BuildERS

BUILDERS D4.3 Practice & product innovation “Applying mobile positioning data for more precise rescue planning and emergency management under cyber-hazard in Estonia”

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Project title: Building European Communities’ Resilience and Social Capital

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Executive Summary

This report D4.3 demonstrates the possibilities of mobile positioning data (MPD) usage in the crisis management area. This report is based on the task 4.3 that is aiming for product innovation for more precise rescue planning and emergency management in Estonia.

The University of Tartu together with Positium demonstrates a product innovation of how people's vulnerability against man-made and other hazards could be reduced by creating spatio-temporal human dynamic maps. Such maps will more precisely inform the professional rescuers about population distribution at different locations and times and help to deliver better need-calibrated relief services. Positium, University of Tartu and the Estonian Rescue Board are looking at crises like cyber attack or extensive storms where connections are down to assess if and how historical MPD could help in these situations.

The dashboard that has been built by Positium shows historical MPD. It shows visually how many people are in different areas and what kind of people are there (people living in the area, people working in the area, people who regularly visit the area, domestic tourists, foreign tourists) and also how many people in the area have a secondary home and how far away it is from the chosen spacial unit. Dashboard also shows movements' directions and counts between different areas. Secondary homes information shows counts of people who have a secondary home that they could use as shelter in case of evacuation information helps to plan evacuation routes and accommodation more precisely. The dashboard can give daily, weekly and seasonal volume changes and movement patterns that other databases cannot do.

The end-users evaluated this dashboard to being highly valuable asset to their pre-crisis phase where they learn from past crises and events. Based on this information it can be seen how people usually behave, if and how they move during crisis, respond to crisis notifications etc. It can also be very well used for doing risk evaluations on regions and buildings, for playing through crisis scenarios in trainings and to plan evacuation accommodation and routes.

The dashboard increases societal resilience against disasters by increasing situational awareness of relief and medical workers, humanitarian and governmental organisations. The dashboard is foremost directed to official responders in crisis situations. It decreases societal vulnerability by helping disaster managers make more informed decisions and disaster mitigation plans and also to allocate their resources more effectively. This, consequently, potentially reduces individual vulnerability of people and increases their social capital, as officials have greater likelihood of reaching more people in potential danger faster.

MPD is a great data source that has a lot of scientific and technological potential that could be used for crisis management. In order to make it easier and clearer on if and how this dashboard could be used, MPD usage for crisis management should clearly regulated by EU and on a national level as well.

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List of Acronyms

AB	Advisory Board
BuildERS	Building European Communities Resilience and Social Capital project
D	Deliverable
DoA	Description of Action
GPS	Global Positioning System
MNO	Mobile network operator
MPD	Mobile positioning data
OD	Origin-Destination
PDM	Positium data mediator
SMS	Short Message Service
SSIM	Structural Similarity Index
WP	Work Package

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1. Introduction

The overall focus of the BuildERS project is to help improve government policies aimed at enhancing the disaster resilience of European populations, with a focus on disadvantaged groups and the effects of false information. There are 7 international case studies within the WP4. Multiple case analysis of WP4 has the following objectives:

- tools and guidelines development, since the practicalities related to technologies and other tools must be field-tested, piloted or simulated before considering their up-scaling and transferability to other contexts;
- demonstrations of the tools, techniques or technologies can be applied and utilized;
- empirical testing of what works and what does not work in practice; the cases serve also policy, strategy and other recommendations given in latter work packages;
- multiple case studies offer additional material for comparative analyses and supplement the field surveys and questionnaires offering wider base for synthesis and increase of reliability and validity of conclusions drawn from the research;
- innovation identification and proof-of-concepts.

This report D4.3 demonstrates the possibilities of mobile positioning data (MPD) usage in the crisis management area. This report is based on the task 4.3 that is aiming for product innovation for more precise rescue planning and emergency management in Estonia.

The University of Tartu together with Positium demonstrates a product innovation of how people's vulnerability against man-made and other hazards could be reduced by creating spatio-temporal human dynamic maps. Such maps will more precisely inform the professional rescuers about population distribution at different locations and times and help to deliver better need-calibrated relief services. Positium, University of Tartu and the Estonian Rescue Board are looking at crises like cyber attack or extensive storms where connections are down to assess if and how historical MPD could help in these situations. As MPD is anonymous and does not allow identifying any individuals or groups based on socio-economic characteristics, we are seeing all people in the hazard area as potentially vulnerable.

For this case study, Positium has built a dashboard based on the input from the Estonian Rescue Board and University of Tartu. These participants have had multiple meetings and many discussions to go through what MPD is capable of, which indicators are possible to be calculated and which ones could be useful in crisis management. The cooperation has been going on over several months and thanks to the close cooperation, the result is great and the feedback from participants of the validation has been very good. You can read more about validation's results from chapters 4 and 5.

This dashboard is mostly meant for the pre-crisis phase where previous disasters and events can be analysed (how people usually behave versus how they have behaved during previous disasters) and based on this knowledge, planning of resources and processes for future crises can be adjusted. This dashboard can be used during disaster as well. Dashboard is knowingly built so that it works offline as well, meaning that if all other connections are down and other databases can not be used, then this dashboard still works. Dashboard's goal is to give rescuers enough information so that they could predict population behavior in crisis situations, plan their resources and processes better and by doing that, reduce the costs on aid and relief for emergency proliferation.

The dashboard that has been built by Positium shows historical MPD. It shows visually how many people are in different areas and what kind of people are there (people living in the area, people working in the area, people who regularly visit the area, domestic tourists, foreign tourists) and also in a table form, how many people in the area have a secondary home and how far away it is from the chosen spacial unit. Dashboard also shows movements' directions and counts between different areas. Secondary homes information shows counts of people who have a secondary home that they could use as shelter in case of evacuation information helps to plan evacuation routes and accommodation more precisely. The dashboard can give daily, weekly and seasonal volume changes and movement patterns that other databases cannot do. More precise description of the dashboard is in chapter 3.

The dashboard was validated by multiple end users, such as Estonian Rescue Board, Police and Border Guard Board, Defence Forces and others. The validation was done in a tabletop exercise where the dashboard was demonstrated and case scenarios were played through. All participants could freely elaborate, if and how they could use this dashboard in the perspective of their organisation and area of expertise.

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2. Alignment to the BuildERS theoretical framework

2.1 Mobile positioning data and disaster management

MPD is quite a novel information source and scientists have yet started to discover its potential to develop decision-support tools in crisis situations. One of the first of such explorations was provided by Bengtsson et al. (2011), who examined the usability of MPD to assess the number of dislocated people after the earthquake in Haiti in 2010. Later a number of research projects followed assessing (i.e) the usability of MPD in disease outbreaks (Tatem et al. 2014, Cinnamon et al. 2016, Peak et al. 2018), floods (UN Global Pulse 2014) and earthquakes (Wilson et al. 2014).

MPD enables to evaluate mobility behaviour of people – where, when, how nad how much people move and stay – of wide ranges of population more dynamically and in greater detail than traditional census-based approaches (Panczak et al. 2020). Mobility is shaped by demographic, social, economic and environmental actors, all of which influence population distributions and movement flows between locations spatially and temporally (Charles-Edwards et al. 2020). Although MPD is anonymous and, thus, does not enable to distinguish between socio-economic characteristics directly, some research has been done to describe socio-economic status of people through their mobility behaviour (Šćepanović et al. 2015). Long-term mobility of most people is highly regular, which allows researchers to predict approximate home or work locations, regular visiting places and geographical distribution of tourism trips of phone-users (Ahas et al. 2010, Saluveer et al. 2020).

Despite promising results, the preliminary use-cases of MPD in disaster management have also received accusations such as not taking into account the actual needs of disaster responders regarding the data they need to make decisions and not considering with wider (possibly negative) social implications of using that kind of data (for a more comprehensive discussion see McDonald 2016, Fast 2017, and Maxmen 2019). Consequently, it is important to understand how MPD-based solutions align to important concepts related to disaster management to avoid possible misuse and -interpretation.

2.2 BuildERS key concepts and the dashboard

The dashboard draws upon the BuildERS framework to relate possibilities and limitations of MPD to key concepts in disaster management, such as vulnerability, social capital, risk awareness and resilience.

Vulnerability

BuildERS framework uncovered two prevailing perspectives of vulnerability: firstly, vulnerability as a static characteristic to certain population groups (people with disabilities, elderly, the poor etc) and secondly; vulnerability as a dynamic characteristic that can change over time and could apply to any individual. By creating a narrative of vulnerable groups being equated to socio-political categories can lead to neglecting the heterogeneity of social groups. Thus, BuildERS defines vulnerability as a "dynamic characteristic of entities (individuals, groups, society) of being susceptible to harm or loss, which manifests as situational inability (or degree of situational weakness) to access adequate

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resources and means of protection to anticipate, cope with, recover and learn from the impact of natural or man-made hazards." (D1.2, page 31-32, 68)

MPD allows us to take a **dynamic approach to vulnerability**, in line with BuildERS framework and Wisner et al. (2004), who maintained that in a hazard situation, all individuals in the disaster zone can be considered vulnerable. We do not associate any group with vulnerability due to their pre-event stage. As mentioned earlier MPD also does not distinguish socio-economic backgrounds of people, because mobile network operators (MNOs) provide data anonymously. Using MPD, based on comparing locations of people at certain time-frames with their long-term individual mobility patterns, it can be estimated with a certain degree of likelihood the roles (local resident, worker, tourist etc) they fit to in different geographical areas (Ahas et al. 2010). As previous studies have shown, some temporary population groups, such as as tourists, may often be underrepresented in official crisis plans (Becken et al. 2014, Aznar-Crespo et al. 2020). Thus, MPD allows researchers to discuss potential vulnerabilities of different temporary population types in greater detail.

Social capital

BuildERS framework defines **social capital** as "networks, norms, values and trust that entities (individuals, groups, society) have available and which may offer resources for mutual advantage and support and for facilitating coordination and cooperation in case of crisis and disasters". Social capital is considered an important enabler of resilience in crises and disasters. (D1.2, pages 46, 68)

Although it is difficult to assess networks, norms, values and trust that entities have available based on MPD, analysing the mobility behaviour of people can address the **dynamic dimension of social capital**: at different places and temporal timeframes the social capital of people may be temporarily decreased. For example, on tourist trips (especially to foreign countries) the networks, norms and values that people would benefit from during their everyday life may be of no assist. Additionally, during COVID-19 crisis transnational people (people who are strongly connected to more than one country based on their mobility behaviour and social ties) were restricted from crossing borders and had to choose in which country they would be staying (Järv et al. 2021). MPD based solutions can promote discussion on the accessibility of social capital to people in different timeframes.

Risk awareness

BuildERS framework defines **risk awareness** as "collective (groups and communities) acknowledgment about a risk and potential risk preventing and mitigating actions, fostered by risk communication". Here, risk communication does not address only sending and receiving information, but includes wider communicative behaviour: how people interact with each other and authorities, send and seek information or react upon warnings. (D1.2, pages 56, 68)

The dashboard based on MPD presented here is directed to increasing situational risk awareness of rescue workers, humanitarian workers, local municipalities and other official institutions. Beside giving more dynamic view to mobility behaviour and geographic population distributions, the dashboard can be used for other purposes too. At the moment there is not much empirical data on how people react to and change their mobility behaviour due to risk warnings. MPD can give information

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whether people followed instructions of risk warnings (for example, to what extent people left their homes or stayed put when they were told to do so), which can help official institutions evaluete the successfulness of their messages and develop them accordingly. Also, MPD helps to distinguish areas in which cell coverage was severely decreased. This can assist rescuers assess the potential degree of people who could not communicate (by calling) their need of help. Although the data is historic and geographic distribution of potential communication obstacles in an ongiong disaster is not yet possible, that kind of information can help to make long-term investments to critical infrastructues and crises strategies.

Conclusively, the dashboard itself does not include in it risk communcation or potential risk preventing and mitigating actions, but it can be used as a medium to understand interdependencies of afforementioned concepts with mobility behaviour of people.

Resilience

According to BuildERS framework **resilience** is defined as "processes of proactive and/or reactive patterned adjustment and adaptation and change enacted in everyday life, but, in particular, in the face of risks, crises and disasters". Concerning crisis management and resilience there are two diverging strategies: "a social-democratic society, where the state deals with crisis or disasters on behalf of the individual" and "a more neoliberal resilient society, where the state just enables and facilitates individuals' ability to deal with their own risks". BuildERS framework does not prefer one to another, but calls for a deeper and wider discussion on best ways to govern society to increase our resilience to disasters. (D1.2 65, 68)

The dashboard aims to **increase resilience through increasing situational awareness** of rescue workers, humanitarian sector, governmental organisations and other official institutions in all phases of disaster management cycle. Having a better understanding of population distribution in geographical space helps to make more informed preparations to disasters, for example reallocate crisis response resources or develop evacuation plans. In the acute crisis phase the dashboard helps to assess the number of people in geographical regions who may be in the need of help. Lastly, after the crisis is over, the dashboard enables to look into changes of the spatial behaviour of people, thereby, giving rescue workers feedback to future disasters.

Although the dashboard itself does not pre-associate any characteristic with vulnerability, it can assist rescue workers in identifying the locations of possibly vulnerable groups. Specifically, in a certain situation rescue workers can associate some characteristic with some sort of vulnerability. For example, in case of a sudden shutdown of international travel the most vulnerable group are international tourists. In such a situation rescue workers can look at the numbers and geographical distribution of foreign tourists in the country. To bring another example: in case of a big forest fire tourists are not in a big threat, because they can leave any area quite easily. In those kinds of situations rescue workers can instead look at the number of local residents in the disaster area, as they may not be willing to leave their properties. Foremost, the dashboard increases risk awareness of local authorities and rescue workers. Most data sources in use today do not take into account temporary populations inside a disaster area. MPD increases knowledge of rescue workers regarding figures of

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people in potential harm, enables them to plan their resources better, and therefore, enhance the social capital of society in general and through this increases individual social capital as well.

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3. Description of mobile positioning data and the developed dashboard

3.1 Mobile positioning data

MPD in the context of this dashboard refers to passive mobile positioning, meaning the data that is automatically collected by the MNO based on customer billing, network maintenance and performance monitoring. Passive MPD has been becoming a more popular data for statistics. There are multiple reasons for that, such as the fact as data is collected passively and without any burden on people. There are many data points per person within a longer period, which gives the data consistency throughout the whole time period and does not only reflect one day, week or a season, but the changes throughout a longer period as well. MPD is also not as expensive as surveys that reflect less and the results can be used in many different domains, such as tourism statistics, transportation planning, mobility analysis and population statistics.

Usage of mobile phones is very common in the whole world and in Estonia as well. Estonia's population is around 1.3 million and the SIM-card count is around 1.9 million. This means that the SIM-card coverage in Estonia is around 1.46 SIM cards per person on average. Therefore, the data collected by MNOs covers the majority of the population and is a very good method for analysis and statistics.

The most common form of passive MPD is call detail records (CDR). MNO-s collect location data (records) from subscribers each time a subscriber uses data, makes a call, receives a call, sends an SMS or receives one. The spatial accuracy of passive MPD is not as high as with GPS (active mobile positioning), since passive MPD locations are calculated from cell towers' coverage areas with probability algorithms. MPD is anonymous. When MNO sends their data to Positium for calculations, subscriber ID-s are already anonymised with their own confidential algorithm and outside the MNO the personal information is not known, meaning that these persons can not be identified.

In the Table 1 below you can see how raw data structure from MNO looks like. Subscriber ID in MNO's database could be the phone number for example, but when data is sent to Positium, all IDs are anonymised. Second column shows the time of the record, meaning timestamp of call/SMS/data usage activities. Third column Cell ID shows to which cell tower subscriber was connected to perform this activity. Usually, each subscriber has many data rows like this per day, especially when mobile data is being used. One data row is called 'record'.

Table 1. Raw data structure from MNO.

Subscriber ID (anonymised)	Time of the record	Cell ID
123456789	2019-05-12 18:21:58	12345

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MPD is divided into three parts: domestic, inbound and outbound.

- **Domestic** MPD data covers subscribers with local SIM-cards that are present in a certain country for most of the year (local people). For domestic data we have subscriber ID, record time and location for each record.

- **Inbound** roaming data covers foreign visitors (SIM-cards registered in foreign countries) that come to a certain country. For inbound data we have subscriber ID, record time and location for each record and the country code where the subscriber comes from.

- **Outbound** roaming data shows local people (local SIM-card) travelling to foreign countries. For outbound we only have subscriber ID, timestamp of the record and the country where the subscriber went to, but no exact location or information about records done in the foreign country.

In the 4.3 Estonian case study domestic and inbound data are used. All data is stored and managed securely and according to all laws on data protection.

Positium's technology is called Positium Data Mediator (PDM), which cleans raw data, does the calculations and forms results. The first thing PDM does is cleaning the data. This means for example removing all invalid rows, duplicates and machines (machines that use SIM-cards but are not phones, such as security cameras, vehicle's GPS devices etc) from MNO's raw data. After this, PDM calculates anchor points for each subscriber on an individual level (anonymously). Anchor point is an area where a subscriber is often and these are calculated based on each subscriber's usual whereabouts during different hours of the day and visiting regularities. In case study 4.3 we look at following anchor points:

- **Home anchor point refers** to the area where the subscriber lives (place of residence).

- **Secondary home anchor point** refers to the existence of another place (besides place of residence) that the subscriber visits regularly.

- **Working time anchor point** refers to the area where the subscriber spends his/her working time hours.

- **Regular anchor point** refers to the areas that the subscriber visits often, for example gym, shops, friend's place (but not home, secondary home or working time anchor point).

- **Usual environment** is the sum of the areas of previous anchor points. This shows where each subscriber usually spends time regularly. If a subscriber goes outside of his/her usual environment, he/she becomes a domestic tourist.

Based on these anchor points PDM can distinguish following subscriber groups that you can also see in the developed dashboard on population statistics layer:

- **Place of residence** is the area where the subscriber lives.

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- **Work** is the area where the subscriber spends the majority of their daily activity time. Work is not strictly related to being employed, it can also refer to being at school or university as a student.

- **Regular visitor** refers to either Estonian or a foreign SIM-card owner who is present in their usual environment and visiting regular activity places such as training halls, shops, friends etc. Note that here regularly visited places do not involve home or work-time related locations.

- **Domestic tourist** is a subscriber with an Estonian SIM-card that goes out of his/her usual environment. Usual environment is a sum of the areas that a subscriber visits often (home, work, shops, training etc). If a subscriber goes out of this sum of areas, the subscriber becomes a domestic tourist in the other areas in Estonia.

- **Inbound tourist** is a subscriber with a foreign SIM-card that is linked to Estonian cell towers to perform calls, sending SMS-s or to use mobile internet and who is not detected to be a resident of Estonia (haven't spent more than 6 months during the past 12 months in Estonia). Similarly to domestic tourists, inbound tourists need to travel out of their usual environment to be counted as a tourist.

- **Transit** are subscribers on a transit trip. Transit visitor class includes:
    - foreign SIM card owners who are on a transit trip through Estonia. A subscriber's trip will get a transit status when their movements are linked to usual transit corridors in Estonia (e.g Tallinn-Ikla, Tallinn-Narva) and the trip's duration is less than 4 hours.
    - visitors whose visits to the referenced area last less than 2 hours at a time. Such visits are related to Estonian and foreign SIM-card owners both.

On an individual, but still on an anonymous level, stays and moves are calculated as well. On the Figure 1 you can see how a ‘pipeline’ of each subscriber’s records can be drawn. Based on this pipeline, it is also possible to take out movements between different areas that are shown in the origin-destination matrices layer on the dashboard.

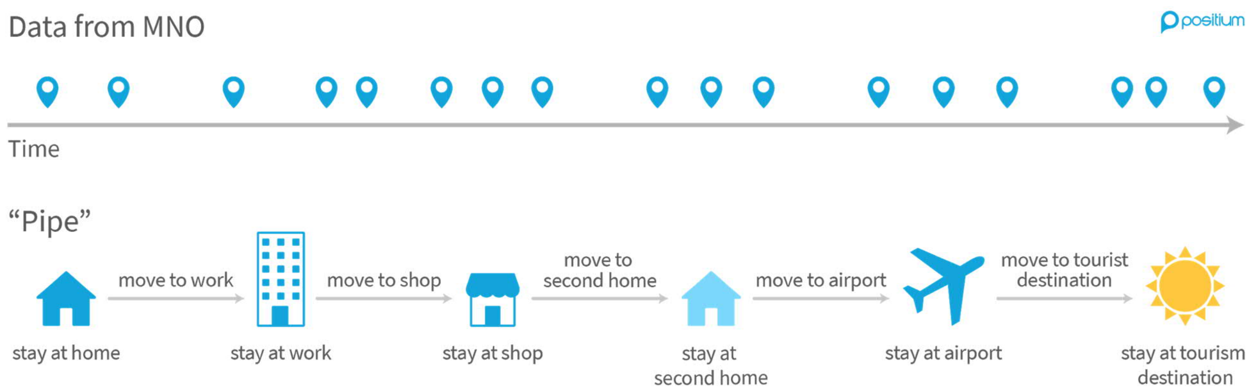

Figure 1. Stays and moves pipeline

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After calculations are done on an individual level (anchor points, stays, moves), PDM aggregates the data. As Positium has the MPD from one MNO in Estonia, but there are all together three of them, results are multiplied with a coefficient to cover the whole population. This means that no individual results are shown, only general count of subscribers or movements between areas. Furthermore, all values under ten are either shown as '<10' or excluded from the dashboard for privacy reasons.

3.2 Limitations of mobile positioning data and the dashboard

There are some limitations of using MPD. First is that the calculations take time. MPD is big data and therefore processing raw data of each subscriber's all records for a longer period takes time. For example, the calculations of 2019 whole year for whole Estonia domestic and inbound data took over 3 months. The biggest reason why it takes so much time is the calculation of anchor points, stays and moves. This is also the reason why having real time data with these population groups is difficult to achieve. To calculate anchor points, at least 6 months of data is needed and this can not be calculated overnight. Gathering real time data during a crisis is also complicated due to the fact that in case of power outage, cell towers are down if there are no backup generators. This means no new data can be gathered. Also, Positium can not do calculations nor send results to clients if electrical power is down.

Second limitation of MPD is that it can not be used to identify individuals or subscriber groups based on their socio-economic backgrounds. This sets limitations for very detailed crisis management planning, but it is not a limitation in other domains like tourism statistics and infrastructure development. When Positium gets the data from MNOs, all subscriber ID-s are already anonymised. Additionally, Positium aggregates the individual results and generalises to the whole population. Also, results smaller than 10 are either shown as <10 or left out of the dashboard to make sure that individuals can not be tracked. It is also important to understand that due to the generalisation with coefficients, the dashboard does not show exact subscriber counts, but the estimated count of subscribers in the area.

Generally historical MPD is very reliable later on as well as population counts and movement patterns do not differ that much throughout the years. But 2020 has been a very unusual year due to the coronavirus outbreak. Not only has this changed where people work and also their movement patterns and whereabouts, but it also changes the way people work and behave in the future. If this dashboard gets taken into use, 2020 or 2021 should be calculated and pulled to the dashboard (additionally or instead of 2019) as this will reflect the new reality better than the data of 2019.

3.3 Advantages of mobile positioning data and the dashboard

MPD has many advantages. The data is passively collected by MNOs anyway so that they could bill their customers at the end of the month. No extra effort for gathering the data is needed. MNOs are obligated to gather this data and also to store it for a certain amount of time. In case of tourism statistics, gathering data with MPD is 4 times faster and sample size is up to 200 times higher, compared to travel questionnaires. It is also more cost efficient and less burden on tourists. MPD covers most of the

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population as SIM-cards are widely used by almost everyone. Positium has over 15 years of experience and expertise in using MPD for statistics and developing tools and methodologies that help to calculate the data and present reliable results.

Unlike many other databases, MPD allows clients to see hourly, daily, weekly and seasonal changes in subscriber volumes and movement patterns. These volumes and patterns are very similar throughout different years and these can be used as reliable data in the next years as well. Unlike static population statistics that show where people should live throughout the year, MPD shows where people actually are and how they commute between different areas. MPD also allows to distinguish subscriber groups based on their whereabouts and mobility.

The dashboard that has been built helps rescuers create more accurate risk assessments for different crises. Dashboard is very case universal, meaning that it can be used not only for storms and power outages as stated in the case study, but also to plan for evacuations, chemical leakages, bombings, earthquakes, volcano eruptions and so on. Additionally, when the power is out and most databases are inaccessible, this dashboard is still working as it is knowingly built to be able to work offline as well. This dashboard can not only be used by rescue service providers for crisis management, but it can also be used for infrastructure or regional planning or to design services better etc.

As mentioned earlier as well, MPD is anonymous and the security is guaranteed with different steps, such as

- storing and managing data safely in safe servers with different security methods (physically separated and virtually isolated server rooms with limited access, access only through special processes);
- anonymising all subscriber ID-s;
- creating aggregates based on individual (but anonymous) results;
- using coefficients to generalise results to whole population;
- values smaller than 10 shown as <10 (not only on the dashboard, but also in the database).

This means that no one's privacy is compromised.

3.4. Dashboard

Positium has built a dashboard that helps rescue organisations plan their human and material resources more accurately, learn from past crisis scenarios and base their decisions of future crises on this. Through more exact risk assessments and knowledge of human behavior before and during crisis, the processes of aid and relief during disaster can be much faster and more effective. Rescue organisations can use this dashboard for many different purposes and save their timely, human and technical resources by doing that. You can read more about the use purposes in the results chapter.

Dashboard has MPD for the whole of 2019 in it. It includes domestic and inbound data from one mobile operator in Estonia and the results are expanded to the whole population by coefficients. Dashboard has three possible spatial units to choose from (county, municipality, village - Figure 2)

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and daily and hourly view. The smallest spatial unit has been named ‘village’, although it is actually a custom-made spatial unit where in some places one unit consists of multiple villages. The reason is that with MPD, when going too small on the spatial unit, results might become inaccurate. Dashboard consists of three layers: population statistics, origin-destination matrices and secondary homes. Users can choose between all of the combinations of spatial units and time steps on all layers.

Figure 2. Spatial units on the dashboard: county, municipality, village

Note: On the figures of the dashboard in chapters 3.4.1 - 3.4.3, all amounts or otherwise sensitive information is hidden on images for privacy purposes.

3.4.1 Population statistics layer

Population statistics layer shows how many and what subscriber groups are usually in the area during the chosen time frame (Figure 3, Figure 4, Figure 5). This information can be used to plan human and technical resources more accurately.

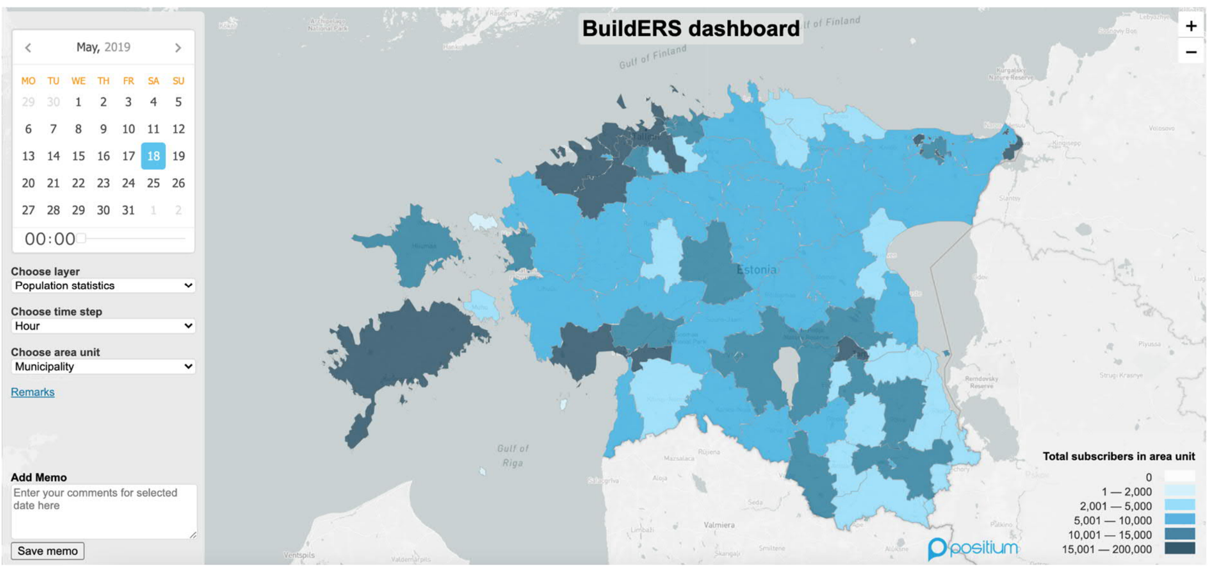

Figure 3. Population statistics layer on 18th of May 2019 midnight with hourly view on municipality level.

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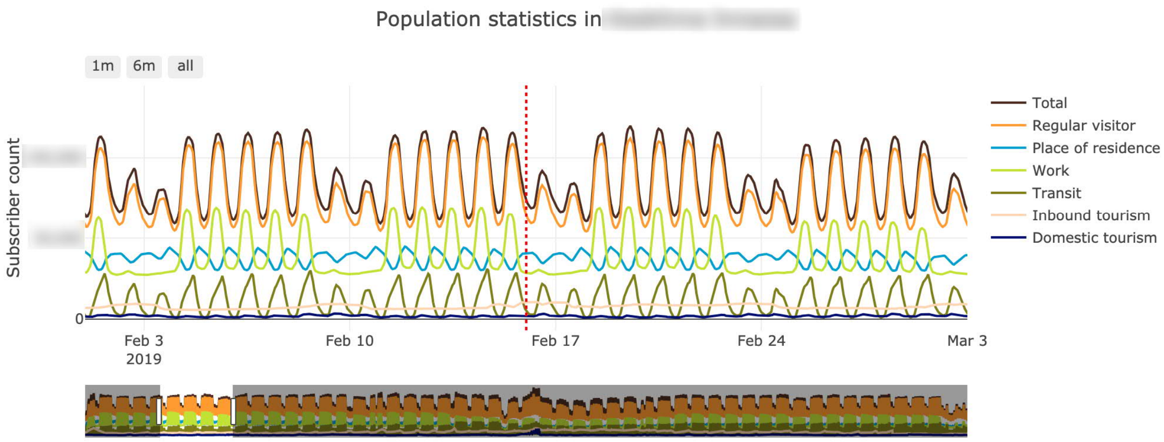

Figure 4. Hourly changes in population counts per subscriber groups in one area. Higher total value is during weekdays and lower values during weekend. Higher values during daytime, lower values during nighttime.

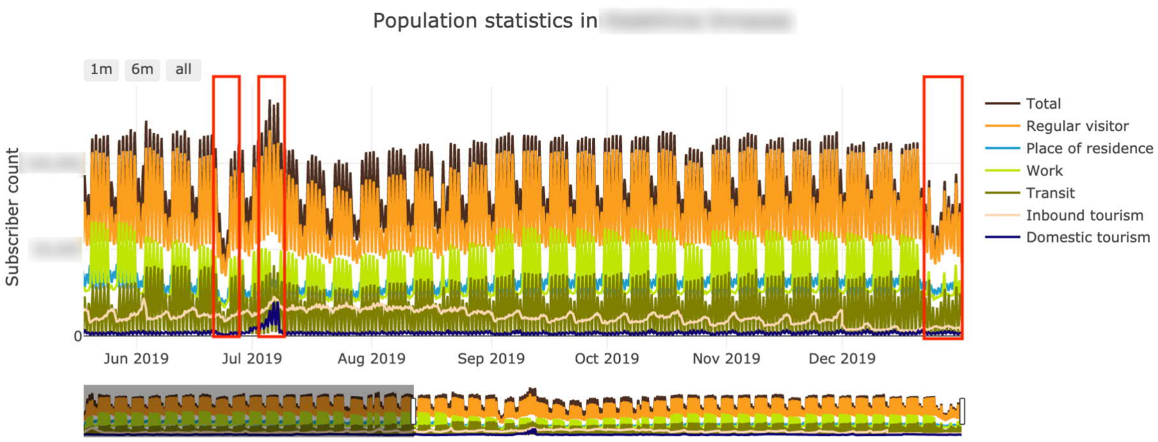

Figure 5. Hourly changes between June and December. There are visible different events such as Midsummer day, Song and dance festival and low subscriber counts at the end of the year due to Christmas (all marked in red)

Definitions on population statistics layer:

- **(Unique) Subscriber** is a SIM-card user. Unique subscriber refers to the visitor class where subscriber is counted only once regardless of the number of times they visit the area. For example, a person can be present in Tartu as a resident and as a worker during the same day at different times, but we want to count them only once to estimate the total number of people present regardless of their visitor class.
- Other anchor point descriptions can be found in chapter 3.1

Map options on population statistics layer:

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- On the dashboard, users can choose between a daily and an hourly view. This shows how many unique subscribers were in the chosen spatial unit in the whole day or in the chosen hour. (Figure 3)

- Users can choose between county, municipality and village as the spatial unit.

- If user hovers over an area, a tooltip will appear showing how many subscribers were in the chosen area at the chosen time per subscriber group. If user clicks on the area, a modal opens up (Figure 4, Figure 5). There, user can see the changes throughout different periods. User is able to look at the whole year or a shorter period as well, by just moving the slider below the graph to choose the period the user would like to see. User is able to see seasonal, weekly and hourly changes in subscriber counts per population groups.

- Total is not the sum of all subscriber groups. Total shows the count of unique subscribers that were in the area. The sum of subscriber groups is bigger than total, because a subscriber might be living and working in the same area, therefore this subscriber is counted in “work” and “place of residence” groups both, but only once in the total. This is why the sums do not match.

- The subscriber count in a county is not the same as the sum of subscribers in all the municipalities or villages inside the county. This comes from the fact that a subscriber might be for example a resident in one municipality, regular visitor in another and a domestic tourist in a third municipality. Therefore, this subscriber is counted once in all municipalities, but only once in the county. This is why the sums do not match.

3.4.2. Origin-destination matrices layer

Origin-destination matrices layer shows the volumes and directions of the movements (Figure 6, Figure 7). This layer can be used to prioritise which roads to block first or to estimate the amount of resources needed for different purposes.

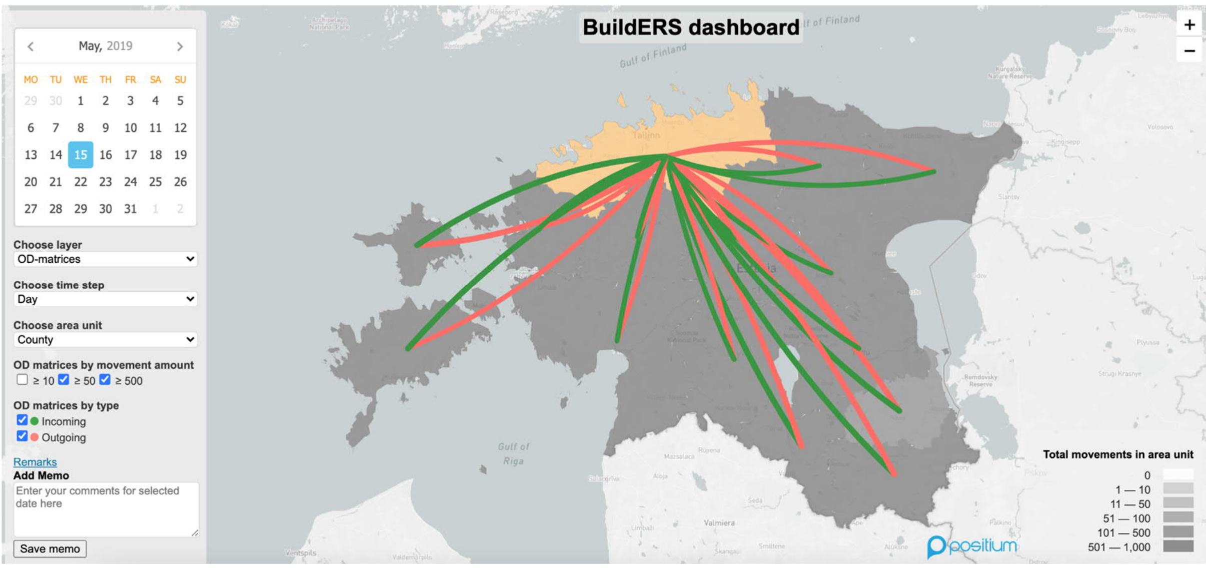

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Figure 6. Origin-destination matrices layer showing movements on county level and daily view between Harju county and other counties.

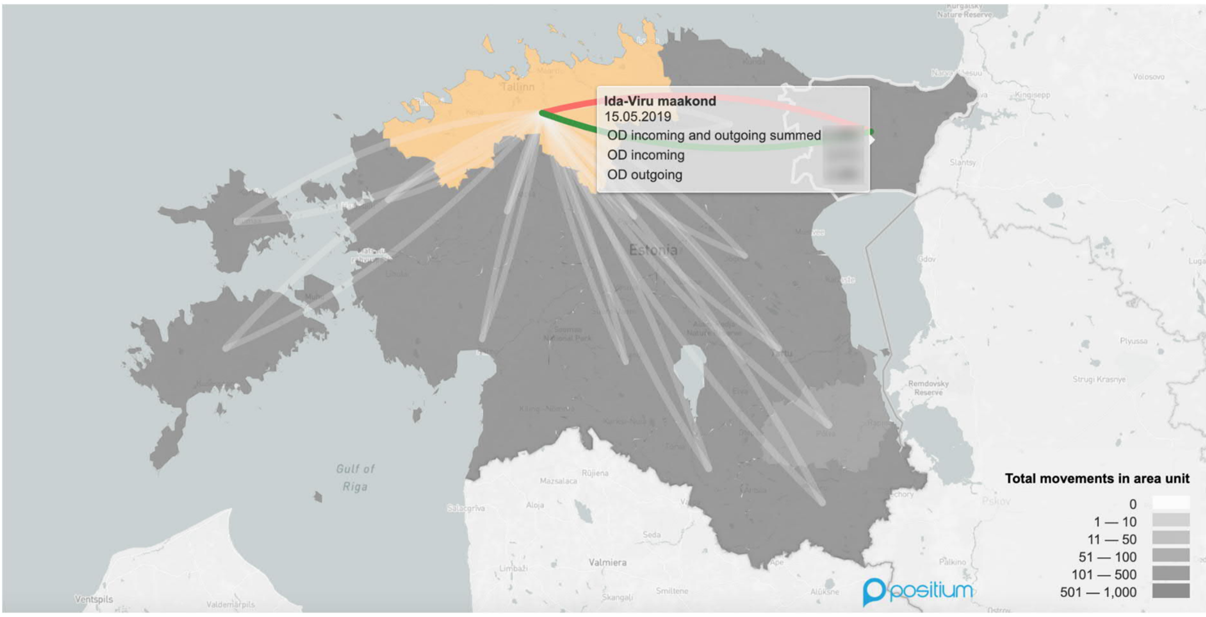

Figure 7. Origin-destination matrices layer showing movements count between Harju county and Ida-Viru county.

Definitions on the origin-destination matrices layer:

- **Incoming movements** show movements from other areas into the chosen area.
- **Outgoing movements** show movements from the chosen area into other areas.

Map options on the origin-destination matrices layer:

- User is able to choose between a daily and an hourly view.
- User can choose between county, municipality and village as the spatial unit.
- User can filter out smaller or bigger amounts of movements and also incoming or outgoing movements.
- The graphs show movements started in the chosen day or hour (end of the trip can be in another day or hour). The destination is the place where the subscriber spent the most time. For example, if a subscriber drives from Tartu, stops in Mäo for 20 minutes, continues to drive and stays in Tallinn for several hours, then Tallinn is the destination as the subscriber spent more time there than in Mäo.
- Movements with a count less than 10 are taken out of the graph for privacy reasons, but they are still in the total amount of movements. Therefore the sum of incoming and outgoing values

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on the graph is not always equal to the total count of movements. Incoming and outgoing values show all 10+ movements, but total also includes the values less than 10.

3.4.3. Secondary homes layer

Secondary homes layer is meant for evacuation planning purposes. This layer shows how many subscribers would have a secondary home to go to outside the crisis area based on MPD methodology (Figure 8, Figure 9), meaning that they do not need accommodation.

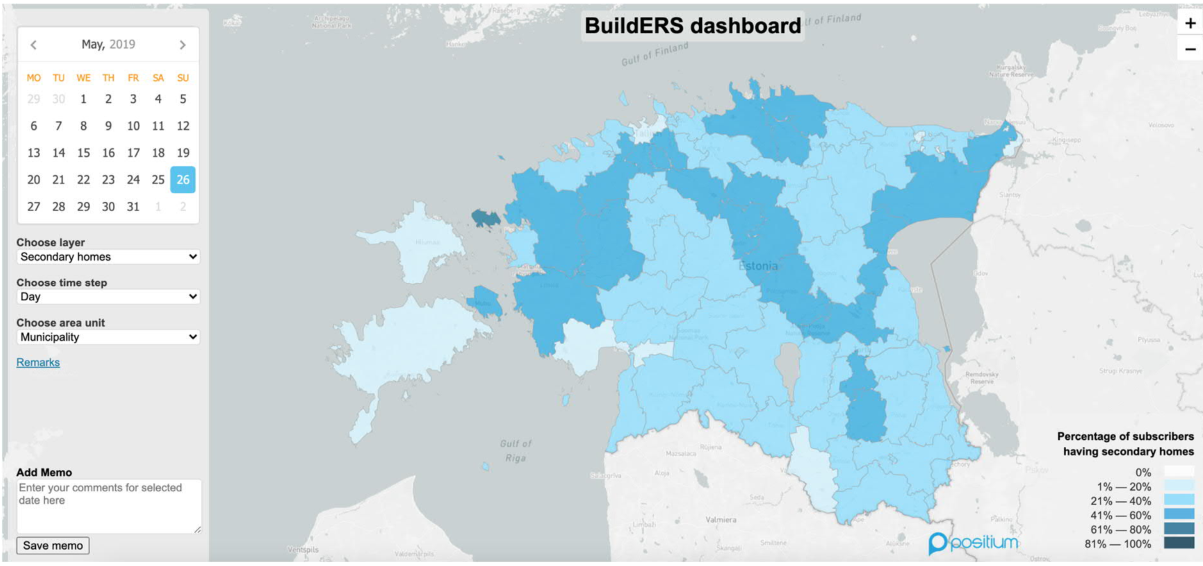

Figure 8. Secondary homes layer on municipality level.

Table 2. Secondary homes layer information structure with random numbers.

Area name and date		
Total amount of people	**50,000**	
	Home as evacuation location (primary home)	Secondary home as evacuation location
Evacuation location exists for	**10,000 (20%)**	**8,000 (16%)**
0-10km	6,850	<10
10-20km	2,200	625
20-50km	925	4,370
50-100km	<10	1,800
100-200km	<10	1,200
>200km	<10	<10

Table 2 shows that in the chosen spatial unit on the chosen day were 50,000 subscribers. From all these subscribers, 20% = 10,000 subscribers are visiting the spatial unit, but their home location is outside of the chosen spatial unit. They are able to use their primary home as an evacuation place. Most of them (6,850) live 0-10 km away from the chosen spatial unit, for 2,200 subscribers, their primary home is 10-20 km away. There are 8,000 subscribers living in the chosen spatial unit who have a secondary home, meaning that they are unable to evacuate to their primary home as it is in the crisis area, but they can evacuate to their secondary home. In conclusion, rescuers can see that 36% of subscribers have an accommodation on their own and they need to plan shelters for the rest, 64% (32,000 subscribers) as they either can not go to their primary home as it is in the crisis area or they do not have a secondary home based on Positium's secondary home methodology.

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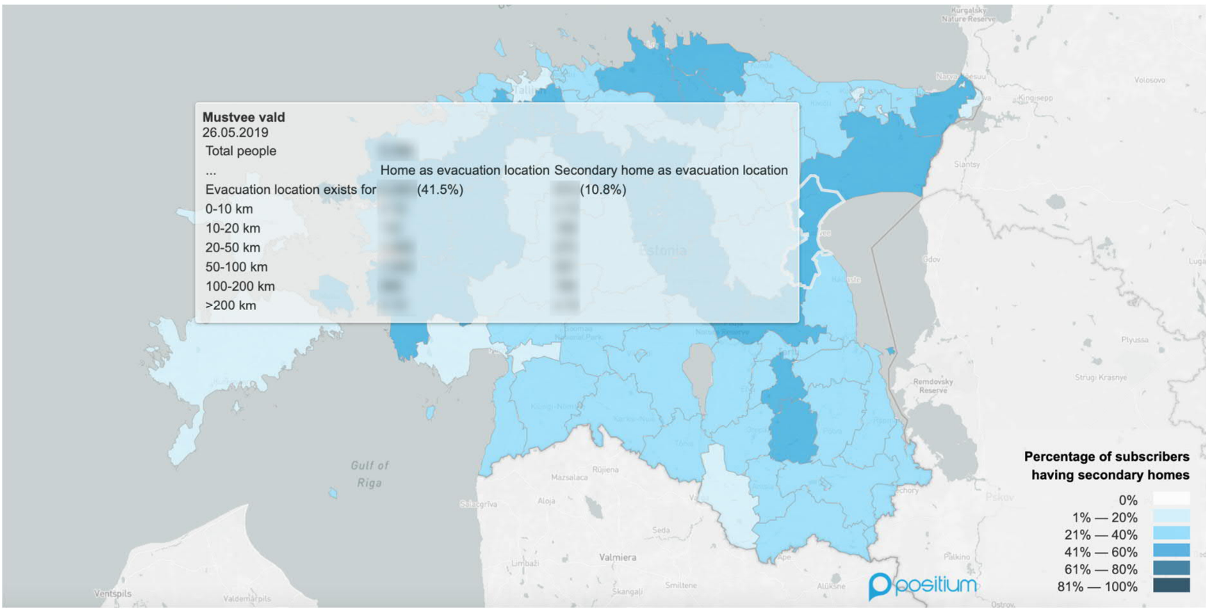

Figure 9. Secondary homes layer when an area is chosen.

Definitions on secondary homes layer:

- **Secondary home** - All subscribers are linked to a primary home location by their whereabouts' patterns. This is called the place of residence (primary home). Subscribers might also be linked to a secondary home if they have been to this secondary place at least in three different months (do not have to be consecutive months), each month at least four days within a 12 month period. These are usually peoples' summer homes, relatives' or friends' places.

- **Home as an evacuation location** shows how many subscribers (that were in the chosen area at the chosen day) have a primary home outside of the chosen area to evacuate to. These subscribers are usually people visiting the area and they can go back home and use the primary home as their shelter.

- **Secondary home as an evacuation location** shows subscribers who have their primary home in the chosen area, but are able to evacuate to a secondary home that is outside of the chosen area. This means that if they are unable to use their own homes for shelter, as it is in the crisis area, they are able to evacuate to a secondary home that they visit often.

Map options on secondary homes layer:

- Secondary homes layer has a daily view only. It shows all the subscribers that were in the chosen area during the chosen day and how many of them have a secondary home to go to outside of the same area. For the people living in the area it shows how many of them have a secondary home, but for people visiting the area it shows if they have a primary home outside of the area. Results are also divided by the distance of the area's border to home location.

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3.4.4. Other information about the dashboard

- Adding memo - There is a possibility to write a memo that is attached to a specific day (Figure 10). User can add information about storms or events of 2019 that could explain why subscriber counts or movements are different than usual. Once the memo is added, it will appear on all layers when the same day is chosen.

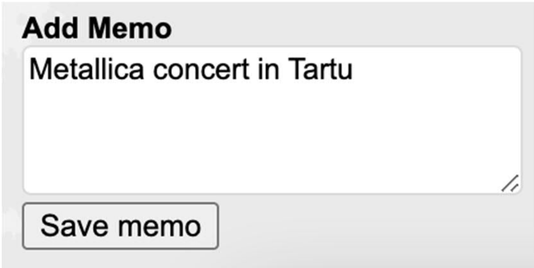

Figure 10. Possibility to add a memo about different events on all three layers.

- All amounts shown in the dashboard are estimated counts, not exact numbers. The dashboard is based on one MNO's data and generalised to the whole population with coefficients.

- All values under 10 in subscriber counts are shown as <10 and less than 10 movements are left out of the dashboard in order to keep the privacy of all subscribers.

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4. Methodology of empirical testing

There are three main barriers one has to overcome before a MPD based dashboard can be taken into use in disaster management. Firstly, approval of MNOs to share such data has to be acquired and technological capabilities to use MPD have to be developed. Explaining, how to achieve this goes beyond the scope of this deliverable. Secondly, it has to be ensured that historical population data is a trustworthy source of information or, in other words, overall precision of historical mobility data has to be estimated and temporal and spatial factors that may decrease predictability of mobility patterns have to be specified. How it was done methodologically has been explained in chapter 4.1 And the results are represented in chapter 5.1. Thirdly, it has to be validated if and to which purposes historical mobility data can be of use for crisis responders. This has been explained in chapters 4.2 and 5.2 respectively.

4.1. Statistical validation

Statistical validation has four main goals. Firstly, we analysed daily, weekly and yearly rhythms of population and mobility data to see whether there are any times of day, week or year wherein deviations from the mean are higher. Secondly, we analysed whether there are any places or regions where historical mobility data is less precise. Thirdly, we explored how regular is the spatial and temporal variation of different population types described in chapter 3.3. Fourtly, we compared MPD based mean total populations with data from the population registry provided by the Statistical Board of Estonia, which is the main data source in use of assessing population sizes in geographical places today. Next, we describe indicators used in statistical validation.

Percentage error from long-term average is calculated by comparing the number of people in a specific location in each hour of the year with its respective hour of the weekday. For example, if in some place on 2019-02-23 at 2PM (which is a Saturday) there have been 800 people, but the yearly average in the same location on Saturdays at 2PM is 1000 people, the error is 20%. To estimate how the error varied temporally or spatially, we calculated mean percentage error over all spatial units or timestamps accordingly.

Structural similarity index (SSIM) has been used to analyse how mobility flows - the number of people moving from one spatial unit to another - vary daily, weekly and seasonally. SSIM was first created by Wang et al (2004) for image detection. Its suitability for OD matrix comparison was explained by Djukic (2014), after which there has been widespread discussion regarding the best usage methods of SSIM in spatial networks (see f.e Day-Pollard and van Vuren, 2015, Behara et al. 2020). To understand how SSIM is generated it is best to visualise OD matrices as a spatial grid, where each row and column represent locations and matrix values the number of people that have travelled from one location to another.

SSIM consists of three components:

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1) luminance – the comparison of mean values of the number of travellers of two matrices;

2) contrast – the comparison of standard deviations of the numbers of travellers of two matrices;

3) structure – the correlation coefficient between mobility flows of matrices that are standardised by subtracting mean values of corresponding matrix.

To calculate mean SSIM, firstly SSIM is calculated in local windows (in other words, a submatrix) of the full matrix, after which the mean of all local windows is calculated (Wang et al, 2004). The methodology of this deliverable follows the article of Ros-Roca et al. (2021), who advised to use respecting rows and columns instead of sub-matrices in the averaging process. In this deliverable average matrices were calculated for each hour of corresponding weekdays around the year. So, for example, there was a "mean matrix" of all Mondays at 10 AM, of all Wednesdays at 7 PM etc. Next, SSIM was calculated for each spatial unit in all of the hourly matrices comparing it with its corresponding mean matrix of a weekday-hour combination.

SSIM takes a value between 0 and 1, where 0 means that two matrices have nothing in common and 1 means that they are identical. When presenting results, we subtracted SSIM value from 1 to express error from the average and converted the units to percentages - **percentage SSIM error**.

We then used mean percentage error of total population from long-term average and mean percentual SSIM error as dependent variables in multiple linear regression models to assess the influence of different times of day, week or season to probable precision of historical mobility data.

4.2. Tabletop exercise

The tabletop exercise with end users took place on 12th of March 2021. The tabletop exercise took altogether 4.5 hours and was held entirely online. In Estonia, there is no central organisation that is responsible for crisis management. The responsibility is divided between many organisations and each one is responsible for their own part in the process. This is the reason why many different organisations were present in the tabletop exercise. There were altogether 18 participants in the meeting: 14 validators and 4 organisers (3 from University of Tartu and 1 from Positium). Participants (besides University of Tartu and Positium as organisers) were from following organisations:

- Estonian Rescue Board (8 people),
- Police and Border Guard Board (1 person),
- Defence League (2 people),
- Ministry of Economic affairs and communication (1 person),
- City council (1 person),
- Ambulance/First aid (1 person).

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The goal of the tabletop exercise was to validate if and how this dashboard is helpful in crisis management situations. To be able to do that, Positium first explained what is MPD, how it is collected and handled. Positium also demonstrated the dashboard and all its functionalities to participants via screen share. After this all participants were given temporary IP based access to the dashboard and some time to use the dashboard themselves and to get a better overview of how easy/difficult it is to use and to try to find information on their own. After this, 4 different case scenarios were played through and validators were able to use the dashboard to solve the tasks. The tasks' descriptions are in Annex 2.

Task 1. The first task (see Annex 2 for task description) was to analyse based on the dashboard, how people behaved on 27. October 2019 when storm warnings were given for South-East Estonia. There was an exact timeline given at what time what kind of notifications were given and validators compared this knowledge to information on the dashboard to see how people reacted to the warnings. Task was to analyse if these notifications had changed the way people behave (subscriber counts in a normal vs crisis situation) and to analyse how many people were potentially in danger during the storm and how the movements directions or counts had changed (movements counts and directions in a normal vs crisis situation). A discussion round followed to conclude if dashboard allows users to assess population's behavior in regards of crisis notifications, if it can be used for risk assessments and if historical MPD can be used to better predict population behavior during storm and to plan intervention

Task 2. The second task was to analyse how many people were influenced by the power outage during the same storm and in a different storm on Saaremaa island. Timeline was given when in reality the power outage happened and when it returned (see Annex 2 for task description). Task was to find out how many people in Võru were influenced by the power outage, how many people were in the area and how much do these counts change (working day vs weekend, different seasons). How many tourists were in the area, how many people have a secondary home outside of Võru county and how many people left the crisis during power outage. Discussion followed to analyse if historical MPD lets users create better risk assessments, if it gives additional information during a crisis.

Task 3. Third task was about analysing mobile connections existence/outage based on the dashboard (see Annex 2 for task description). Task was to find out how long it took for the power outage to start influencing mobile cell towers' functioning, how many people and for how long were people still able to use mobile phones if there was no electricity. Discussion round followed to conclude what kind of information can be drawn from MPD on people with a high risk of becoming vulnerable in disaster (power outage, mobile connections, communication) and what kind of information on peoples' whereabouts and movements can be used for risk assessments.

Task 4. The fourth and last task was to analyse dashboard's usage possibilities in regards to big events, such as Tartu Marathon, Metallica concert and Defence League training 'Kevadtorm' (see Annex 2 for task description). Goal was to see if and how many people were in the area, if population groups present were different than usual, how long before the concert people arrive in the area and when do they leave (especially in case of domestic and foreign tourists) and if this information helps to plan evacuation routes better. A discussion round followed to conclude if the dashboard can be used for evacuation planning and what information can be gotten from the dashboard to prepare for tourists' protection.

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After the 4 tasks were finished, a general discussion followed where all participants were able to say their opinion of the dashboard and MPD usage in a crisis situation from their perspective and area of expertise. Discussion concluded these topics:

- Can historical population locations' and mobility information from MPD be used for risk assessments?
- What kind of information needs does this dashboard fulfill?
- What would rescuers like to know based on the dashboard by MPD to be able to solve the crisis more effectively?
- Does historical MPD give usable information?
- Which additional information could be needed and which further development ideas there are?

After this, participants were asked to fill in a validation questionnaire that has been put together by BuildERS project partner VTT for WP6. The questionnaire is in Annex 1 and a short conclusion of some of the aspects of it are in chapter 5.3. The results and conclusions of the tabletop exercise are in the chapter 5.2.

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5. Results

5.1. Results of statistical validation

5.1.1. Temporal differences

Overall spatial units throughout the year mean error of total populations was 10% (Figure 11) and mean SSIM error was 5% (Figure 12). For both cases, errors were not even throughout the year, but showed distinct temporal changes. The error is higher in summertime, especially when there are national holidays or bigger events taking place. Mean SSIM error also showed a strong diurnal rhythm that mean error of total populations did not show. Multiple regression analyses results confirmed those findings (

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Table 3). The mean error of total populations is approximately 1% higher in daytime than during nighttime and also on weekends compared to Monday. Mean error is influenced the most by seasons: it is almost 9% higher during summer and 3% higher during winter. Mean SSIM error varies foremost throughout the day: compared to night the error is 6% higher in the mornings, more than 7% higher during daytime and 4% higher during evenings. In addition to weekends, SSIM also shows higher errors during Fridays, although the effect is smaller than 1%. Compared to spring, SSIM error shows higher values in summer, but lower values in autumn and winter. All of the aforementioned differences are statistically significant (p < 0,01 or 0,05).

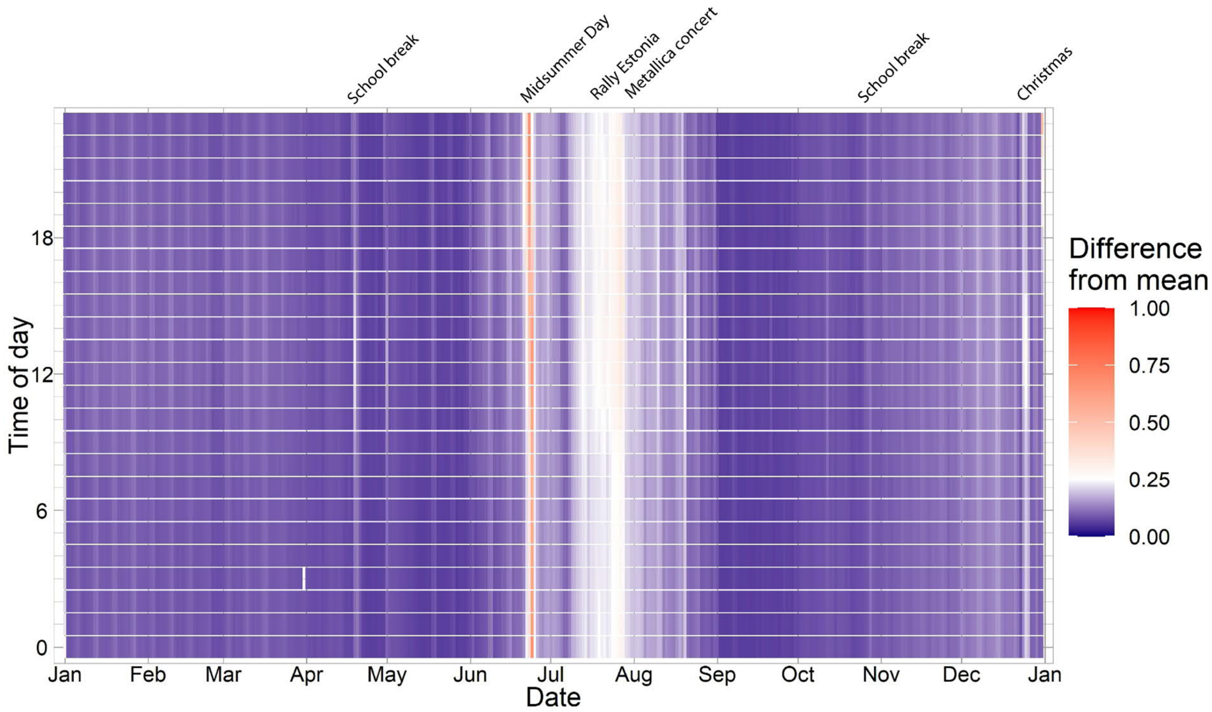

Figure 11. Mean change from average total population throughout the year. Blue areas express time where historical MPD are closer to long-term mean whereas lighter and red areas show greater differences.

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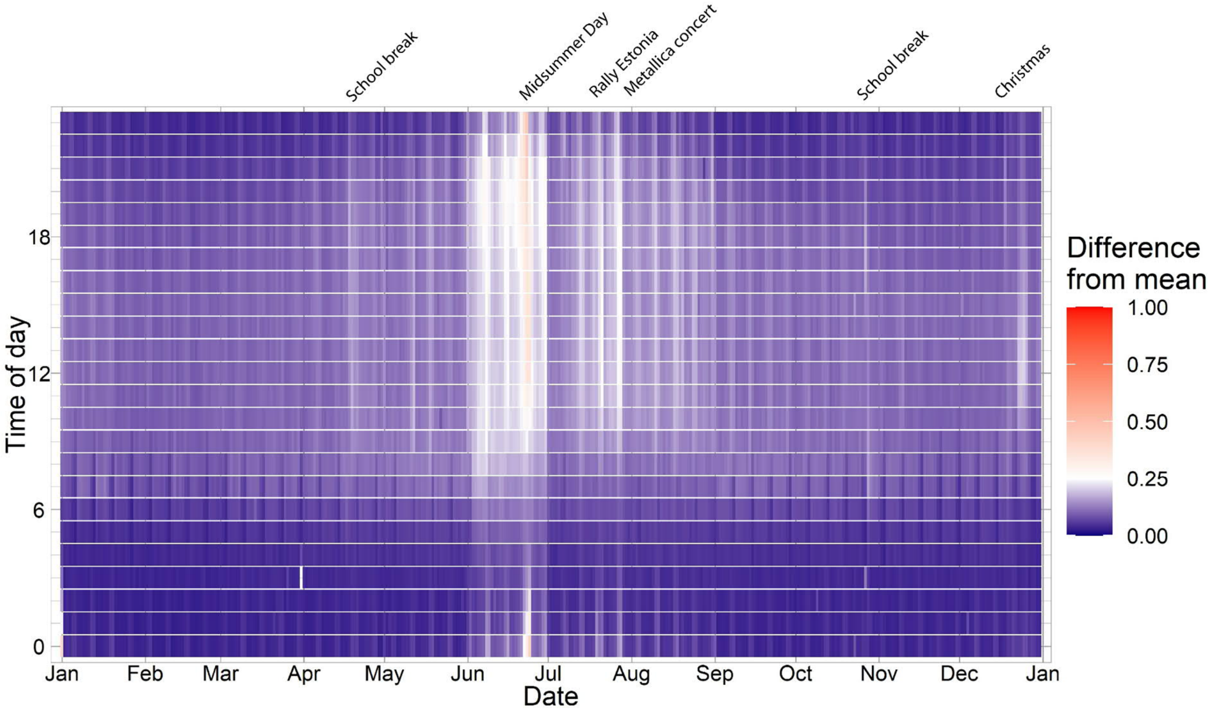

Figure 12. Mean SSIM error throughout the year. Bluer areas express higher suitability for historical mobility data whereas lighter and redder areas lower suitability.

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Table 3. Results of multiple linear regression analysis examining the effect of time factors (time of day or week and season) to average errors from long-term means.

	Population data	**Movement data**
	B	B
Intercept	7,61	4,10
Time of day		
23-6 *(ref)*	0	0
7-9	0,34*	5,92**
10-12	1,15**	7,57**
13-15	1,03**	7,53**
16-18	0,95**	7,04**
19-22	0,58**	4,44**
Weekday		
Monday *(ref)*	0	0
Tuesday	0,00	0,00
Wednesday	0,00	0,00
Thursday	0,00	0,00
Friday	0,00	0,84**
Saturday	1.13**	1,38**
Sunday	0,97**	0,86**
Season		
Spring *(ref)*	0	0
Summer	8,80**	5,21**
Autumn	0,29*	-0,54**
Winter	2,88**	-1,09**
R^2	*0,417*	*0,661*
Adj R^2	*0,416*	*0,660*
$^{**}p < 0{,}01$ $^{*}p < 0{,}05$		

5.1.2. Spatial differences

Generally total population numbers are quite close to their long-term means in the same locations (error is less than 10%). Mean total population errors are smaller in and near bigger cities and inland (Figure 13). Bigger differences are in some regions with few people (i.e north of Peipsi) the error can be up to 50% and in some units where there are more people, but big seasonal changes in populations present (i.e the islands and some seaside places) the error is approximately 25%.

Bigger errors can have three possible explanations:

1. Many bigger errors are created due to smaller populations - if the population is small, then even a small variance in numbers can make a big difference in percentages.

2. Many of the regions are near seaside where people spend only some time of the year - for example go there during summers when the weather is nice.

3. In some cases it may be possible that in places where the cell coverage is sparser (mainly in less habitated places near country boundaries) there are more errors in estimating the location of the callmaker based on the location of his/her call. This can happen, for example, if the person is in the same place, but in some cases connects with a cell tower in one region and in other cases to another region.

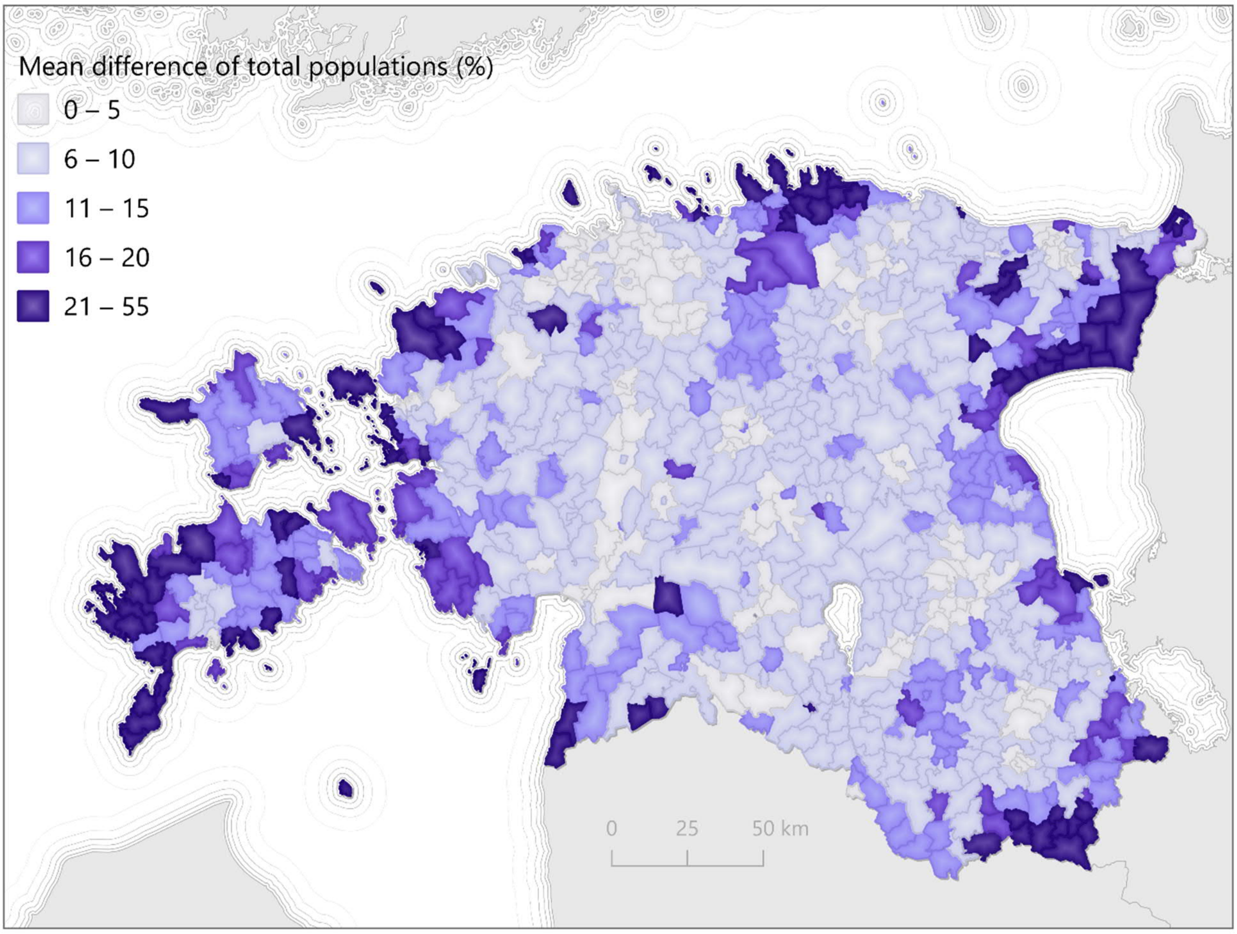

Figure 13. Mean errors for long-term mean population data in predicting total population at specific timeframes.

With movement data and SSIM index the effect of bigger towards smaller errors is even clearer (Figure 14). At the same time, spatial units with big errors are much more seldom, meaning that there are no spatial units where mean errors are more than 20%.

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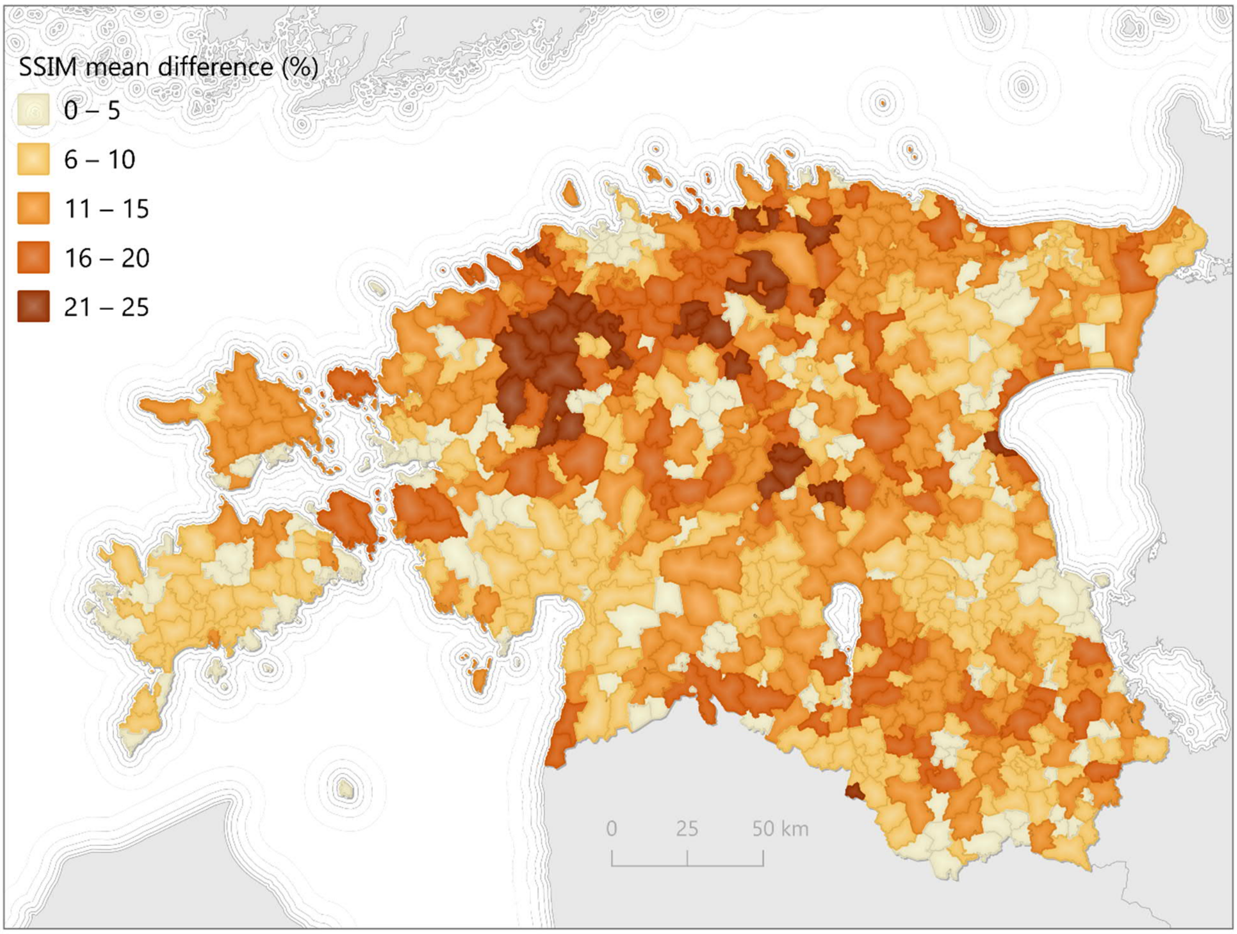

Figure 14. Mean errors for long-term mean population data in predicting movement data at specific timeframes.

In general, historical MPD seems to be most precise in assessing future populations near cities and least precise in places where there are smaller populations (Figure 15). Additionally, in the mainland errors of total populations are quite small, but errors of movement data can be bigger. At the same time, many coastal areas show great stability in movement data but higher variability in population data.

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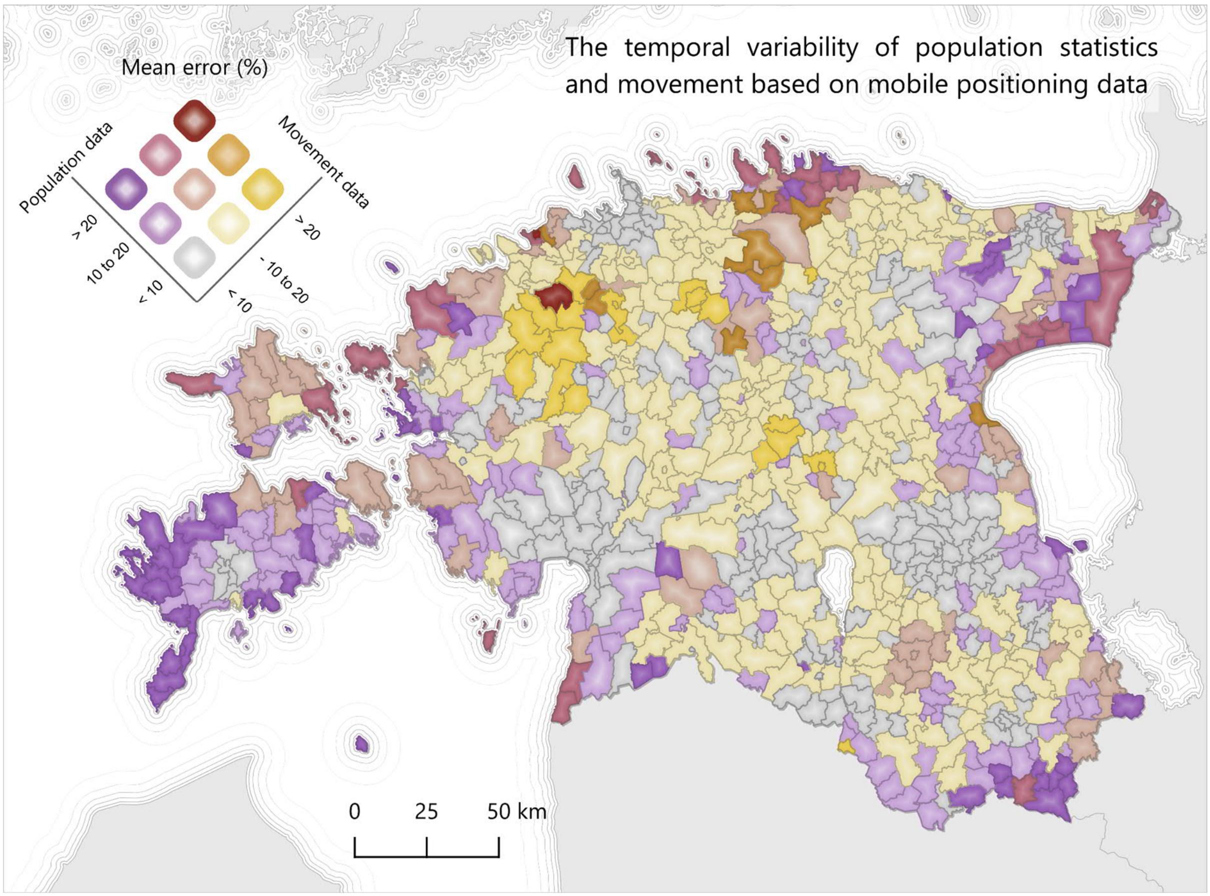

Figure 15. Bivariate map of interlinkages of errors in total population data and movement data. In grey zones the precision of long-term mean population data is the highest and in villages coloured in red the lowest.

5.1.3. Population types

There are big discrepancies in spatial distribution of differences of populations in specific timeframes compared to long-term means (Figure 16). We could claim that the regular part of mobility - for example time spent in work or home - is quite stable. When we leave aside a few villages with a very small population, then average difference from long-term mean is less than 10% (Figure 17).

At the same time unregular mobilities - tourism trips and visits to secondary homes - do not follow hourly rhythms. Even in big cities such as Tallinn or Tartu average difference from long-term mean is approximately 20% and it is even higher throughout most of Estonia (Figure 18). Especially domestic and inbound tourists show high temporal variability. There are differences between population types in how the mean error distributes geographically around Estonia. Domestic tourism trips and transit visits (consisting of short-term visits) look geographically quite similar, whereas secondary home visits and inbound tourists show different results. Still, there are some similarities: historical MPD varies the most on islands and least in big cities.

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This means that the dashboard can be used quite well to estimate in some area the number of people who spend time there regularly, but when estimating the number of tourists in the area, the numbers may be quite incorrect.

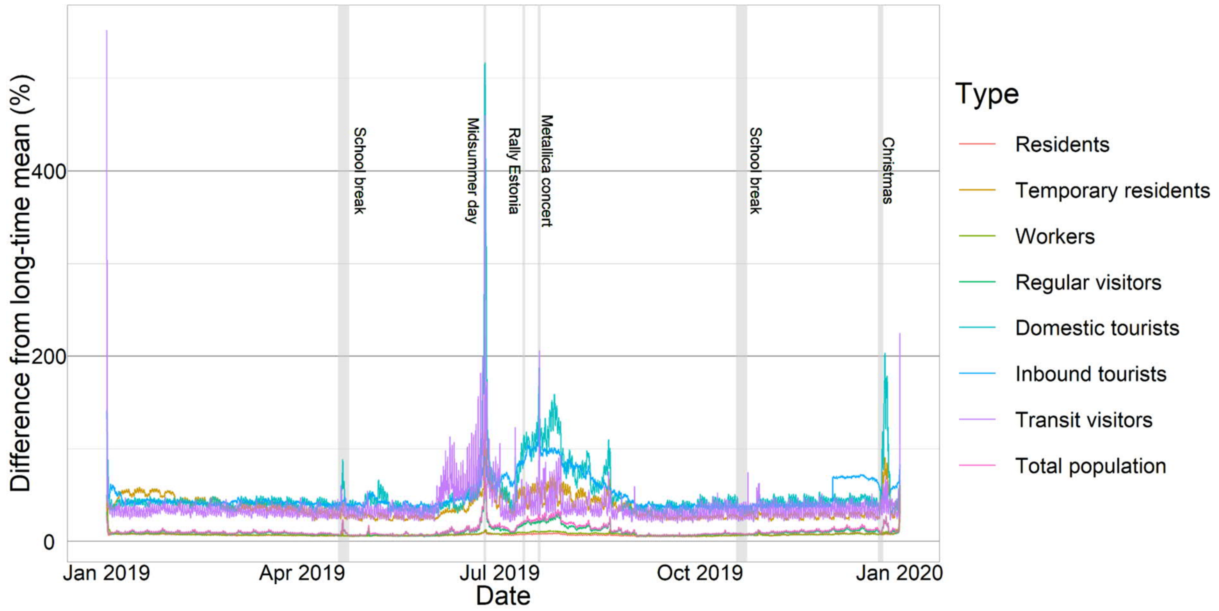

Figure 16. Temporal variance of mean differences of specific timeframes and long-term means of different population types.

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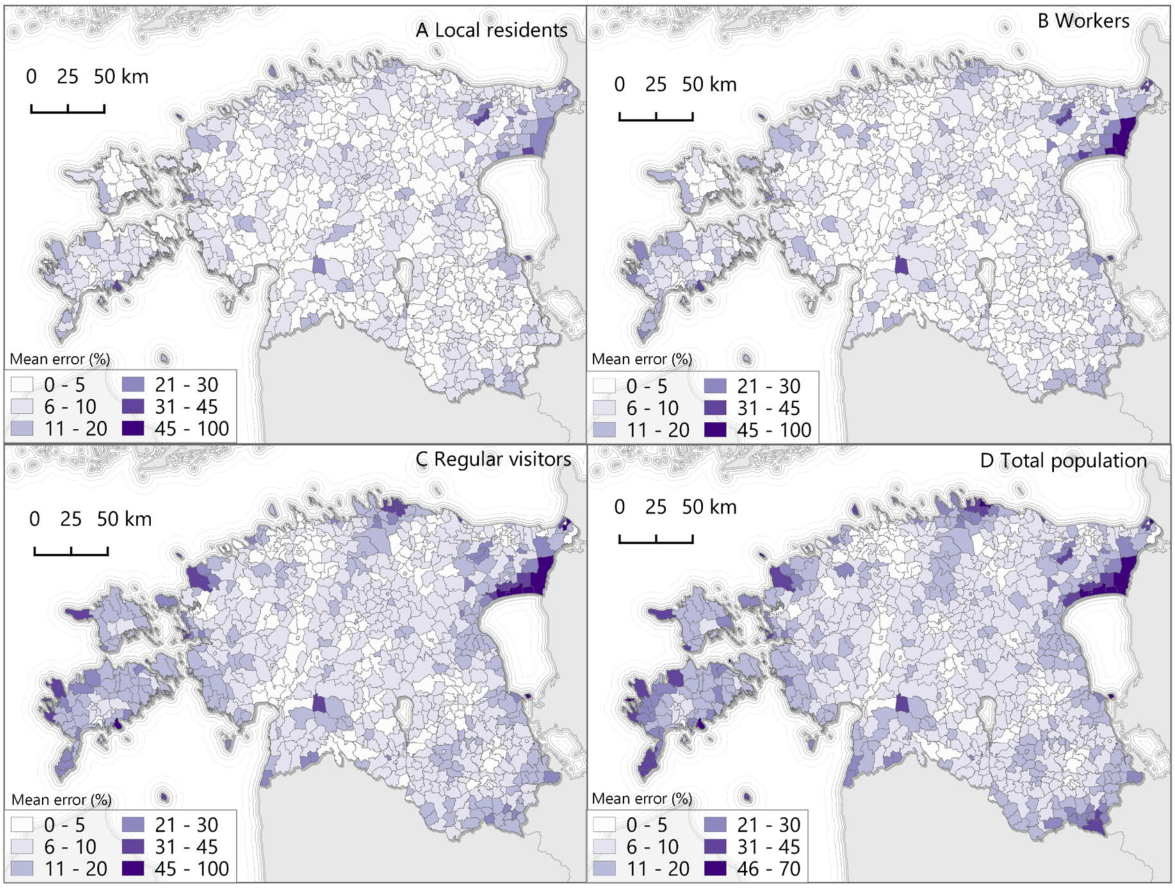

Figure 17. Spatial variance of mean differences of specific timeframes and long-term means of different population types - "regular" mobilities.

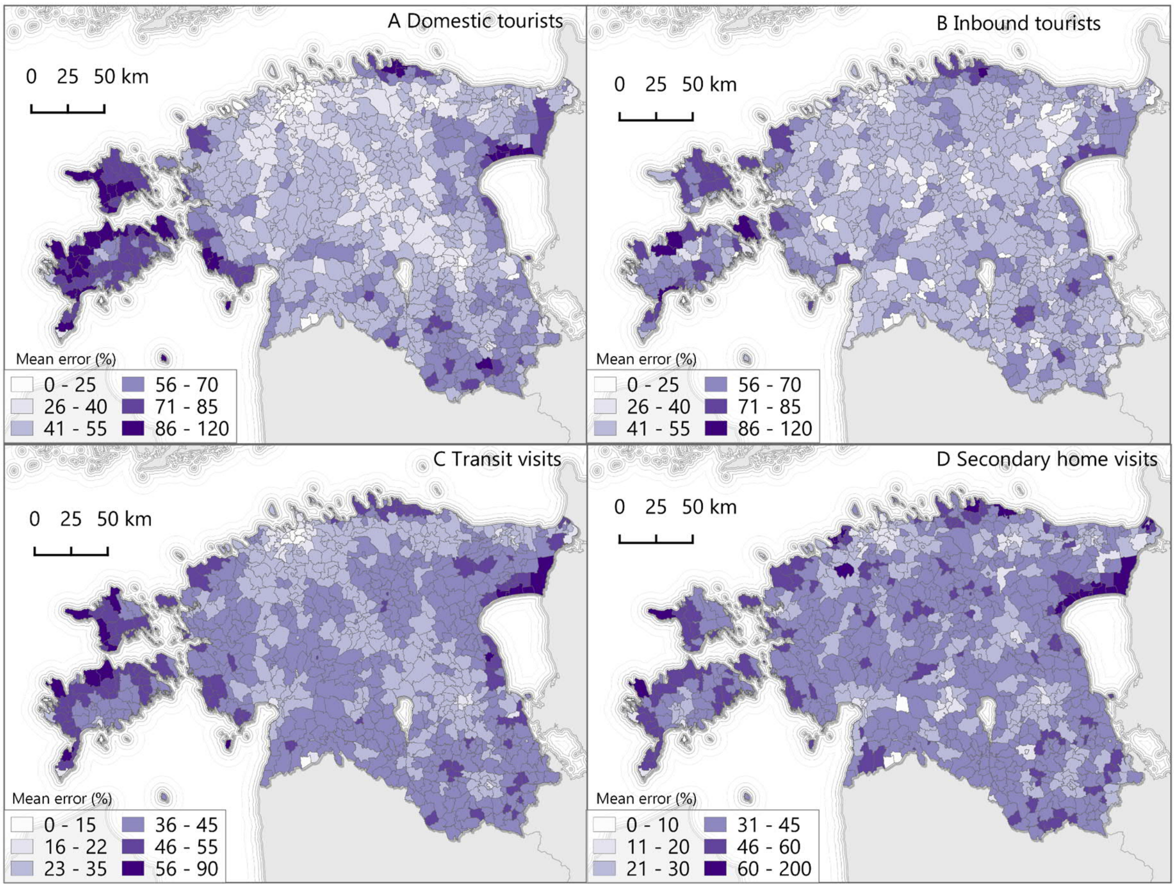

Figure 18. Spatial variance of mean differences of specific timeframes and long-term means of different population types - "irregular" mobilities.

5.1.4. MPD compared to population registry data

There are notable temporal differences in total populations when comparing population registry data and MPD. Apparently, MPD underestimates populations during night-time and weekends (Figure 19). The difference is on average 15% to 20%. Spatially the differences are in absolute numbers the biggest in large cities: Tallinn, Tartu, Narva and Kohtla-Järve (Figure 20).

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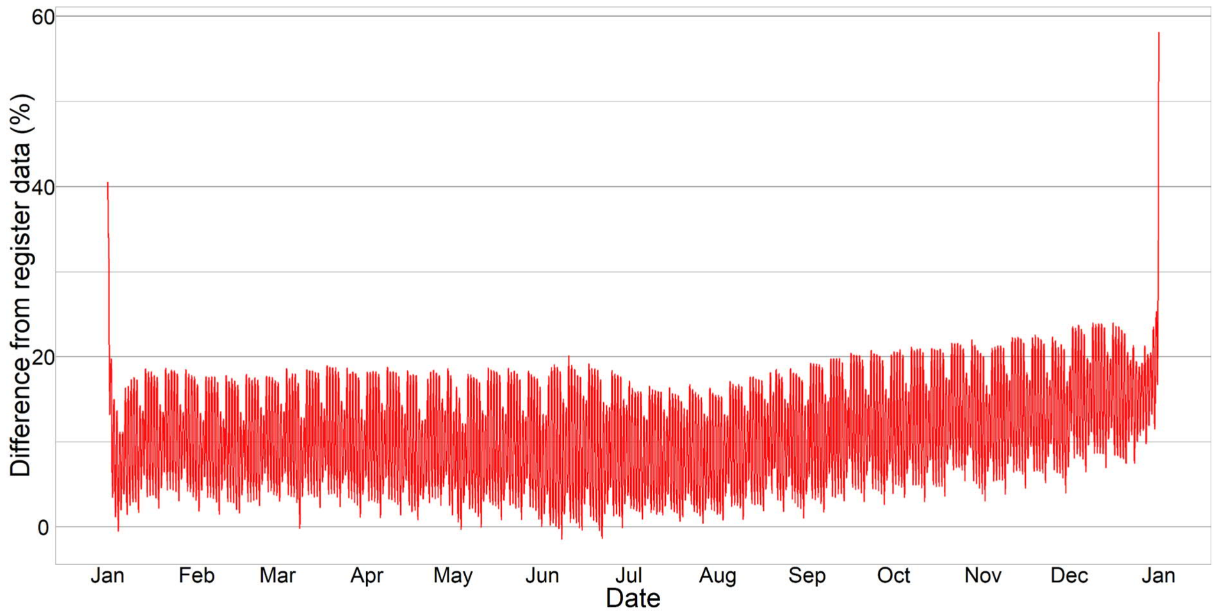

Figure 19. Difference of total population in population registry and MPD.

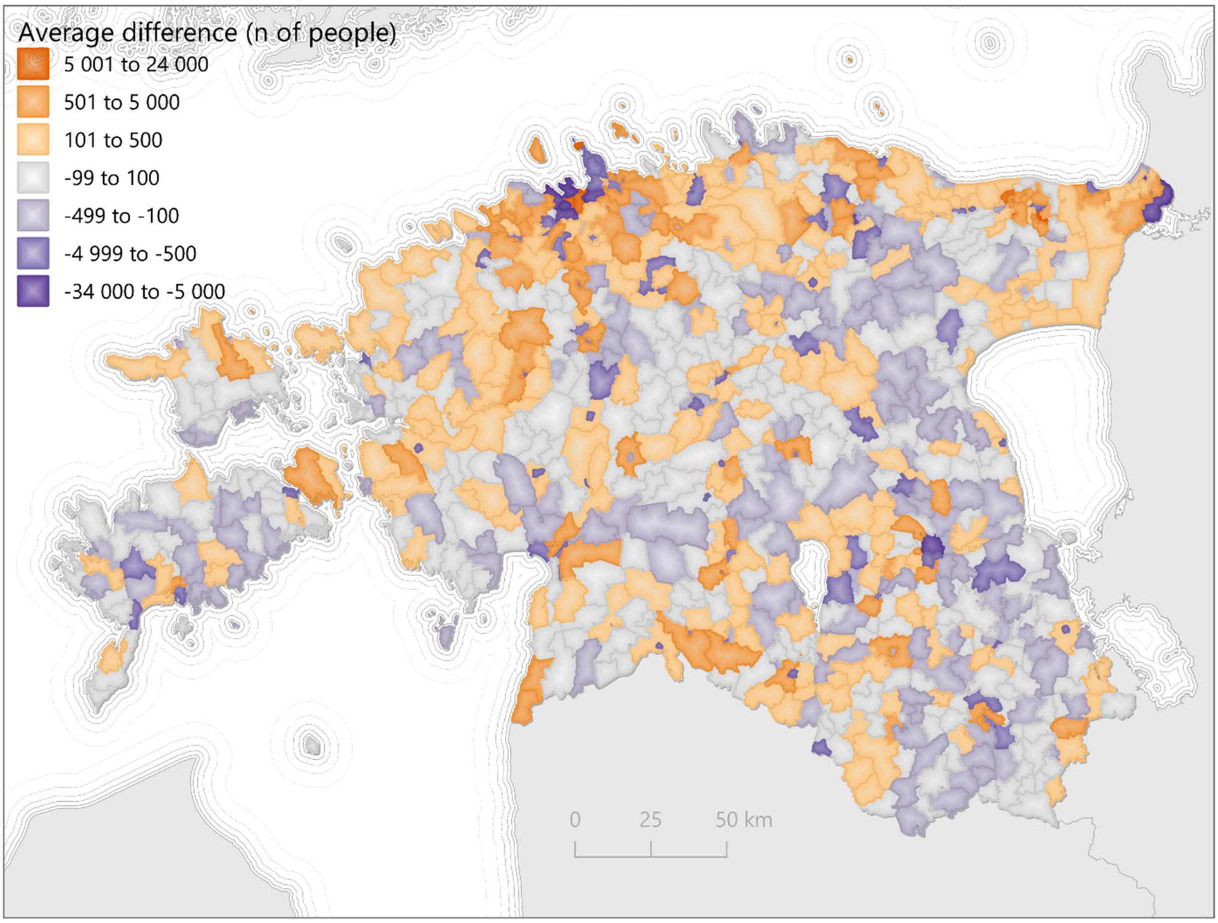

Figure 20. Spatial differences of registry populations and average total populations throughout the year calculated from MPD. In orange tones MPD shows higher values and in purple tones registry shows higher values.

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5.1.5. Main conclusions from statistical validation

MPD shows good potential in complementing population statistics for disaster management. Most important conclusions that can be made from statistical validation are:

1. When looking at historical MPD to assess the total number of people in some geographical area or movements between districts, the probable error is up to 10% from the results that "live" MPD would show. It is bigger in regions which are sparsely populated, have big changes of population because of seasonal tourism or second home visits or are closer to the sea. Imprecision is also higher during summer, when mobility behaviour is much more irregular.

2. Big events can have quite a big impact on population distribution, so users of the dashboard should be aware whether some activities at given times were going on in areas of their interest. It is reasonable to check population composition from several weeks, so that assessment on population would not be based on a special week.

3. It is important to note that in some areas the actual number of people may differ from MPD at all times due to some methodological imprecision in converting MPD to population statistics.

5.2. Results of the tabletop exercise

The end users found this dashboard to be very useful for analysing past events in retrospect.

The dashboard consists of historical MPD (2019) and it can be used to take a retrospective look at the events of 2019 to analyse how different events changed people's regular behavior. The dashboard helps not only to analyse the behaviour before, during and after previous storms and power outages, but also to analyse big events and gatherings. Everything in chapter 5.2 was brought out or discovered by tabletop exercise participants.

Storms and power outages

This dashboard made it possible for validators to see how many people were in different areas at different times and how the count has changed during disasters. It was also possible to analyse their movements' directions and volumes. With the knowledge of subscriber counts, movements' volumes and directions it was mentioned to be possible to plan more exactly how many technical and human resources are needed and how to hinder movements into the crisis area and how to help people out of there.

Validators could see that it is possible to analyse how warning notifications have changed people's behavior as it is possible to see hourly movements and changes in population counts. During the tabletop exercise participants could see the effect of the warning that was given a couple of hours prior to the storm and how it made people move more than usually, probably to shop for food, bring water to close ones, to tank the vehicle or to drive out of the soon-to-be crisis area. Also, validators could see people coming in from 'safe' areas into the crisis area. One validator called it the storm tourism as he

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knew that many photographers wanted to capture a city that is in blackout. As it was unusual, people wanted to witness it and drove into the crisis area, even though it was dangerous.

The end users brought up that the knowledge from the dashboard, especially from the secondary homes layer could be used to create the content for warning notifications. E.g. 'We know that around X% of the people in the area have a place to go to – please go there. We will take care of the rest of you!'

People's locations are calculated based on cell towers' coverage areas. If some cell towers are down due to the storm, people connect to the cell towers from further away (if possible). This makes it visually look as if people are moving out of the power outage area as the coverage area is taken from a different cell tower now. Actually, they may have stayed in the same location. Based on this, it is possible to analyse where the cell towers are down (people are 'moving out') and how long they are down (they are back up when people start to 'come back' to the area). When using the dashboard, it needs to be made sure that the user knows that this does not reflect real subscriber counts, but that this is caused by cell towers being down.

End users confirmed that the hourly view from MPD timely matched the real life events from the storm we were looking at. It made the dashboard even more reliable as users could see it matching the events they participated in themselves.

Analysing big events

In 2019, there were many big events in Estonia, such as the Metallica concert in Tartu, Estonian song festival in Tallinn and international rally event in Saaremaa. Based on MPD it was possible to identify where are people coming from, how long they are staying after the event, when do they go back home etc. It is possible to see how many people are in the area during events and to what subscriber groups they belong to.

On the Figure 21 you can see a drop in subscriber counts at the end of June – this is caused by a national holiday in Estonia (Midsummer day) where everybody drives to the countryside. The peak right after this is the Estonian song festival where domestic tourism rose significantly due to Estonians going to Tallinn to the concert (rise in domestic tourism). The drop at the end of the year is also caused by Christmas holidays where people usually drive to the countryside.

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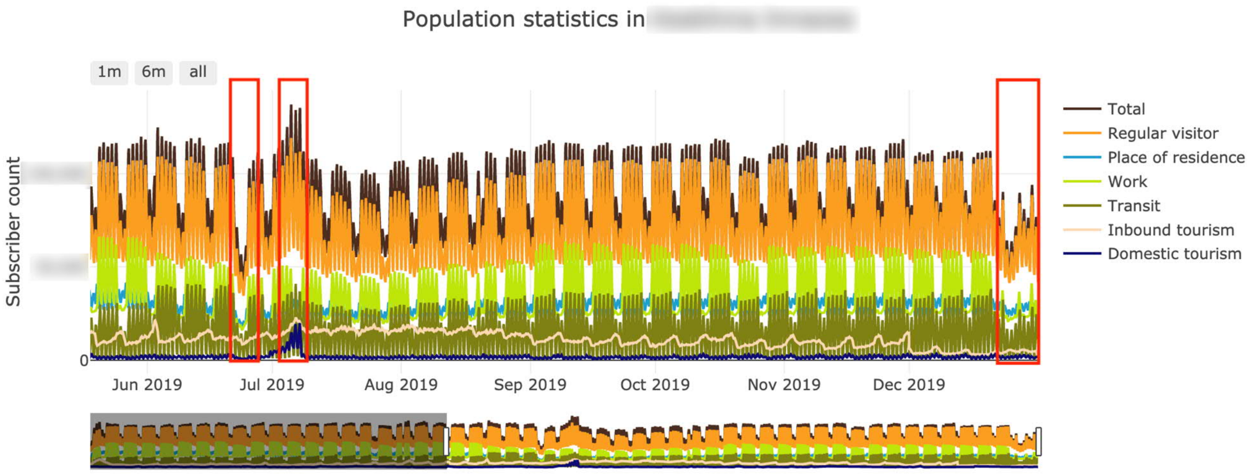

Figure 21. Dashboard's 'Population statistics' layer showing peaks and drops caused by national holidays and bigger events.

It is possible to analyse tourists' behavior during big events. From the Metallica concert example validators could see that people arrive on the same day, they did not come much earlier, but they did not leave right after the concert, many of them stayed for a couple of days afterwards as well (Figure 22).

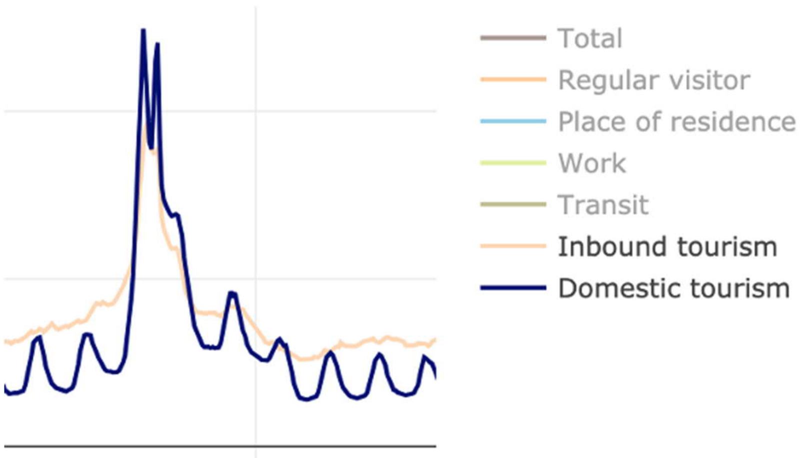

Figure 22. Dashboard's 'Population statistics' layer showing subscriber count change during Metallica concert on vertical axis and changes in time on horizontal axis. In this image, only inbound and domestic tourists are shown.

End users brought out that as the future events will probably look very similar to these 2019 events, then this information can be used to better regulate traffic based on knowledge of estimated subscribers' counts and movement directions.

End-users found the dashboard useful for making risk assessments and more accurate plans

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It was brought out that the dashboard can be used to update evacuation plans based on the information in the secondary homes layer. It is possible to see how many of the total count of the people in the area have a place to go to and how far away it is. It gives much more accurate input to the shelter planning than has been used until now. These results can also be combined with previous questionnaires done by the Estonian Rescue Board or to compare them with future researches.

One participant made an example that they have had the case where they plan the accommodation for X amount of people, but actually, just small percentage of them show up as people rather want to spend a night in a location they know (friends'/parents' place) than in a gym full of people they do not know.

Based on this, it is possible to create an evacuation plan not only for accommodation, but also for the evacuation routes so that there would not be any bottlenecks. In case of a crisis where time is short, traffic jams can not be afforded.

This dashboard was found to be rather a tool of higher level organisation, but it could also be used to make regional plans. One participant from the municipality office brought out that he has many ideas on how to use this dashboard besides crisis management for the general leadership of the city and how it can be used for example for city and regional traffic planning.

One participant brought out that some organisations are daily delivering dangerous materials through the country. Based on this dashboard they could plan the routes and timing of deliveries to times and locations where the least people are exposed to the danger. If anything should happen to the dangerous materials, the damages would be minimal.

Similar approach can be applied for the trainings of the defence forces. They could choose the areas and times for the trainings where the least people are disturbed by the noise or are exposed to certain dangers. They would know better what kind of possible risks they have in operating in different areas (how many people, what kind of people, how many stay the night etc). From the state security aspect it was brought out that it is important to know, especially in border areas, how many people are there during the day and during the night.

Other aspects that end-users found useful

This dashboard displays *de facto* data that is more exact and accurate than other static databases and registries. For example, at the moment, a database is used that shows where people should live (population registry). But this data does not include the commuting between different places and the fact that if e.g. a student's home is in Tallinn, but he's/she's going to the University of Tartu, he/she lives in Tartu. Static databases show wrong information in this case. MPD shows present population distribution.

The end-users found that if this dashboard gets taken into use, more thorough trainings are needed in order to play through real life scenarios. Also, the data in the dashboard and the previous events and disasters need to be analysed and the conclusions made need to be communicated during these trainings to all parties involved. This analysis could be done during next researches.

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At the beginning of the tabletop exercise, there was a training of the dashboard, showing what MPD is capable of and how to use the dashboard. The organisators from Positium found that the end-users used the dashboard very well and understood easily how to find different information from different layers and how to paint a general picture based on this. It is not easy to understand MPD when you have not had any contact with it previously and therefore the participants did very well.

Many organisations showed interest in using this dashboard in future as well. One very interested potential future client is the Estonian Rescue Board and with other interested parties discussions will follow to figure out the best possible way of usage between organisations. The dashboard will be also demonstrated to different ministries in the near future.

5.3. Presentation to the ministries

On 26th of May, the dashboard was also presented to several ministries. Aim of the meeting was to introduce ministries with new possibilities in crisis management area. The results of case study 4.3 and also 4.4 were presented. Meeting included over 40 participants, including Ministry of Interior, Ministry of Social Affairs and Government Office of Estonia. Many contributors to these case study joined to listen in as well: Estonian Rescue Board, Defense Forces, Police and Border Guard Board and many others from 4.3 tabletop exercise and interviewees and partners of 4.4 case study.

Ministries' feedback was very good and they did see potential in both case studies and their implementation. Politicians from the ministries said that the Emergency Act of Estonia is being updated and they will include the new information from this meeting to the discussions of the Emergency Act and this gives hope that both case studies will get an actual use in the near future.

So far, only the department of Southern region of Estonian Rescue Board had seen the dashboard. During this meeting, the other departments of the Estonian Rescue Board saw it as well. They showed very clear interest in using this dashboard for training purposes already this summer. They are doing risk assessments for flood areas and are struggling with getting accurate information of population counts in different areas and are asking municipalities for this kind of information. This takes a lot of time and resources and unfortunately, the municipalities do not have accurate information from recent years as well. Therefore, this dashboard is exactly what they need, it helps them save their timely and human resources and help doing better risk assessments for flood areas.

Users also brought out some development ideas for the dashboard and you can read more about them at the end of section 5.4.

5.4. Preliminary evaluation of the dashboard – validation questionnaire results

Preliminary results of the evaluation of the case study show that Positium's dashboard could be very beneficial in preparing for crises and learning from crises. The evaluation was done using questionnaire targeted for end-users i.e. those who participated in the workshop. Questionnaire is in the Annex 1. The questionnaire consisted of 7 sections: Background information, Usability of the tool, Perceived risks or challenges of the tool, Ethical acceptability of the tool, BuildERS model, Technical readiness of the tool and Free word.

In total there were 12 questions that had different statements. Likert-scale 1-5 was used in all questions that were applicable (i.e. other than multiple choice questions in the Background information section and Free word section). Depending on the question, in the scale 1 stands for strongly disagree, very unlikely or very minor, while 5 stands for strongly agree, certain or very serious. Due to the nature of the questions and target group, respondents were also given the 'I do not know' option. In the spirit and guidelines of the BuildERS project, the questionnaire was translated to Estonian and respondents answered the survey in their native language.

In this preliminary evaluation of the tool, sections 'Background information', 'Usability of the tool' and 'Free word' are pre-analysed. Final evaluation of the tool will be done in Work Package 6 and results will be reported in Deliverable 6.4: End-user assessment of the new tools and technologies for disaster management. In total, 11 responses to the survey were received. Roughly about 80% of the exercise participants answered the survey. 64% of the respondents represent rescue organisations, 9% were local authorities, 9% police or border controls, 9% research organisations or universities, and 9% represented defence unions. 73% of the respondents indicate that they used the tool and 27% said that they have not used it.

All respondents agree (63,6%) or strongly agree (36,4%) that the tool is effective in achieving its purpose. Respondents also mostly agree that regular use of the tool would be efficient in terms of resources. It also seems that the tool was found to be useful and respondents indicate that the tool should be in regular use in their country. Furthermore, the usability of the tool can be considered to be very good as most of the respondents agree or strongly agree that they would be willing to use it again and that it was easy to use, and there are clear instructions on how to use the tool. Most of the respondents said that the tool is suitable for civil protection and disaster risk reduction, but there was more dispersion when crisis management was considered. Accessibility of the tool is also a bit unclear as the responses were dispersed quite evenly on the scale from 2 to 5 and to 'I do not know'. This might be a result of unclear understanding of the "digital" accessibility, though the term was briefly explained in the questionnaire. The distribution of responses to the Usability related statements is presented in Table 4.

Table 4. Answers' distribution on likert scale of 'Background information' and 'Usability of the tool' sections.

	1 (Strongly disagree	2	3	4	5 (Strongly agree)	I do not know

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The tool or technology is effective in achieving its purpose	0%	0%	0%	63,6%	36,4%	0%
Regular use of the tool or technology would be efficient use of resources (such as money or working time)	0%	0%	9,1%	63,6%	27,3%	0%
The tool or technology should be adopted to regular use in my country	0%	0%	9,1%	54,5%	36,4%	0%
I would be willing to use the tool or technology again	0%	0%	0%	27,3%	72,7%	0%
The technology or tool is easy to use	0%	0%	18,2%	45,4%	36,4%	0%
There are clear instructions how to use the tool or technology	0%	0%	9,1%	54,5%	27,3%	9,1%
The tool or technology is suitable for civil protection	0%	0%	18,2%	54,5%	27,3%	0%
The tool or technology is suitable for crisis management	0%	18,2%	18,2%	45,4%	18,2%	0%
The tool or technology is suitable for Disaster Risk Reduction (DRR)	0%	0%	0%	63,6%	36,4%	0%

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The technology or tool is accessible	0%	9,1%	27,3%	36,3%	18,2%	9,1%

In the ‘Free word’ section respondents were allowed to answer openly e.g. how they would develop or improve the tool. The answers to this question mainly contribute to the technical development of the tool to make the use of it easier. It was suggested that naming and wording could be improved, and that additional map or other attribute layers could be added (e.g. location information, people categories). There also was a suggestion to move from development phase to operational use as the tool was considered to be very good already.

However, the section included a comment: “If later on a module for data analysis could be created for crises in ‘hot phase’, it would be a very grateful tool for organisations involved in crisis management.” (translated from Estonian). Compared to the responses in the Usability section, it could be that respondents feel that to be suitable for crisis management, the tool needs to be developed further. It is unclear what kind of “module” the respondent means in the comment, but as the respondent refers to a “hot phase of crisis”, it might be that they wish to have real-time analytics instead of history data analysis.

From the view of preliminary evaluation, it could be said that Positium’s dashboard or similar tool would be beneficial in crisis preparation and learning from past crises. However, some further development is needed to make the tool more usable and suitable for other crisis phases. This preliminary analysis did not consider all the questions and responses to them, so further analysis is needed. The detailed analysis regarding the tool will be reported in Deliverable 6.4.

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6. Innovation potential

Location-based services and data is proven to be potentially very beneficial by BuildERS' earlier estimations made by disaster management stakeholders about the need for new tools and technologies (D2.4, page 60) and previous research (Weidinger 2017). There have been essential gaps in transferring disaster management tools from development phases into real use (D2.4, page 59), which is why it is important to emphazise potential innovations BuildERS dashboard beholds to ensure its further development and use after the BuildERS project.

Scientific innovations

Foremost, a methodology for the whole process of converting MPD to population statistics has been developed (incl. pre-processing of data, definitions until generalisation to the whole population), which can be applied in other countries as well. This methodology is also a good basis for the production of official statistics. As passice MPD is relatively standard everywhere, the methodology developed for the dashboard is easy to transfer to other countries where MPD is made available to researchers or relief workers.

MPD and the dashboard enable to cover population groups, which is impossible to present by any other data sources. MPD enables to show spatial distribution of different population groups (residents, workers), including temporary populations (commuters, domestic tourists, foreign tourists). Dashboard shows for example how many people have a secondary place to go in a disaster situation (this knowledge can be used in evacuation planning) or how many people at a given time are regular visitors in some place and how many of them are tourists. Estimations of the amount of different population groups are made in a more precise time step than before.

In tabletop exercises it was seen, that information on the location and movement of people with a precise time and space units, is needed in many governance areas, in addition to risk management, also in transport and urban / regional planning, etc.

Throughout development of the dashboard and its validation we have gained hindsight into needed future development in using MPD in disaster management - here the communication with rescue workers has been very useful. Some of potential problem areas, such as the impact of mobile coverage problems due to power breakdowns, were detected. Thanks to statistical validation there is now more information regarding where and when (geographical areas and time durations) historical MPD is more precise and where there are potentially more problems. It helps to understand the dashboard clearer and can make future methodology more accurate in these problem areas.

Technological innovations

Research by Weidinger et al. (2017) has shown that universal using opportunities and simple readibility of information-based tools are important factors for rescue workers. Dashboard consists of a map application that makes vast amounts of data easily comprehensable through its cartographic display. The map application can be used both on- and offline, ensuring that potential increase of situational awareness would not be restricted by power outage or lack of network connection in disaster

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area. Additionally, technological requirements to develop and sustain the dashboard can be estimated, which is a prerequisite to ensure that potential users have or can develop ICT-infrastructure to start using the dashboard.

Process innovations

The dashboard provides a new medium to use as a basis to both tabletop or full-scale exercises. The effectiveness of exercises is increased when they imitate real situations with greater precision. The dashboard can be used to simulate dynamism of population processes amidst disaster situations.

Also, the dashboard can be helpful in any type of disaster - even in those which have not happened in some areas until today. This supports rescue workers in making decisions in situations they have not been in before and which may have been evoked by new conditions related to climate change and global warming, such as bigger floods or droughts.

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7. Conclusion and policy recommendations

Conclusion

The dashboard presents to rescue workers geographical population statistics which is more accurate in time (on an hourly basis) than based on traditional data. It was evaluated highly useful by people working in the field of disaster management. Dashboard based on historical MPD can be a great extension to population statistics in use today, as it enables rescue workers to consider daily and seasonal changes of population distribution.

The dashboard enables to get information about different population groups, distinguished on their past mobility behaviour. Dashboard shows presence of people living in the area, workers, regular visitors, domestic tourists and foreign tourist in spatial units. It also gives some additional information based on their previous mobility: how many people have a second place to go and in what kind of connection people have with distinct geographical areas, how many are regular visitors (like workers), how many live there or how many are tourists. The dashboard not only presents rescue workers knowledge of society's ordinary mobility behaviour, but it can also be used to study effects of disaster situations which can help rescue workers to prepare for future crises.

The dashboard increases societal resilience against disasters by increasing situational awareness of relief and medical workers, humanitarian and governmental organisations. The dashboard is foremost directed to official responders in crisis situations. It decreases societal vulnerability by helping disaster managers make more informed decisions and disaster mitigation plans and also to allocate their resources more effectively. This, consequently, potentially reduces individual vulnerability of people and increases their social capital, as officials have greater likelihood of reaching more people in potential danger faster.

The end-users evaluated this dashboard to being highly valuable asset to their pre-crisis phase where they learn from past crises and events. Based on this information it can be seen how people usually behave, if and how they move during crisis, respond to crisis notifications etc. It can also be very well used for doing risk evaluations on regions and buildings and playing through crisis scenarios in trainings.

It takes time and planning to start using dashboard presented in this deliverable: on the one hand scientific community has to think through working principles of the tool, potential conflicts with privacy and vulnerabilities; on the other hand rescue workers have to devise ways where such a solution is most beneficial and make investments to their technological preparedness to use the tool.

To enable crisis responders to use the tool in disaster situations, long-term stability in laws and agreements regarding handling MPD is needed. This needs all-around agreements regarding privacy policy. In addition, the MPD has to be available for scientific research to develop methodologies of using MPD. There is a lot of information to pre-process before one can make smart decisions using the map dashboard, which needs time, cooperation and planning. We have, thus, proposed some policy recommendations that would simplify using historical MPD in disaster situations.

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Policy recommendations

Based on the results of the tabletop exercise and Positium's and University of Tartu's long experience with MPD, authors have come up with several policy recommendations.

EU-level policy makers

There should be clear laws about passive MPD usage for dashboards like this. At the moment use of MPD is differently regulated in various countries and there is a lot of insecurity in future accessibility to data. This also restricts the use of the dashboard geographically and puts rescue workers in a doubtful situation: should they make investments to start using such a tool, if, at some point, they can not add new data into it. Allowing MPD to be used for scientific researchers assures that new dashboards, applications and solutions could be developed. Restricted data access can also drastically slow or even stop scientific and technological advancements in the use of MPD in disaster management. The laws should consider and include the protection of privacy and data management.

MPD usage could be standardised, including having unified definitions, speeds up scientific and technological advancements in the use of MPD in disaster management.

Main indicators of MPD could be added to the composition of official statistics of European countries so that simpler indicators could be used to solve everyday problems. As in Estonia and in other countries as well, disaster management includes different institutions, many of whom have different responsibilities in disaster situations, using some indicators of MPD as official statistics could accelerate benefits of MPD. Many of the institutions would not necessarily need access to all using opportunities of the dashboard but only some (perhaps more aggregated) statistics.

National policy makers

Results show that at times of widespread power breakages there are issues in mobile phone coverage. In other words: people may be unable to inform anybody by phone that they are in need of help. This could be resolved by setting a minimal time-span for mobile phone towers, through which they have to be operating without power (with built-in batteries). In addition, hazard of cell coverage loss can be integrated into risk analyses.

The dashboard can be used as a basis to plan routs and timings of deliveries of dangerous goods, as in case something would happen with the dangerous good, there would be less people in traffic at the time.

The dashboard seems to surpass traditional sources of population statistics, which may be useful in evacuation planning, especially when there is a pre-fixed need to create such a plan (e.g. near a dangerous factory). Additionally, the dashboard can be used for risk analyses, urban and regional planning and disaster management strategies in general, especially in areas where there is heightened disaster risks (threat of floods, storms or man-made disasters). This would enable to mitigate disaster effects in the long term.

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Regional/local practitioners

Information from the dashboard could be included into local disaster plans. Some new methodologies could be developed to distinguish (besides already existing population groups) people with multiple homes, people who move between two or more places very often etc. With the information of these additional groups, rescue planning with this dashboard could get even more exact. The dashboard we have presented distinguishes between population groups that are common in regular situations - residents, workers, tourists etc. Through cooperation of rescue workers and scientific community new groups - corresponding in particular to disaster situations, could potentially be identified.

These policy recommendations would help crisis managers to reach better level of preparedness, stable trust in MPD usage in the future and therefore also to reach the goals of the BuildERS project.

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9. Annexes

Annex 1. Validation questionnaire for the end-users

Background information

Background information is used to evaluate if the tool or technology is seen differently by different type of users. In addition, purpose is to find out, what tool or technology was used and whether the tool or technology was used or only demonstrated to respondent.

Do you represent:

- Citizen / individual user
- Non-governmental organisation (NGO)
- Municipality
- Local authority
- Government
- Rescue organisation
- Police or border control
- Industry
- University / research organisation
- Education, shools
- Other (specify

2. Which of the technologies or tools you are evaluating?

Select the option that represents the tool or technology that you are evaluating. All questions will be related to the selected technology.

- Estonia: mobile positioning
- Other, please name or describe the tool or technology

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3. Have you used the technology or tool in question?

- Yes
- No

Usability of the tool or technology

Purpose of the following questions is to evaluate user experience and usability of the tool and thus, the technology readiness level, too.

4. Please indicate your opinions of the tool or technology, in regard to the following statements (from 1: strongly disagree to 5: strongly agree)

	1 (Strongly disagree	2	3	4	5 (Strongly agree)	I do not know
The tool or technology is effective in achieving its purpose						
Regular use of the tool or technology would be efficient use of resources (such as money or working time)						
The tool or technology should be adopted to regular use in my country						
I would be willing to use the tool or technology again						

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The technology or tool is easy to use						
There are clear instructions how to use the tool or technology						
The tool or technology is suitable for civil protection						
The tool or technology is suitable for crisis management						
The tool or technology is suitable for Disaster Risk Reduction (DRR)						
The technology or tool is accessible*						

* Accessible means that website and mobile dashboards and their contents are such that anyone could use them and understand what is meant in them.

Perceived risks or challenges of the tool or technology

Following questions are used to evaluate potential risks and challenges related to implementation of the tool or technology.

5. Please indicate your opinions on the risks and challenges potentially related to the tool or technology, in regard to the following statements (from 1: strongly disagree to 5: strongly agree)

	1 (Strongly disagree	2	3	4	5 (Strongly agree)	I do not know

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Benefits of the tool or technology are unclear						
The costs of the tool or technology are unclear						
The costs of implementation are too high compared to the benefits						
The operating costs are too high compared to benefits						
Technological maturity of the tool or technology is not sufficient for practical use						
Implementation of the tool or use og the technology is prevented by regulatory barriers						
Vulnerable groups may be affected in an adverse way						
Acceptance of the tool or technology by the general public is unclear						
Acceptance of the tool or technology by general public is not likely						

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The tool or technology violates privacy or otherwise does not meet applicable data protection requirements						

Ethical acceptability of the tool or technology

Following questions are used to evaluate ethical aspects regarding the tool or technology. Purpose ise to find out if the usage of the tool or technology might have negative impact on lives of individuals.

6. How likely is it that the following risks will be realised when the tool or technology is used? Please state your opinion on following risks (on the scale from 1: Very unlikely to 5: Certain)

	1 Very unlikely	2 Unlikely	3 Likely	4 Very likely	5 Certain	Do not know
Discrimination of individuals						
Deprivation of personal autonomy of an individual person						
Infringement of privacy						
Abuse of a relationship of trust						
Causing personal disadvantage for an individual person						
Stigmatisation of individuals						

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Inequality of individuals						
Inequality of different groups of people						
No freedom of choice to opt-out of the use of the tool or technology						
Restriction of individual's life						
Security of personal data is compromised						
Collection of non-essential personal data						
Automatic profiling						
Accessibility* requirements will not be met						

*Accessibility means that websites and mobile dashboards and their contents are such that anyone could use them and understand what is meant in them.

7. How significant are the negative impacts to an individual or a group if the following risks related to the technology or tool are realised? Please state your opinion on the following risks (on the scale from 1: Very minor to 5: Very serious)

	1 (Very minor)	2 Minor	3 Moderate	4 Serious	5 Very serious	Do not know

Discrimination of individuals						
Deprivation of personal autonomy of an individual person						
Infringement of privacy						
Abuse of a relationship of trust						
Causing personal disadvantage for an individual person						
Stigmatisation of individuals						
Inequality of individuals						
Inequality of different groups of people						
No freedom of choice to opt-out of the use of the tool or technology						
Restriction of individual's life						
Security of personal data is compromised						

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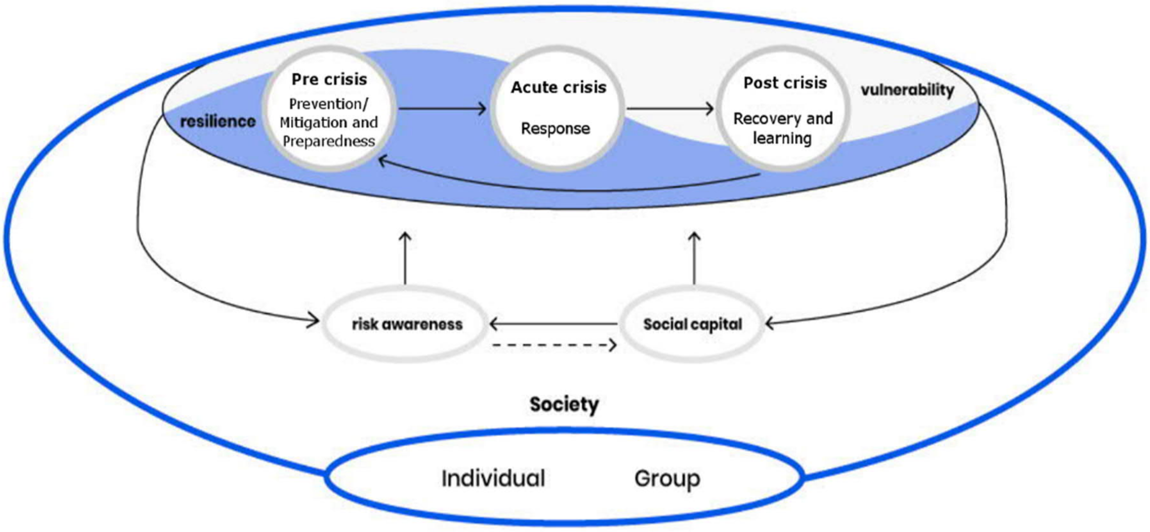
Collection of non-essential personal data						
Automatic profiling						
Accessibility* requirements will not be met						

*Accessibility means that websites and mobile dashboards and their contents are such that anyone could use them and understand what is meant in them.

BuildERS model

The section includes questions regarding the tool or technology in the context of BuildERS model.

BuildERS model is described below.



Before crisis (prevention, preparedness), acute crisis (response), after the crisis (recovery, learning). Reslience impacts more before risk and during the risk. Vulnerability increases during the crisis and is highest immediately after the crisis. Risk awareness and social capital affect fundamentally to reslience and vulnerability of individuals, groups and society. By learning from crisises and preparing to them, it is possible to increase risk awareness and social capital.

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This section includes special terminology of BuildERS project. The terminology is described below

Resilience: Processes of proactive and/or reactive patterned adjustment and adaptation and change enacted in everyday life, but, in particular, in the face of risks, crises and disasters. (BuildERS definition)

Risk awareness: Collective (groups and communities) acknowledgment about a risk and potential risk preventing and mitigating actions, fostered by risk communication. (BuildERS definition)

Social capital: Networks, norms, values and trust that entities (individuals, groups, society) have available and which may offer resources for mutual advantage and support and for facilitating coordination and cooperation in case of crisis and disasters. (BuildERS definition)

Vulnerability: Dynamic characteristic of entities (individuals, groups, society) of being susceptible to harm or loss, which manifests as situational inability (or weakness) to access adequate resources and means of protection to anticipate, cope with, recover and learn from the impact of natural or man-made hazards. (BuildERS definition)

8. In which phases of the crisis management or emergency management circle (BuildERS-model) is the technology or tool relevant? Please, express your opinion with a number from 1 (Not relevant at all) to 5 (Highly relevant).

	1 Not relevant at all	2	3	4	5 Highly relevant	Do not know
In the Pre-crisis (prevention / mitigation and preparation)						
In the Acute crisis (response)						
In the Post-crisis (recovery / learning)						

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Other possibilities? Please specify						

9. Please indicate your opinion on the scope of the technology or tool. Please, state your agreement with the statements from 1 (strongly disagree) to 5 (strongly agree).

	1 (Strongly disagree	2	3	4	5 Strongly agree	Do not know
The technology can be used to improve the protection of Individual citizen in crisis						
The technology can be used to improve the protection of Specific groups in crisis						
The technology can be used to improve the protection of the Whole society in crisis						

10. How does the technology or tool contribute to resilience building in a crisis? Please indicate whether you agree with the following statements, from 1 (Strongly disagree) to 5 (Strongly agree).

	1 (Strongly	2	3	4	5 Strongly agree	Do not know

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	disagr ee					
The use of the technology / tool can improve risk perception of an individual citizen						
The use of the technology / tool can improve risk awareness of specific groups						
The technology / tool is beneficial for society at large in terms of improved risk awareness and social capital						
The use of the technology / tool can improve social capital of individual citizen						
The use of the technology / tool can improve social capital of specific groups						

Technical readiness of the tool or technology

These questions are used to evaluate the Technology Readiness Level (TRL) of the tool. TRL is a method for estimating the maturity of technologies. The purpose is to determine the level of development to guide authorities and others in selection of suitable tools for Disaster Risk Reduction (DRR).

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	1 (Strongly disagree	2	3	4	5 Strongly agree	Do not know
The technology or tool provides the functionality you expect						
The technology or tool operates in a reliable manner						
The technology or tool requires further development to be relevant for practical use						
A prototype of the technology or tool has been implemented and validated in relevant environment						
Technical feasibility of the tool or technology has been fully demonstrated						
The tool or technology has been demonstrated in real operational environment						
The tool or technology has been accepted for practical use (by at least one intended user)						

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The technology or tool has been utilised in real operating environment for its intended purpose						
The technology or tool is available on the market for large-scale deployment						
The technology or tool meets applicable accessibility* requirements						

*Accessibility means that websites and mobile dashboards and their contents are such that anyone could use them and understand what is meant in them.

12. Free word

Here you can stat e.g. how you would develop or improve technology or tool in question.

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Annex 2. Tabletop exercise tasks

EXERCISE 1

Aim of the exercise

Using mobile data to analyse the behaviour of people after issuing warnings and to identify vulnerable people during a storm (storm warnings in South-East Estonia on 27 October can be compared with 18 December warnings).

Background and chronology:

The Estonian Weather Service issued the following warnings:

- 7:05 – 27.10 around noon the wind speeds will grow in the Gulf of Riga area, in the afternoon also in the southern corner of mainland with gusts of 15-20 m/s from SW and W, and in the evening the wind will turn NW.
- 14:30 - 27.10 continuing SW and W wind in Saare and Pärnu counties with gusts of 18-25 m/s and up to 30 m/s on the coast. In the next three hours the wind speed in South Estonia will increase, with gusts of 18-25 m/s. In the evening the wind will turn NW.

Estonian Rescue Board's perspective of the situation and public safety announcement:

- Approx. 16:00 – the chief operating officer in Viljandi called the standby press to notify of a high number of emergency calls and of the need to proritise response calls. The press was to give a public safety announcement to notify the public that moving outdoors is dangerous.
- Approx. 17.00 – the chief operating officer in Tartu went to the public safety answering point (Tartu P5) to assist in managing the overview of responding to emergency events.
- 17:16 – Estonian Rescue Board's press representative issued the following press release: „Due to the storm there are fallen trees on roads across Estonia. The Rescue Board recommends to avoid travelling by car if possible. Today's storm has broken a large number of trees across the country and made the roads impassable. Many households are already without electricity, the number could increase. (...) We have added recommendations on how to move about during the storm and to prepare for loss of power.
- 18:50 – The standby press received info about a person injured by a tree that was broken in by the wind in Räpina. Making a Twitter post (tweet) – do not move outside.

Task:

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- Did the warnings issued by the Estonian Weather Service and the Estonian Rescue Board influence people's behaviour? Analyse whether people's mobility during a storm warning differs from the regular (no storm) situation.

- How many people were endangered during the storm (did not follow warnings of not travelling by car)?

- Analyse if it is possible to identify people's mobility during the active time of the storm and whether it differs from other periods. Is it possible to identify different groups (locals, workers, tourists, etc.)?

- Which population groups are the most vulnerable and how many are in those groups? Which groups should be considered most during rescue?

Discussion:

- Does the data enable to assess people's preferred behaviour during risk assessment (stay at home, move to home, move to secondary home, etc.)?

- Does the historical data from a real crisis example enable to better predict people's behaviour during a storm during risk assessment and the plan interventions?

EXERCISE 2

Aim of the exercise

Using mobile data the analyse the number and mobility of people impacted by a power outage (storm in South-East Estonia on 27 October, can be compared to the power outage in Saaremaa (Saare county) on 9 January).

Background and chronology:

- The town of Võru experienced a power outage on 27 October at 16:32.

- At 18:24 the maximum number of households in Estonia without power was 64 717.

- On 28 October at 1:35 the power had been completely restore in Võru.

- On the morning of 28 October there were a total of 32 000 clients without power across Estonia.

- Trees had fallen onto roads in many areas of South-East Estonia and many roads were impassable.

Task:

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- How many people in Võru were impacted by the power outage? What is the number and location of people in the crisis area? How does it fluctuate during different periods (working day vs weekend, seasons)?
- How many different types of population groups were in the crisis area (local residents, tourists, workers, etc.)?
- Which groups were most impacted by the power outage? Which group should receive more attention in crisis management?
- How many people have a secondary home outside of Võru county?
- How many people moved away from the crisis area during the power outage?

Discussion:

- Does the analysis of mobile data from previous crises help to make a better quality risk assessment? – continuity of vital services
- Does using historical mobile data give additional value to solving a crisis during its active phase – the predicted whereabouts of residents and their mobility, and planning evacuation based on this information?
- Would data that is a week, month, 9 months (exact time period is not important) old be suitable to answer these questions? If during the October storm you only had access to the data from the first six months of the year, which month's data would you look at to get an overview of the situation?

EXERCISE 3

Aim of the exercise

Using mobile data to analyse the continuity of mobile communications and the vulnerable groups that emerge when communications are cut off (warnings for the storm in South-East Estonia on 27 October, can be compared to the power outage in Saaremaa (Saare county) on 9 January).

Background and chronology:

- The the town of Võru experienced a power outage on 27 October at 16:32.
- Due to the power outage and the immediate effects of the storm the area experienced mobile communications and data interruptioms.
- Disruptions to the continuity of mobile communications in South-East Estonia continued until the restoration of power in the area (about 1 week).

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Task:

- How long did it take for the power outage to have an effect on mobile communications (assessment of the continuity peeriod during a crisis)?
- How long were people reachable by mobile phone (ability to call for help, state can send warnings via SMS)?
- How many people lost cellular service? How many did not?
- How many different types of population groups were in the crisis area?
- Which population groups were impacted most by the mobile communications disruption (local residents, tourists, workers, etc.)? Which group should receive more attention in crisis management?
- From what time and in which areas are people without cellular reception and require other forms of communication and visits from social workers?
- Did the use of mobile communications come alive/activate during the power outage?

Discussion:

- What information about potential vulnerable groups in emergency situations can you get from mobile positioning data from the time of previous crises? (power outage, cellular reception, communications)
- What info about people's whereabouts and mobility can be considered in risk analyses?

EXERCISE 4

Aim of the exercise

Using mobile data to analyse the mobility of people during mass gatherings – number of people, mobility pathways, unexpected evacuatin planning, etc. (Tartu Ski Marathon, multinational defense exercise Kevadtorm (Spring Storm), Metallica concert)

Background and chronology:

- 17 February 2019 – Tartu Ski Marathon. At 9.00 start onto the 63 km track. The initial strong wind warning is changed at 9:30 by the Estonian Weather Service to a level 2 snow storm warning, which is expected to reach the area in about 1.5h (at 11:00).

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- 29 April – 17 May 2019 –Spring Storm and mobility connected to it. Ida- and Lääne-Viru counties, but also Harju and Jõgeva counties. Estonian Transport Administration announces extraordinary weather conditions and the need to plan road maintenance for mobility.
- 18 July 2019 – Metallica concert in Tartu at the Raadi airfield. The storage area of tyres at Raadi is set extensively on fire and the wind carries smoke from the City of Tartu and towards the Estonian National Museum (behind which the concert will be held). It is necessary to cancel the event and prepare for the evacuation of the residents of Tartu.

Task:

- Spring Storm – how much info does mobile data show about the arrival of participants to the military exercise and the mobility of participating units? Is it possible to identify the mobility of foreign nationals?
- Tartu Ski Marathon – how much info does mobile data show about the arrival of participants to the marathon? Do we get an overview of the general location of the mass of participants at our chosen time to plan further actions (muster points, exit routes, etc.)? Is it possible to identify the mobility of foreign nationals? How much does the population in the area change, and what is their mobility like before and after the marathon – home-marathon-home or staying in the marathon area for longer?
- Metallica concert – pattern of visitor arrival and departure, number of foreign visitors and their mobility (pattern of arrival and departure). How long does it take to evacuate the Estonian National Museum area? Planning evacuation for foreign visitors.
- Does mobile positioning data give additional information to plan the evacuation?

Discussion:

- What kind of information can be obtained from mobile positioning data to plan the evacuation of residents?
- What kind of information can be obtained from historical data to prepare for the protection of tourists?

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