional

level the municipality and region boards are activated. On the local level the head of local office is the responsible person, on the regional level the president is the responsible person. The central flood committee is only activated in the case of great extreme natural disasters. According to the needs other committees can also be activated. These central committees are established by central government authorities. In the last a few years they have been activated once a year. Moreover, the regular exercises are done on all levels, thematically focused on various crisis phenomena. They are carried out in the cooperation with other neighbouring countries.

Based on the mentioned real extreme weather events, flood control plans have been developed on all levels of the state administration. On the national level thousands of euros are invested into the flood control measures.

Nowadays, it is very important to improve information support of crisis management. On the web sites of villages, towns, district and regional offices there is the information regarding the proper behaviour in the case of crisis phenomena. In the current conditions the issues of prevention are basic activity of emergency committee. As the challenge of today it is necessary to improve communication in the field of cooperation of crisis committees in villages, towns and regional state administrations with the administrators of network infrastructures. Nowadays, the modernisation of information and communication technologies is not completely used on the communication between the public administration and the operators of railway and road infrastructure in the case of extraordinary incidents. For this reason it is important to test present possibilities and to prepare the system for the changes.

The partial conclusion

The preventive measures which are solved by the municipalities and the regional state administration come out of the level of the actual knowledge. Until a large extraordinary incident happens the presented measures are taken as adequate. The analysis of the status quo evaluates the strengths and weaknesses of road and railway transport. The modernisation of transport infrastructure is one of the possibilities to increase the resistance against extreme weather. Another possibility is the detailed analyzation of the risks on the local level and the preparation of the measures for the reduction of the risks.

11. Analyses phase after the event - scenarion

The case study analysed in this document is focused on the model situation of a hypothetical climatological event. As mentioned, road and railway transport corridors intersect in the northwest part of Slovakia. The objects identified as potential objects of critical infrastructure on the national level are assumed to be built with relatively high resistance against weather phenomena. Nevertheless, they could suffer from extreme climatological events, for instance due to floods or to the consequent landslides.

The presented scenario is the case of a hypothetical event in which the Liptovská Mara Dam would burst as the result of extreme snowfalls and rainfalls, flooding the surrounding area. As a result of the floods there would be landslides, causing the destruction of the road bridge and the tunnel portal Strečno I. It is highlighted that the presented situation is hypothetical; the probability of this event is relatively low because dams located on the Slovak rivers are continuously monitored. If they were damaged the adequate measures would be taken immediately.

The basic goal of the presented situation is the creation of a river flood scenario with the worst possible consequences. During WWII the allied troops took air raids on the German dams to disrupt the operation of the German economy and normal life, for instance the Edersee Dam (70 dead people in 1943) or the Möhne Dam (1579 victims in 1943) (The Dambusters. 2015). Since the end of the Second World War there have been some accidents on the European dams related to their disruption with catastrophic consequences, such as the Vea de tera Dam in Italy (44 victims in 1959), the Malpasset Dam in France (423 victims in 1959) (Duffaut, 2013), the Kurenivka Dam in the Ukraine (1500 victims in 1961) (Online Video Guide, 2015), the Vajont Dam in Italy (2000 victims in 1963) (The Landslide Blog, 2008), the Mina Plakalnitsa Dam in Bulgaria (107 victims in 1966) (Chillopedia, 2013), the Ajka Dam in Hungary (10 victims in 2010) (Engineering Failures, 2010), the Ivanovo Dam in Bulgaria (8 victims in 2012) (novinite.com, 2012).

11.1 Description of hypotetical meteorological event

In the last few years extreme weather phenomena have increased. Rainfalls, snowfalls, river floods, landslides, windstorms, tornados are the most frequent natural events with influence on the operation of land ways in the Slovak Republic.

Some of these phenomena, such as snowfalls and strong gusty winds, appear more frequently than other phenomena such as floods and landslides. Higher frequency of the event is usually related to lower consequences. Therefore, the analysis of the historical data about natural threats in conjuction with their corresponding rate of danger becomes necessary.

Floods; data about floods and their ranges are available in the form of special GIS layers as 5-year floodplain, 20-year floodplain and 100-year floodplain. It is a theoretical range that is based on the digital terrain model. It is also possible to obtain the range of the largest recorded flood (real prediction overflows).

Flood maps (see Figure 43) are the common name for these flood hazard maps and flood risk maps. On the flood hazard map the range of floods from 5-year flood to 1 000-year flood is available. Flood

risk maps contain the information about the potential unfavorable consequences of the floods. Flood risk maps provide the data about estimated number of potential threatened inhabitants and type of potential disrupted economic activities on the threatened area. Other data that can be found on this map is:

- the localities with industrial activities which can cause water pollution after the flooding,
- the location of the potential threatened areas of water consumption for human consumption and recreational activities.
- the localities with water suitable for swimming,
- the information about other important sources of potential pollution of water after their flooding,
- the areas which are part of the national network of protected areas and European network of proposed and declared protected areas (Maps of risk flooding, 2015).

Slovak Water Management Enterprise, Banská Štiavnica, ensures the production of the flood hazard maps and the flood risk maps.

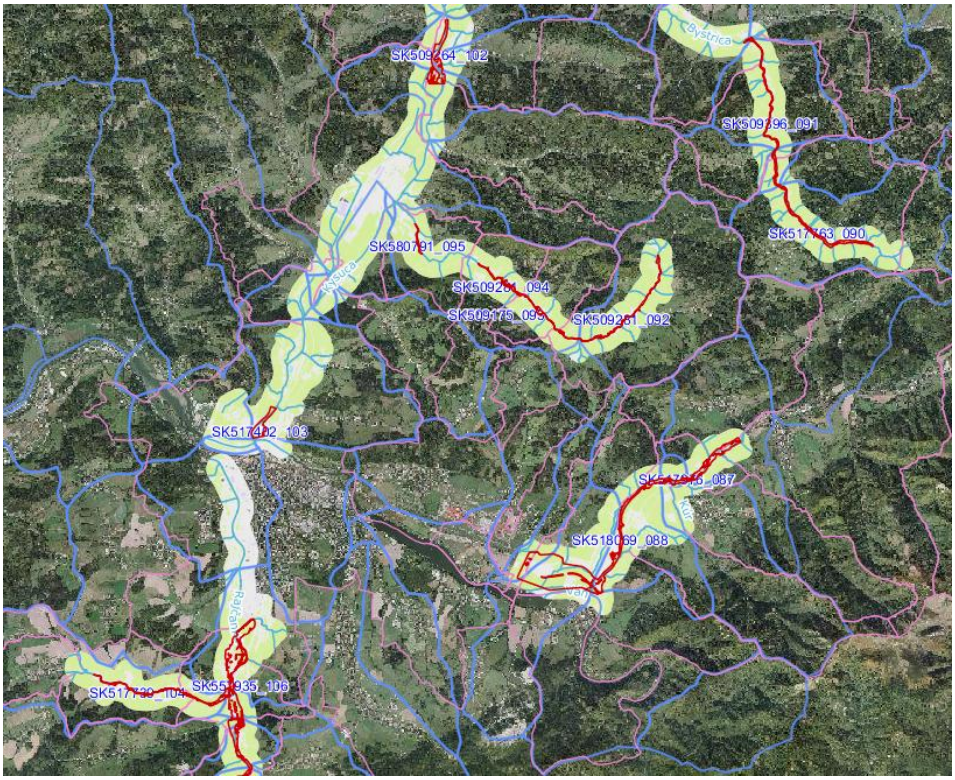


Figure 43. Flooding area during hundred year flood from risk forecasting map (Maps of risk flooding, 2015)

The Directive of the Ministry of Environment of the Slovak Republic from 23 July 2014 is used for the calculation of a breakthrough wave from the construction. This directive calculates with the breakthrough wave which consists of clean water. Its density is 1 000 km.m-3 and the temperature is 4°C. The movement of the sediments, which are located on the riverbed, is not included in the calculation. In practise table figures are used in the calculation such as the course of emptying of the dam, maximum values of the heights of water surface and the speed of water movement, the height

of level in all junctions of the calculated network, time evolution of the height of water surface and the flows, wave arrival time, time and height of culmination of water level and the decrease of the water flow under the culmination flow of flood. The devastating effects of breakthrough wave are evaluated in relation to build-up areas, the buildings of supra-regional and regional character, dams, hospitals and social service institutes, the buildings where dangerous cargoes are made and are stored, and the buildings which are important for ensuring of the basic needs of people.

The calculated values are plotted in the maps with the measuring scale 1:10 000. In the maps there are plotted external circumference flood lines and the location of breakthrough wave front every 15 minutes of model period.

Landslides: they are the most frequent, caused by the properties of subsoil and lasting rainfalls when water starts seeping gradually into the layers of subsoil or during short-term rainfalls and consequent lightning floods.

In the case of slope deformations, it is possible to come out of the data operated by the State Geological institute of Dionýz Štúr. Its activity is oriented at the geological research and exploration. The institute also produces the geological maps, where the areas with low, middle and high stability of the country are shown (see the Figure 44).

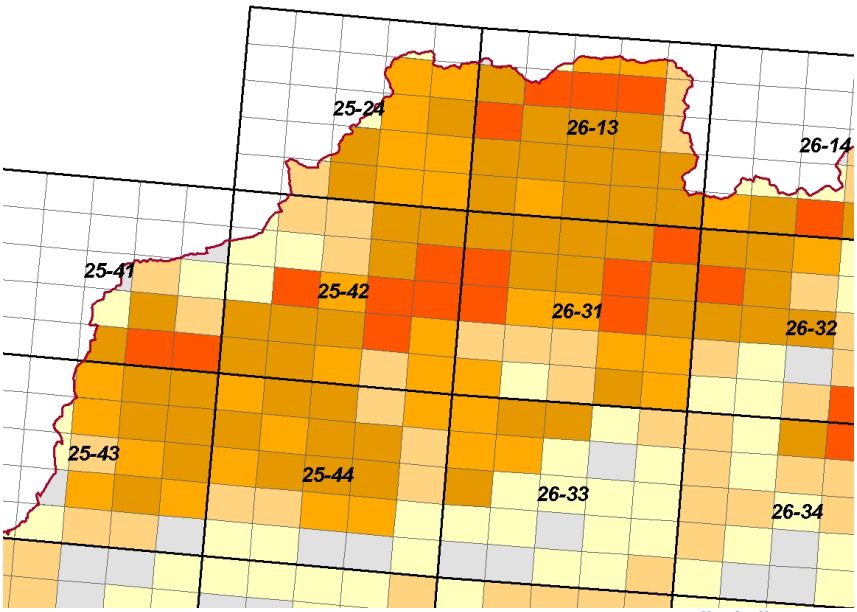


Figure 44 Map of frequency slope deformations, northwest Slovakia (ŠGÚDŠ, 2015)

The register records the documented slope deformations in the Slovak Republic. This database has thousands of records about the location of landslides and other negative landslides events including their detailed description. In the database there are differentiated point landslides (small sizes) and sheet landslides, see the Figure 45.

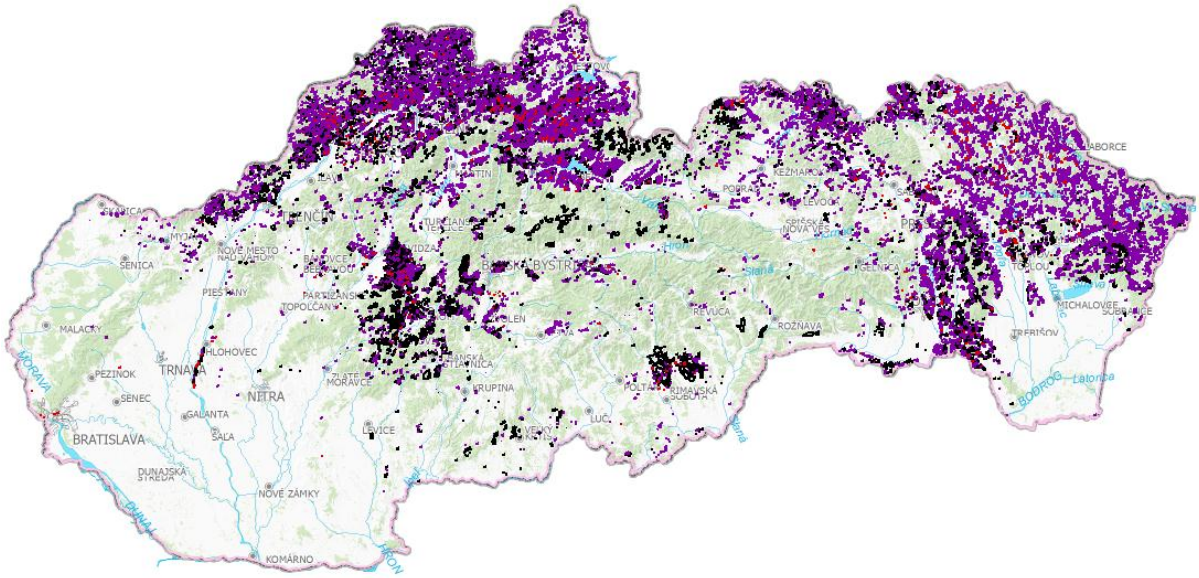


Figure 45. Map of slope deformations throughout Slovakia (ŠGÚDŠ, 2015)

Northwest part of Slovakia is strongly predisposed to the slope deformations (see Figure 33).

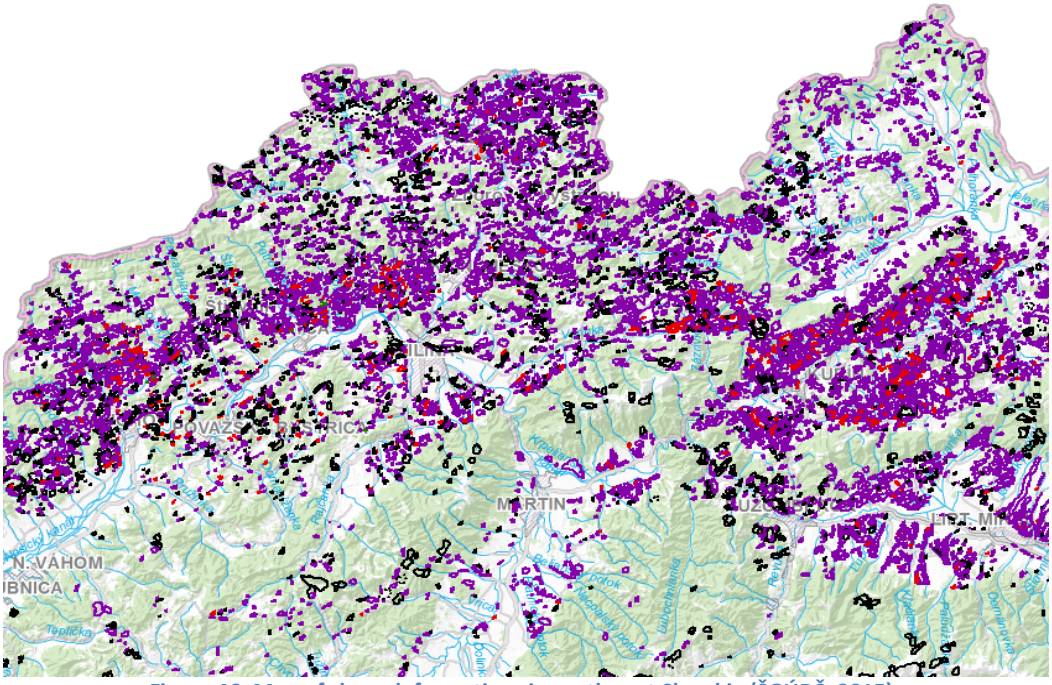


Figure 46. Map of slope deformations in northwest Slovakia (ŠGÚDŠ, 2015)

The table with information about a possible landslide is assigned to each landslide. This table consists of an identification number of the landslide register, geomorphological unit, engineering and geological area, information sources, the type of landslide deformation, the activity level, geological formation, geological structure, hydrogeological proportions, area, grade slope, threatened objects, causes of origin and etc.

In the application it is possible SQL searching according to differently chosen searching criteria, for example the level of activity (active, potentially and stabilized landslides). The landslides database provides the information about the status of land rupture to a specific period. However, it is necessary to update it.

Extreme snowfall: a strong snowfall represents the complication in the use of transport infrastructure, mainly when a lot of snow falls during a short time. These values describe the grid layer "height of new snow". The averages of seasonal precipitations and amount of new snow are starting figures which are used for the prediction of the areas with high probability of extreme snowfall. These figures are provided by the Slovak Hydro-meteorological Institute.

Floods and the system of their regulation

The system of flood protection in the SR is regulated by the Flood Protection Act, n. 666/2004. This act defines the roles of the state authorities, municipalities, flood committees and rescue services in the field of flood protection and the rights and the obligations of legal entities and natural persons in flood protection. The ministry, regional and district offices of environment and municipalities belong to the state authorities. The Government of the SR approved the Flood Protection Program of the Slovak Republic by 2020. Its goals are:

- the reduction of flood flows by increasing of retention in the river basin,
- the retention of the peaks of flood waves in the retention spaces of dykes and polders and the reactivation of the flood areas,
- providing of a necessary flow capacity of the river bed and the increasing of a retention space of a dyke where it is possible,
- reducing of drain rate by re-naturalization of original riverbeds,
- building of protection dykes,
- early warning and forecasting service.

The program contains a whole complex of short, medium and long-term flood preventions including a set of scientific and technical projects and the improvement of flood warning and forecast system of the SR.

POVAPSYS is a flood warning and forecast system in the SR. It is focused on the innovation of flood warning and forecast methods, operational services and the necessary infrastructure. In the Slovak Water Management Enterprise, the system of the maps of areas that might be threatened by floods has been developed. It comes out of the valid legislation of the SR and fills the mandatory types of maps which enable to improve the whole system of flood risk management.

This system consists of the following types of maps:

- floodplain map,
- map of the potential area of floodplain,
- flood risk map,
- flood inundation map area
- map of the course of flood of inundation area,
- danger map and potential consequences of floods,

- historical flood map and map of breakthrough wave.

The floods that are caused by flash flooding in the northwest part of Slovakia are relatively frequent. The storm activity is relatively high in rugged mountain and foothill terrain especially in summer months. Hydrological and meteorological warnings are available on the web site of Slovak Hydrometeorological Institute (Figure 47).

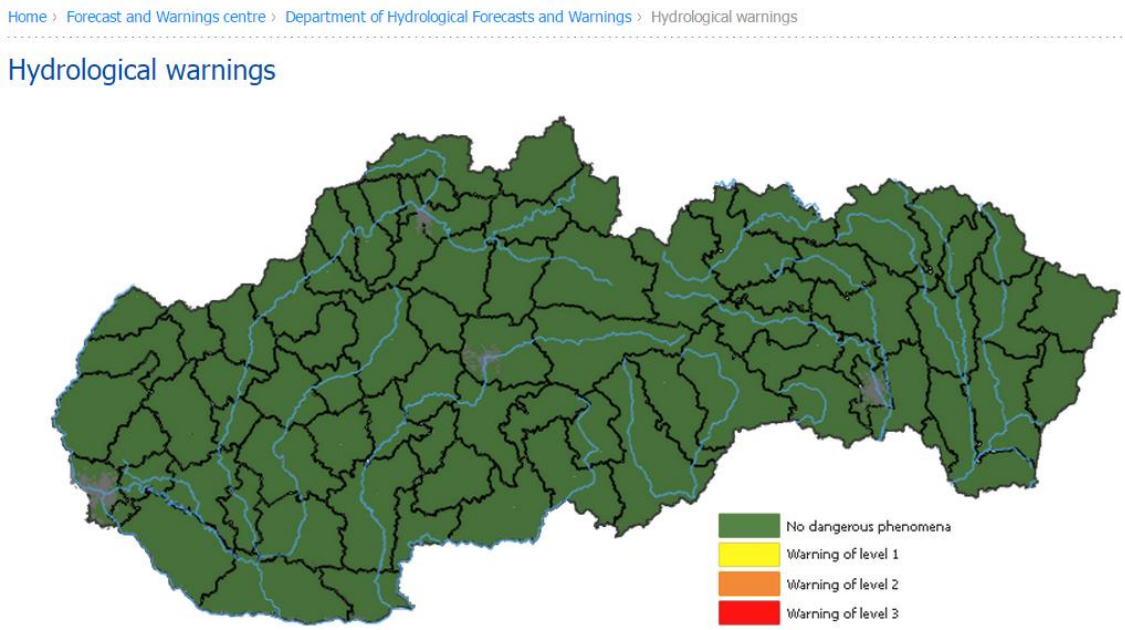


Figure 47. Map of hydrological warnings in Slovakia (SHMI, 2015)

The Váh River, which flows through the territory of Žilina, drains water from all over the north-west part of Slovakia. Its tributaries are the Revúca, Orava, Turiec, Kysuca and Rajčanka rivers. Water levels are available in the online system on the web site of the Slovak Hydrometeorological Institute, (Figure 48). Several dams have been built on the mentioned rivers. The biggest dams are the Liptovská Mara Dam and the Orava Dam. The Orava Dam was built at the confluence of the White and Black Orava. It is located in the north of Slovakia of the Žilina Region. The basic data are: the total area of Orava Dam: 35 km2, the water volume is 350 mil. m3, the average depth, 15 m, and the maximal depth at the dam wall is 38 m.

The Liptovská Mara Dam was built between 1965 and 1975. Its water volume is 360,5 mil. m3 of which the useful volume is 320,5 mil. m3 and the protection volume is 14,5 mil. m3. It is the biggest dam in Slovakia, the surface of the flood area is 27 km2. The dam consists of the natural dam that is 43,5 m high (the construction height is 52 m) and the hydroelectric power station with 4 turbines with the output of 203 MW.

The emergency plans have been prepared in the case of extreme precipitation in the region or the real possibility of disruption of the walls on these dams. The scenarios have been prepared in the case of breaking of both dams. The mentioned scenarios contemplate with the hypothetical

possibility of breakage of the two dams at once. The total maximal cumulate volume of water is 710 mil km3 (Figure 48).

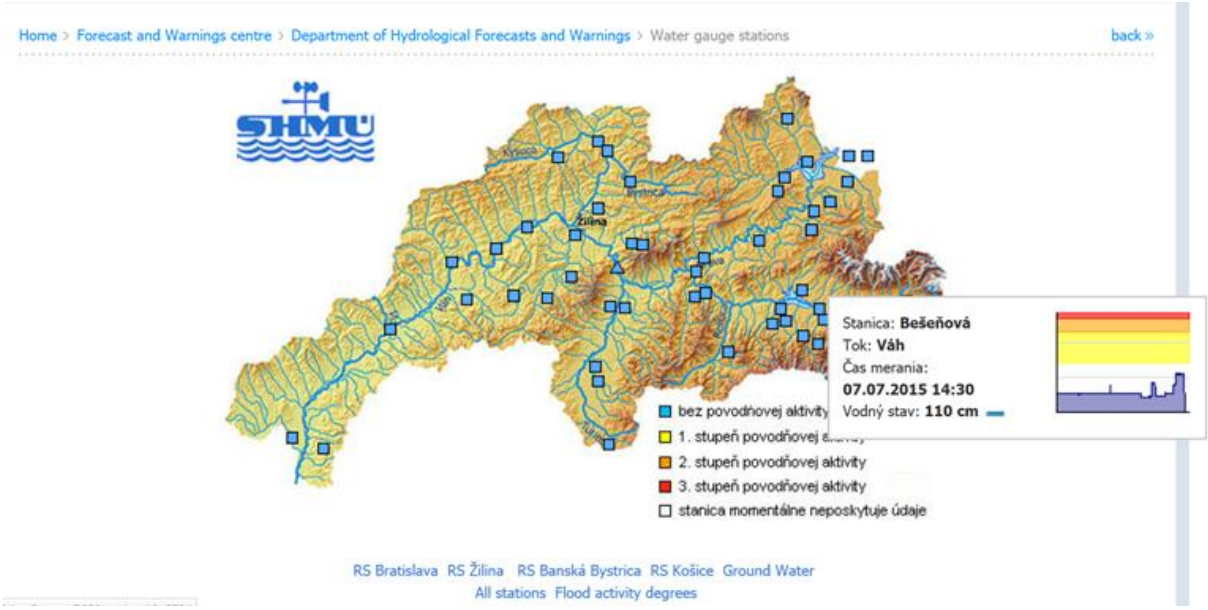


Figure 48. Map of water gauge stations in northwest Slovakia (SHMI, 2015)

In the mentioned hypothetical situation there is considered the rupture of the Liptovská Mara Dam. Existing flood hazard maps and risks consider 5, 10, 50, 100 and 1000-year floods.

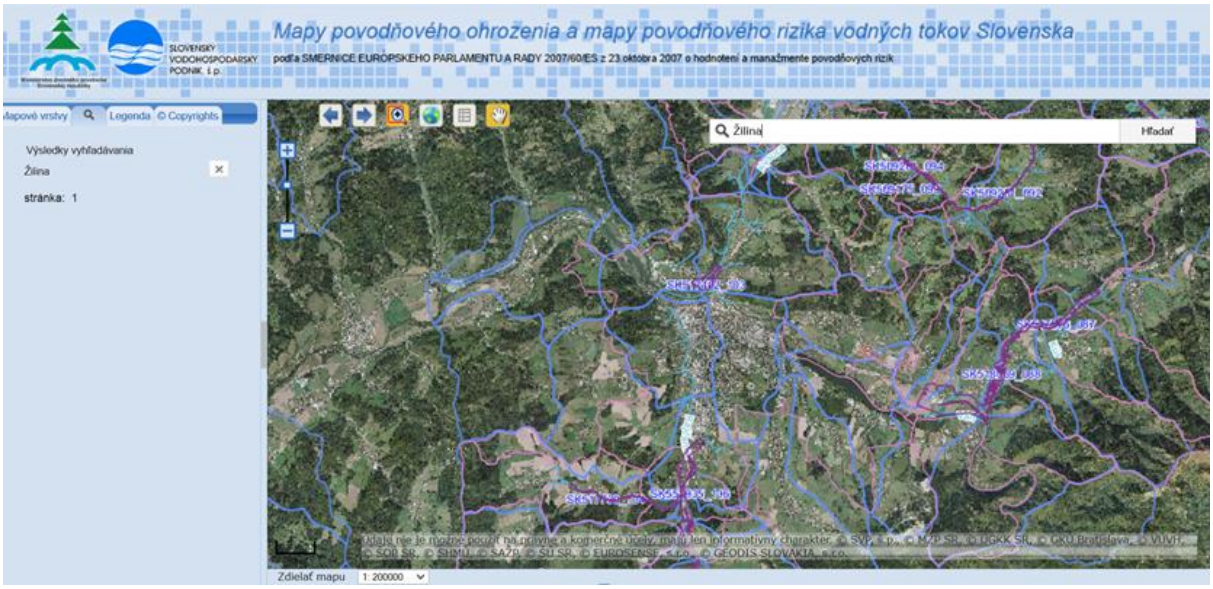


Figure 36. Map of flooding risks in North West Slovakia (Maps of risk flooding, 2015)

The Slovak Water Management Enterprise uses maps of flooding risks. Zilina region is characterized by very broken terrain and therefore there is a relatively high probability of flooding (Figure 49).

The rupture of the Liptovská Mara Dam would flood a significantly bigger land and it would cause strongly bigger damages. At the expected speed of 7 m/s there would be gradually flooded towns and villages (Bešeňová, Liptovská Teplá, Lisková, Ružomberok, etc.) that are located on the banks of the Váh River. Except residential areas like block of flats or houses there would be also damaged the public buildings like Central Military Hospital in Ružomberok, the industrial areas like the factory SCP Papier in Ružomberok or the assembly plant of KIA Motors Slovakia in Žilina. Nowadays, about 16 800 companies and 144 950 houses are registered in the Žilina Region. The economic damages which would be caused to the citizens, public institutions and companies would be so high (hundreds of millions of euros). In the case people were not be evacuated in time there would be hundreds of dead in the valley of the Váh River as the result of the flood. Near the river Vah, at the place of assumed flooding, there is a range of manufacturing and logistics businesses and companies (Figure 50).

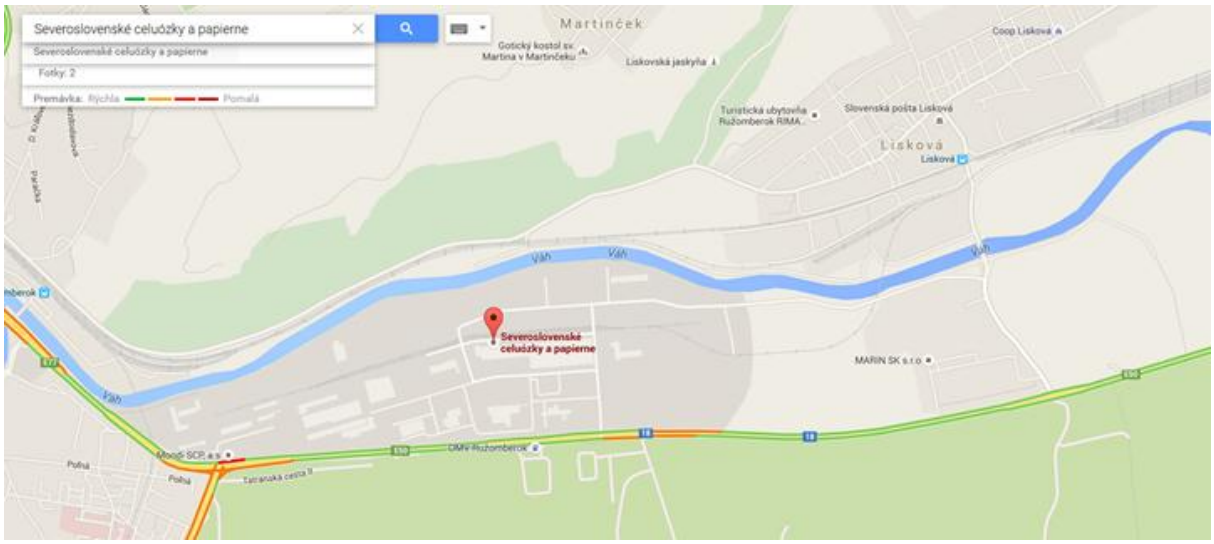


Figure 50. Maps of industrial objects in Zilina region (Google Maps, 2015)

11.2 Description of transport infrastructure after the hypothetical event

According to the administrator of the dam Liptovská Mara Slovak Water Management Enterprise, the maximum volume of water retention is 360,5 million cubic meters. In case of crisis situation there is a scenario of rapid discharges when the dam will be depleted after 7 days and 17 hours. In a hypothetical scenario, the authors suggest that this will undermine the dam without prior flashing. On 15/03/2015 a protracted rainfall repeatedly reached more than 100 mm of rain in 24 hours and caused the failure of the construction of the dam Liptovská Mara.

The river flood would rupture the Liptovská Mara and the prolonged rainfall launched would hit large parts of northern Slovakia. A breakthrough wave of 14.00 meters would reach the boundaries of Žilina region. The high breakthrough waves and the amount of water gradually would flood a large area. It would significantly undermine the infrastructure of the region (homes, businesses and transportation infrastructure), meanwhile a large proportion of the population would manage to evacuate in time, but dozens of people would die.

From the collapse of the Liptovská Mara Dam all road and railway bridges would be partially or completely damaged, from the wall of the Liptovská Mara Dam to the town of Bytča, involving 10 railway and 13 road bridges (Figure 51).

Figure 51. Dam Liptovská Mara and studied object A (SSC, 2015)

Object A and object B on the route between Vrútky and Varin (Figure 37) have been identified as elements of critical infrastructure in the transport sector, following the methodology described in D3.1. These objects are near the village Strečno, object A is 5 meters above the river Vah, and object B is 10 meters above the water level. The distance from the objects and the wall of the dam is 64 km, according to the risk analysis of processed District office in Žilina. It is believed that the maximum amount of breakthrough wave will be 12 meters, the speed of the water will be 3,8 m/s, and the breakthrough wave front will reach the examinee in 5 hours and 40 minutes (Figure 52). The total duration of flooding object A is 10 hours. According to an analysis of the risks, it would lead to the complete destruction of the railway line (including bridges and tunnels) and the destruction of the road 1/18 (E50) between Vrútky and Strečno. Destruction of objects is expected, leaching subsoil road, damaging the pillars of bridges and leaching ballast in the railway tunnels. Objects of transport infrastructure and a layer of alluvial material (trees, construction of buildings and the varying equipment) would be blocked the tunnels. Given the degree of disruption, recovery time is expected to be in the order of weeks to months.

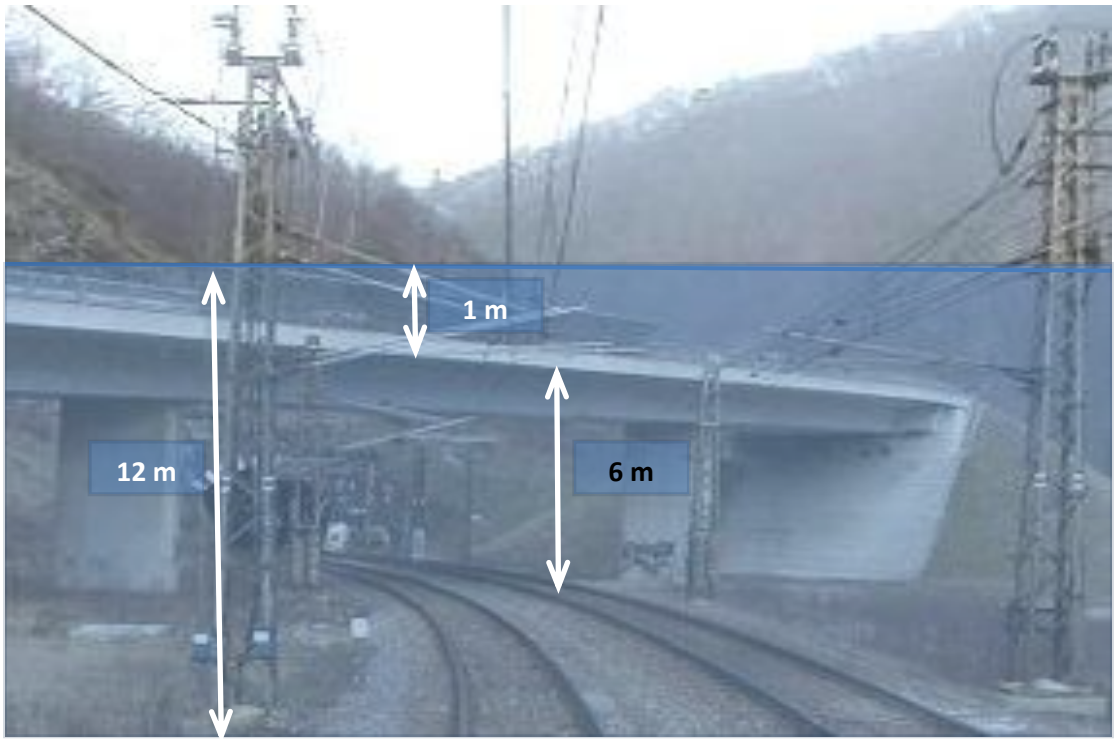


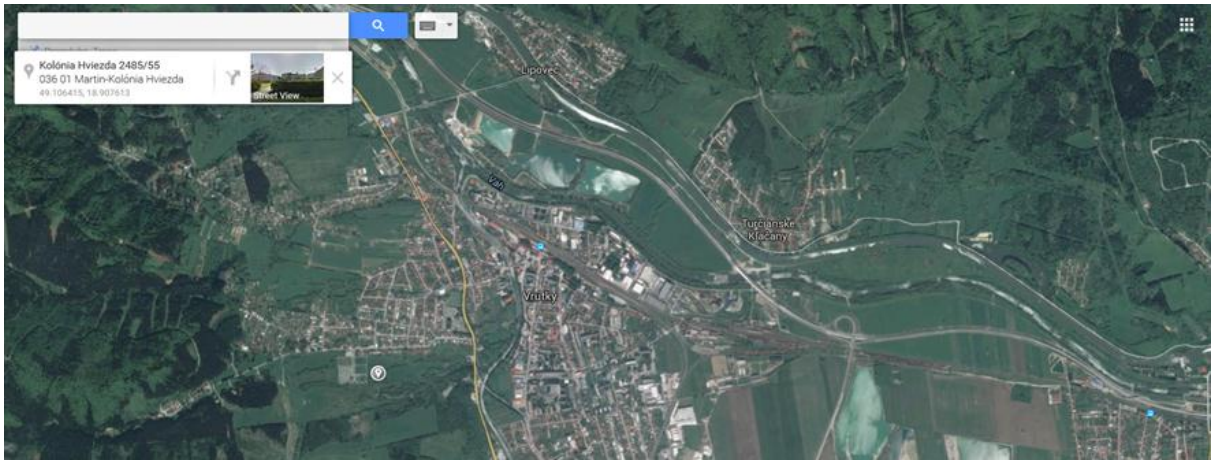
Figure 52. The maximum level of flooding object A

Given the estimated height of flood wave, objects such as the Thermal Park in Bešeňová, the companies located in the central part of Ružomberok, the villages Švošov, Hubová and Ľubochňa, the Krpeľany Dam, the railway station in Vrútky, the Žilina Dam, the railway and bus station in Žilina, the companies situated in the central part of Žilina, the Hričov Dam and the objects in Bytča, would be also partially or completely damaged (see pictures in Figure 53).


Turík
Lintovská Teplá
Beňušová
Lúčovský Michal
Ivachnová
Vlachy


Likavka
Martinček
Liskova
Ružomberok
Severoslovenské celulózky a papierne


Korbeľka
Svätý Kríž
Lubochňa
Hubová


Kolónia Hviezda 248S/55
036 01 Martin-Kolónia Hviezda
49.106415, 18.907613
Street View
Lipovec
Turčianske Kľačany
Vrútky

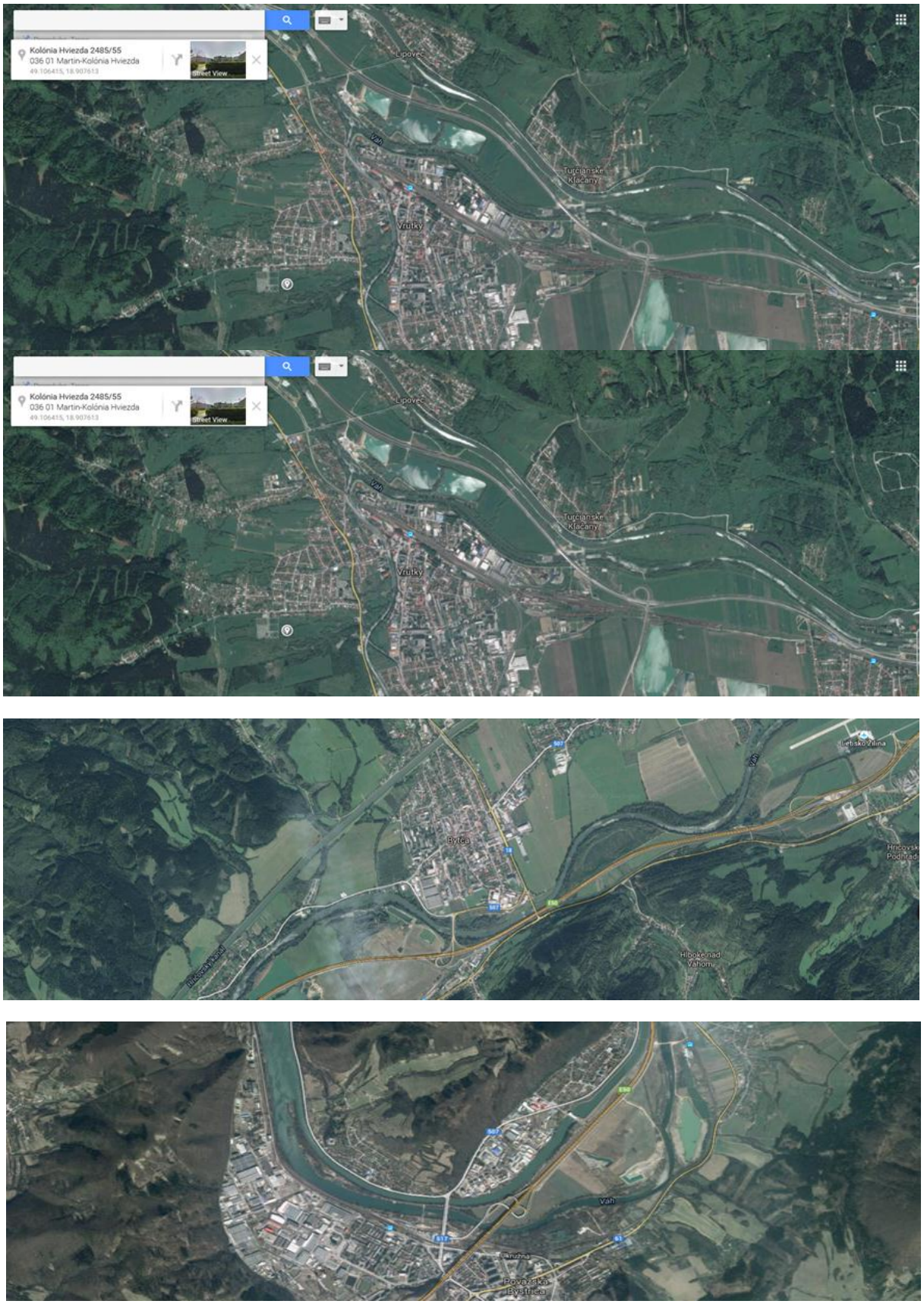


Figure 53. Maps of river Vah and transport objects in Zilina region (Google Maps, 2015)

11.2.1 Function/capacity

The destruction of object A (tunnel corridor for track and road bridge on the road 1/18 (E50)) prevents transport services in the region of northwestern Slovakia. The total number of people living in Žilina region is 690 121. In addition to local transport services (way to school, work, hospital, office and others) in this region there is important transit traffic. Annual average daily traffic road in both directions for 24 hours was 29 300, in 2014. With an average occupancy vehicle with two persons, the total transport capacity is 58 600 passengers. The peak hourly intensity of the E50 road between Žilina and Vrútky exceeded 4,5 times compared to the average, resulting in very frequent accidents and traffic congestion (Figure 54).

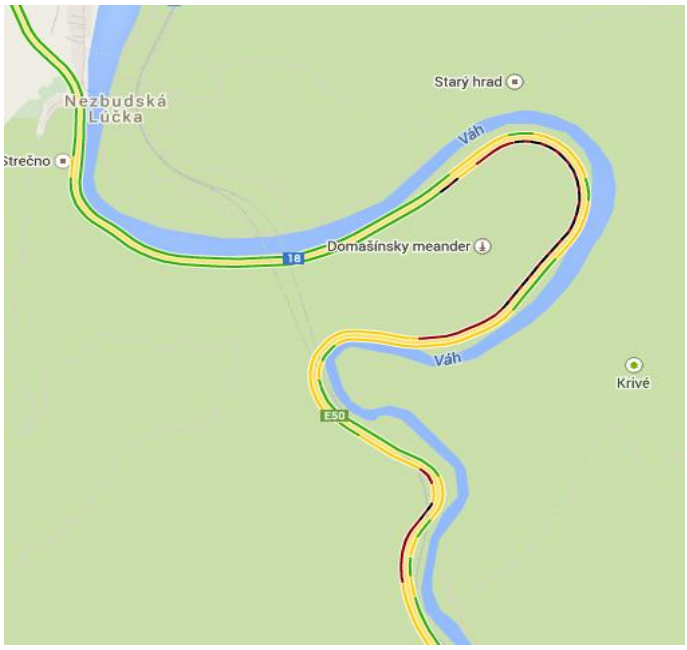


Figure 54. The peak intensity of traffic on the examined road section 18.1 (E50), brown and black color implies a significant delay in the route (Google Maps, 2015)

Railway line Žilina - Vrútky has a capacity of 120 pairs of trains per 24 hours. Especially on Fridays and Sundays passenger trains booked up to capacity. According to the current train timetable referred to stretch a day passes in both directions, there are 94 passenger trains with a total capacity of 55 800 passengers.

Table 5. Number of trains and transported passengers in the section Žilina - Vrútky

Day period	0-12	12-19	19-24	Sum trains	Passangers in one train	Total passangers
IC, EC	2	4	4	10	800	8 000
Speed	6	7	1	14	600	8 400
Regional	5	4		9	500	4 500
Slow	7	5	2	14	500	7 000
Total all trains in one direction for 24 hour						27 900

The total calculated capacity in the area of Žilina - Vrútky in both directions for rail and road together is 58 600 + 55 800 = 114 400 passengers.

11.2.2 Sectoral criterion "Traffic" for including the object A among potential CI elements

The criterion Traffic includes the traffic intensity and the traffic density in the case of road transport (Tables 6 and 7); and the traffic capacity in the case of railway transport (Table 8). The threshold values proposed in Tables 6, 7 and 8 are based on real traffic measurements (survey).

Table 6. Threshold values of criterion Traffic for one lane roads

K1.1	**Traffic (intensity - q)**
1	Negligible (max 1 000 vehicle units (v.u.) /24 hours)
2	Low (max 5 000 v.u./24 hours)
3	Medium (max 10 000 v.u./24 hours)
4	High (max 20 000 v.u./24 hours)
5	Extreme (above 20 000 v.u./24 hours) **Object A – road 1/18 (E50) near Strečno**

Table 7. Threshold values of criterion Traffic for one lane roads

K1.2	**Traffic (density - k)**
1	Negligible (max 8 vehicle units (v.u.) /km)
2	Low (max 16 v.u./km)
3	Medium (max 23 v.u./km)
4	High (max 40 v.u./km)
5	Extreme (above 40 v.u./km) **Object A – road 1/18 (E50) near Strečno**

Note: intensity and density values indicated in Tables 6,7 are derived from reference: (Dvorak, 2010)

- Unit vehicle coefficients - Cyclist = 0,5, Motorcycle = 1,0, Car =1,0, Truck = 1,5 and Heavy truck = 2,5
- Months coefficients - January = 1,15, February 1,12, March = 1,08, April = 1,03, May = 1,00, June = 0,98, July = 0,95, August = 0,94, September = 1,03, October 1,05, November = 1,08 and December = 1,12

Table 8.. Threshold values of criterion Traffic for the two rails railway

K1	**Traffic (capacity - c)**
1	Negligible (max 10 pairs of trains /24 hours)
2	Low (max 40 pairs of trains /24 hours)
3	Medium (max 70 pairs of trains /24 hours)
4	High (max 100 pairs of trains /24 hours) **Object A, near Strečno, real capacity is about 90 pairs of trains / 24 hour**
5	Extreme (above 100 pairs of trains /24 hours)

11.2.3 Other sectoral and cross-cutting crierions and partial conclusion

Calculation of the other sectoral and cross-cutting criterions is described in detail in D3.1 Annex 1. Experts have to progressively test all criteria (K1 to K8) for each examined typological object in the affected area (10 railway and 13 road bridges). It is the element of CI in the case that one of road and railway bridges has got the cumulative value which is higher than 30 and it also fills cross-cutting criterion.

The tunnels are very important typological objects. In the Žilina Region the tunnels Kraľovany, Strečno I, Strečno II and Strečno III have been built and are operated. . From the mentioned tunnels, only tunnel Strečno I was tested.

By means of the methodology developed in Deliverable 3.1, the following data of sectorial criteriawere chosen for the studied case:

K1 – traffic= 5,
K2 – size of the construction = 5,
K3 – recovery demandingness = 4,
K4 – material value of the object (Euro) = 4,
K5 – economic impact (Euro) = 4,
K6 – exceptionality and uniqueness of the object = 4,
K7 – probability of an terrorist attack = 4,
K8 – probability of an emergency event = 4.

The cumulative value is 34, it means, this object belongs to the potential elements of CI.

From the point of view of sectorial criterions the third criterion for the impact on the general public was chosen. The threshold value for the loss of confidence of population is not set. Experts determined the threshold values in the SR as 2 500 people affected by physical suffering, and 2 500 people with disruption of their daily life. About 60 000 people are linked with this hypothetical event.

As a conclusion; the sector criterion was calculated on the value 34 (see D3.1) for the object A - Tunnel Strečno I and the cross-cutting criterion was defined as impact on public (min. 60 000 people affected). Landslide and river flood are the most probable threats for this potential CI element. Based on the mentioned data, tunnel Strečno I is a potential CI element. Daily average of transported passengers through the object A is is of 120 000 persons. It is expected that the restoration of road and rail infrastructure (critical infrastructure elements) will take several weeks.

11.3 Description of extra ordinary situation management

In the Slovak Republic are pre-prepared plans for businesses, municipalities and regions in tabular form. Fragment of an action plan for flood of Liptovská Mara for companies, municipalities and local authority is shown in Table 9.

Table 9. Management activities in the destruction of the dam Liptovská Mara

Tasks and measures	**Legal and natural persons - entrepreneurs**	**Municipalities and District Offices**
Vulnerable districts in the Žilina Region	district Liptovsky Mikulas, district Ružomberok, district Martin, district Žilina, district Bytča	
Threatened municipalities in the Žilina Region	Bešeňová, Ivachnová, Liptovská Teplá, Lisková, Ružomberok, Švošov, Ľubochňa, Stankovany, Kraľovany, Krpeľany, Turany, Sučany, Turčianské Klačany, Martin, Vrútky, Lipovec, Strečno, Nezbudská Lúčka, Varín, Gbeľany, Mojš, Teplička nad Váhom, Žilina, Budatín, Považsky Chlmec, Strážov, Divinka, Horný Hričov, Svederník, Dolný Hričov, Hričovské Podhradie, Bytča, Predmier	
A method of protecting	- timely evacuation	- timely evacuation
2. The urgent and follow up measures	- warning employees - monitoring of companies area - rescue of persons - ensure evacuation measures - create conditions to eliminate the consequences extraordinary event - ensure Patrol Service - regulating the movement of people and vehicles	- population warning - evacuation of people, animals and goods - monitoring area - rescue of persons - create conditions to eliminate the consequences extraordinary event - regulating the movement of people and vehicles - provision of emergency

		accommodation and emergency supplies - verify the damage and costs of rescue
3. Emergency Management	- statutory representative of the company	- mayor and head of the district office
4. The need for manpower and resources to deal with extraordinary event	- rescue units, reconnaissance units, salvage units, decontamination drive, ambulances, police units	- units for the needs of municipalities and territories, emergency accommodation and emergency supplies, funeral services, units providing veterinary measures
5. Forces and resources available	- own forces and resources	- external group - the police - fire and rescue service
6. The possibility of deployment of the integrated rescue system	- after requesting the emergency line 112	- emergency medical service, - other units of the integrated rescue system
7. Creating Civil Protection Units	- develop focused on creating civil protection for the needs of the company	- develop focused on creating civil protection units for the needs of the municipality and region
8. Recommendations - precautions to reduce the risk	- update the emergency plan and flood plan, participate in surveys flood - carry out staff training.	- update the emergency plan (evacuation plan) - participate in the preparation of the population - ensure functional information system in the town and the region

What is the damage caused to people travelling on the transport route during flood? Traffic stops during the hypothetical extraordinary event for flooding. Passenger transportation by trains and buses will be rerouted outside the area of flooding. Police forces will be denied entrance to flood vulnerable routes. Trains and buses with passengers on long-haul will be redirected outside the area of flooding, respectively. In some cases will be deposited in a safe place.

11.4 Management of emergency

The key question will be rescue of the population. Crisis management in the regions, cities, municipalities and companies must ensure timely evacuation of people, animals and things for the affected region. In Figure 55 directions of evacuation of the local population and diversion of transit traffic are shown. It is assumed that the transport infrastructure along the river Vah will be completely destroyed or badly damaged.

Figure 55. Routing evacuation before the flood wave (Google Maps, 2015)

The development of flood event shows a growing trend. In the region of north-west Slovakia the average quantity of fallen rainfall is 100 mm/month. The Slovak Hydrometeorological Institute declares in forecasts heavy rainfall, i.e. rainfall exceeding values of 100mm/24 hours repeatedly for several days. This fact is indicated by Figure 56 where the red coulour means warning of the 3rd degree, orange colour means warning of the 2nd degree and yellow colour means warning of the 1st degree. Based on this fact, the Slovak Water Management Company started the plans for gradually emptying the dams. During this hypothetical event the dam Liptovska Mara was harmed and partially ruptured. From that moment people near the dam have a very short time to save. Evaluated object A is at a distance of 64 km from the dam. For this reason it is relatively enough time (4-5 hours) for evacuation of people, animals and things in Zilina region.

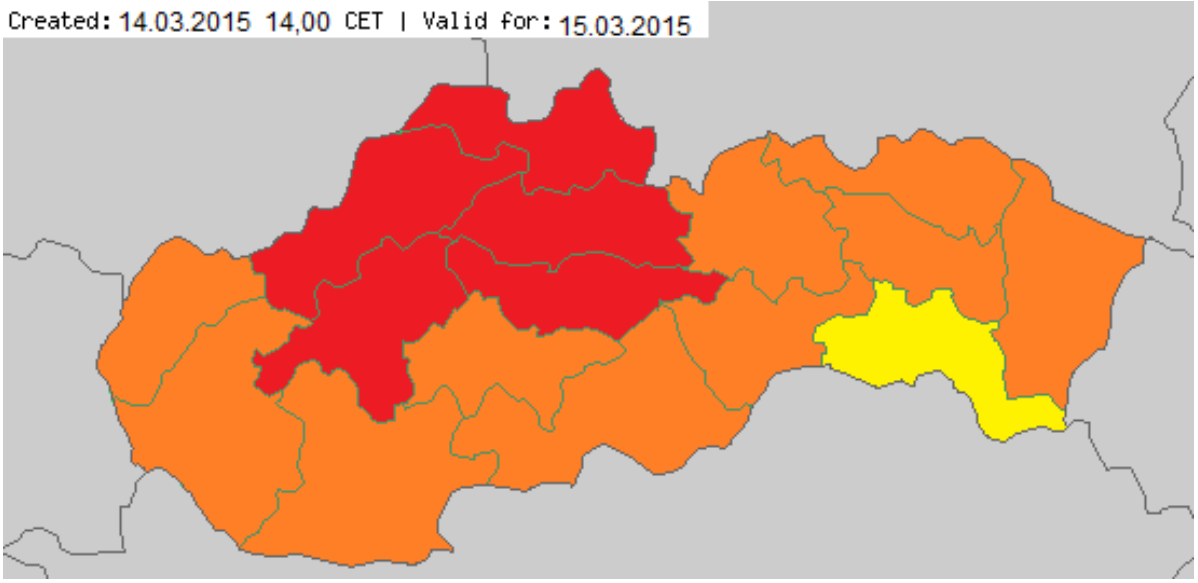


Figure 56. Weather warning for intense rainfall in the hypothetical event (SHMI, 2015)

11.5 Recovery – optimistic and pessimistic scenario

The renewal of partially or totally destroyed transport infrastructure in the Žilina Region (Figure 57) will be ensured in accordance with the plan of transport security. The plan contains three parts, namely, the part ground communications, the part railway transport, and the part for optimal use of motor vehicles. In the case of formation of hypothetical scenario the commission for the organisation of transport security of the Žilina Region will be activated. In the prepared scenarios there are foreseen various variants of destroyed transport infrastructure. In this study we present the three variants – optimistic, realistic and pessimistic.

11.5.1 Optimistic scenario of destroyed transport infrastructure

In the optimistic scenario it is assumed that the breakthrough wave will move gradually without the disruption of other dams on the Váh River. Road communications like 1/18, the intersections 1/18 and 1/70, road 1/61, motorway feeder roads D 1 at Bešeňová, Vrútky and Žilina will be partly damaged (see figure 56). In railway infrastructure it is assumed that railway bridges and tunnels will be partly damaged at Kraľovany, Strečno and Žilina. The optimistic scenario assumes that flooded infrastructure will be in the limited operation after dropping of water and removing of silts and debris. In the optimistic variant it is assumed that the individual objects of transport infrastructure will be out of operation from 10 to 48 hours. The status of the objects of transport infrastructure will be continuously monitored. Under the fulfilment of obligations of transport security the administrators of road and railway infrastructure will deploy all available forces and sources to remove silts and debris. If it is necessary the forces and sources from the local sources (towns and villages) will be deployed.

Figure 57. The most important roads in Zilina region (SSC, 2015)

11.5.2 A realistic scenario of damage of transport infrastructure

In this scenario it is assumed partially cascade effect on one of the other dams, for example the Krpeľany dam. As a result, the bridges at Krpeľany and a bridge in Sučany will be seriously damaged. In the scenario transport services in the Žilina Region will remain partially preserved. Other objects of transport infrastructure, which will be flooded without damage, will be cleaned and put in the operation after dropping of water. In the realistic scenario it is assumed that some objects of transport infrastructure will be put out of service from 48 hours (flooded objects without damage) to a few weeks (seriously damaged objects). The bridges which will be seriously damaged or destroyed will be gradually restored in the system of temporary restoration. This restoration of the objects will be done according to the prepared projects. After a temporary restoration of bridges the speed limit will be 30 km/h. This renewal is planned from temporary bridges materially and financially.

After putting in operation of temporary objects it will be solved the permanent renewal of newly built objects. Financial and time demands of total renewal are high and they will depend on particular object and the degree of disruption.

11.5.3 A pessimistic scenario of damage of transport infrastructure

In the pessimistic scenario a sequential cascade effect is assumed. After the disruption of the Liptovská Mara Dam the breakthrough wave will disturb other three dams (the Krpeľany Dam, the Žilina Dam and the Hričov Dam) on the Váh. In this scenario several potential objects of critical infrastructure (road and railway bridges at Krpeľany, road bride in Ružomberok, road bridge in Vrútky, road bridge in Strečno, tunnel Strečno I and railway and road bridge in Žilina) will be significantly damaged or destroyed. These eight objects of transport infrastructure have got strategic character for the function of transport in the Žilina Region. Transport would be interrupted in all directions (south – north and east - west) in the case of damage or destruction of these objects. Transport services of the Žilina Region would be disrupted (inaccessibility of sub-regions like Orava, Turiec and Kysuce), transit would be completely stopped on the international communications (TEN-T). This scenario assumes the destruction and serious damage the mentioned objects by progressing and growing breakthrough wave. After dropping of water silts and debris will be removed

progressively. Then temporary renewal will be done according to making a decision of crisis management. According to prepared plans road and railway temporary bridges will be progressively built. The renewal of the eight strategic transport objects will take from several weeks to several months. All objects will be restored for the passage (speed limit 30 km/h). The presented temporary restoration will enable to activate transport services of the Žilina Region (see Figure 58).

The full renewal (technical parameters of the objects will be built at least on the level before the destruction) will be another important task. It will take from ten months to several years. Except the financial demands it will be necessary to prepare a unique engineering solution. There will be serious challenges like transparent public procurement and the problem with accumulation of large amounts of specialized bridge works in a small area (lack of supporting bridge constructions are assumed).

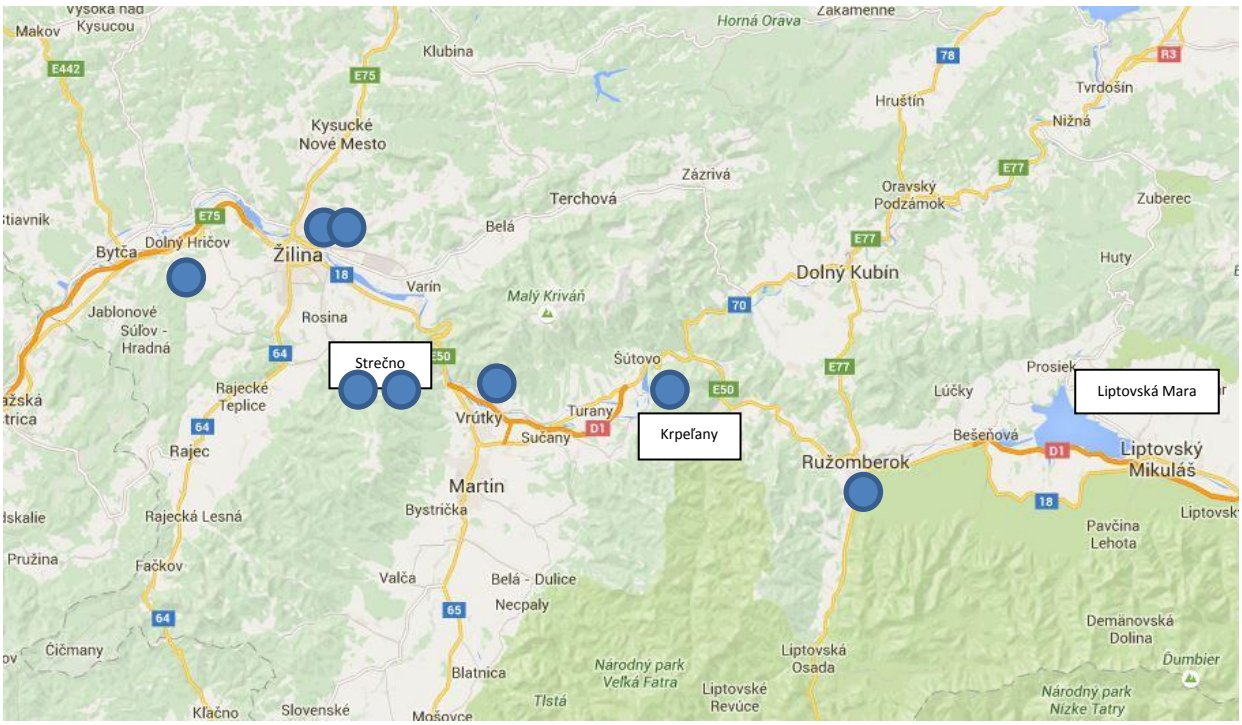


Figure 58. Road and railway bridges at Krpeľany, road bride in Ružomberok, road bridge in Vrútky, road bridge in Strečno, tunnel Strečno I and railway and road bridge in Žilina (Google Maps, 2015)

Due to the destruction of the dam Liptovská Mara and destruction and significant damage to infrastructure in the vicinity of the river Váh section from the dam to the city of Žilina, all domestic renewal forces and resources and request assistance from neighboring countries have to be activated. Within flood plans prepared at regional and national level foresees with that scenario.

After the subsidence of the flood wave a detailed survey of damaged infrastructures will be required. This detailed survey will be realized by police and armed forces of the Slovak Republic. The first phase will include monitoring realized by air forces. The second phase will constist on a on-site survey to document the state of damage and prepare a project to renovate.

Financial security for the estimated recovery of transport infrastructure is divided into three levels. In the first level operational stocks managed by the infrastructure will be used. The second order will

use state reserves, and the third order, Fiance funds from the local level, from the reserves of the Slovak Republic, from the European fund humanitarian aid and civil protection (EU emergency fund) and from the collections of humanitarian organizations.

12. Conclusion

The aim of the Deliverable 3.3 Scenarios and case study of river floods on road and rail critical land transport infrastructures was directed on relevant case studies. The case studies were prepared on national level with the aim of disseminating best practices to other EU countries.

Regarding implications of climate change (extereme weather events) for transport infrastructure we found out that:

- Extreme weather events associated with climate change increase disruptions of transport infrastructure services.
- Disruptions of services in critical infrastructure often result in disruptions in one or more other infrastructures, especially in important transport elements, triggering serious cross-sectoral cascading infrastructure system failures.
- These risks are greater for infrastructures that are located in areas exposed to extreme weather events, located at or near particularly climate-sensitive environmental features, such as rivers and mountains.
- Transport objects stressed by age and/or by demand levels that exceed what they were designed to deliver are very important risk associated with transport service resilience.
- Failures related to infrastructure interdependencies will increase threats to health and local economies in densely populated areas, especially in locations vulnerable to extreme weather events. These effects will be especially problematic for population that are more vulnerable because of limited coping capacities.
- Risks of disruptive impacts of extreme weather events for transport infrastructure can be substantially reduced by developing and implementing appropriate adaptation strategies.
- It is necessary to revise engineering standards for transport infrastructure systems that will take into consideration more and more negative extreme weather events impacts.
- Improving knowledge about interdependencies among infrastructures exposed to extreme weather risks and their impacts will support activities to reduce vulnerabilities. Applications of monitoring systems will support assessments of emerging threats to infrastructures
- Capacities for long-term assessments of vulnerabilities, risks, and impacts of extreme weather events on infrastructures can benefit from effective partnerships among a wide range of experts and stakeholders.

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