

Title: *If things do go wrong: crisis management versus national traffic management in the event of extreme flooding in The Netherlands*

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If things do go wrong: crisis management versus national traffic management in the event of extreme flooding in The Netherlands

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Abstract. The exercise Waterproef in November 2008 was the first national exercise for flooding in The Netherlands, organized by the ministry of Interior and Kingdom Relations and the Ministry of Public Works, Transportation and Water Management. The decision on possible strategies for evacuation and the implementation of nation-wide traffic management was one of the main topics in the exercise Waterproef. National and regional organizations including the national traffic management centre took part in the exercise. This article discusses the relation between optimal use of the road capacity for preventive evacuation and traffic management during evacuation related to crisis management. The exercise Waterproef is used as a case study as well as the preparation for emergency planning. Crisis management is defined as the decision making process during the period of possible flooding. The tension between traffic management experts and crisis managers is addressed. Finally it is concluded that the optimal strategy for traffic management is not equal to optimal crisis management.

Keywords. Evacuation, exercise, traffic-management, crisis-management, decision-making.

Introduction

A mass evacuation in The Netherlands can be caused by several threats. At the moment, the preparation for a mass evacuation in the event of possible flood is very topical, but scenarios of terrorism or nuclear accidents are possible scenarios as well. We used the definition of evacuation as described by Kolen et al. [1]. Evacuation caused by potential flooding from storm surge or extreme water levels on rivers by far exceed the size of the evacuation caused by other disasters in The Netherlands [2]. The Ministry of Interior has an emergency plan which describes the roles of all national organizations in a case of mass evacuation. The need for preparation for mass evacuation is addressed in the program 'National Security' [3]. This resulted in the conclusion of the Dutch Parliament that a total preventive evacuation for coastal areas is impossible in a time span of 48 hours before a dike breach [4]. More attention should be paid to support and improve self-reliance and the role of national coordination in the event of mass evacuation.

In the Netherlands we have limited experience with mass evacuation. The most recent mass evacuations were the evacuation due to the flooding of Zeeland in 1953 and the preventive evacuation caused by extreme water levels on the River Meuse in 1995, where the dikes subsequently turned out to be strong enough. Since 1995, the maintenance and strength of the Dutch dikes has improved. The safety level of The Dutch protection for flooding is high compared to other countries; these are shown in Fig. 1.

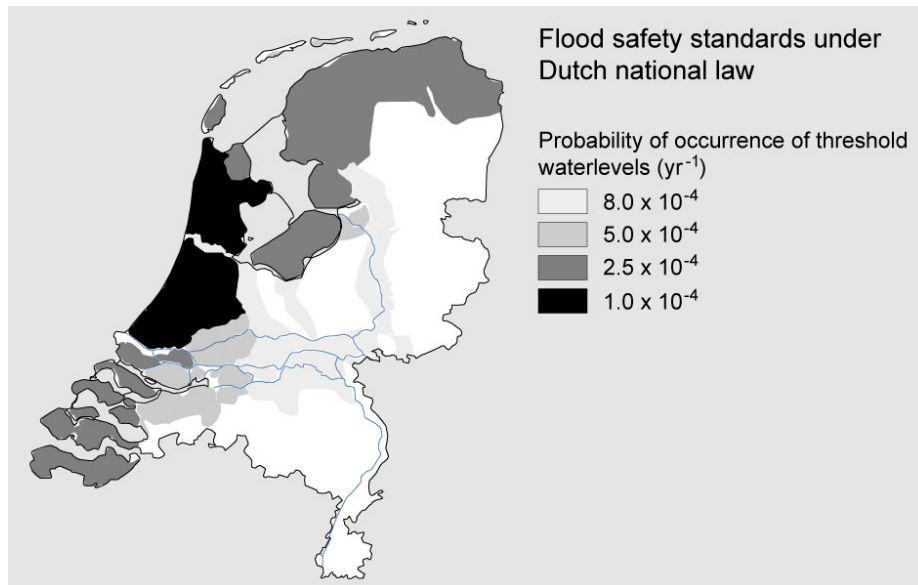


Fig. 1. Safety Standards

Although about two third of The Netherlands is protected from flooding by dikes and dunes, the perception of risk due to flooding is low and equal to other natural disasters [5-7]. Other research done by NIPO [8] shows a higher perception for flooding than other natural hazards, but this research was done directly after Katrina hit New Orleans and resulted in a lot of political attention in The Netherlands.

Evaluation of the Dutch policy on water safety also addressed the need for better flood preparation [9]. In 2006, the Ministry of Interior and the Ministry of Public Works, Transportation and Water Management ordered a Taskforce Management Flooding to improve the emergency planning for flooding and to organize a National Exercise called Waterproof [10]. Before the exercise, safety regions were supported to improve the preparation (emergency planning, training and exercise) for flooding. Almost all safety regions (23 of 25) improved their emergency planning [11].

Coordination of a large-scale evacuation is crucial with respect to autonomic behaviour of civilians and organizations, the local and national governments involved and the available infrastructure. This means that cooperation between national, regional and local governments, who anticipate (or have influence on) the behaviour of companies and civilians, is necessary. Expectations of a successful evacuation are extremely high, but at the same time it is impossible to predict the exact outcome of an evacuation. This is caused by the unknown development of the threat in time, by the unknown behaviour and perception of the people who will evacuate and use the road system, and by several types of accidents which are foreseen to happen but cannot be planned. During the preparation phase planners have to work with uncertainties such as the available time, cooperation between organizations,

implementation of decisions and public behaviour. During the decision making process in a time of crisis these uncertainties are still present, and are combined with the (lack of) information and relations between organizations, people and their belongings.

Objective of this article

An important aspect in the potential outcome of an evacuation strategy is the autonomic behaviour of people and organizations. The population of a threatened area will not act solely on information from the government [1]. Research [12] shows that the behaviour of people is based on rational analyses, which every individual makes based on the available information and their values. This means that they will use the roads, possibly cause traffic jams and hence reduce the capacity and travel times for emergency services and other road users. This also means that the government should be able to anticipate on possible effects to ensure that desirable strategies are still possible in the following days. They have to make sure that future options will still be available, and if not, to take timely action.

This article describes the process of emergency planning related to national traffic management before the exercise Waterproof and defines lessons learned during the exercise Waterproof.

This paper is the third part of a triptych. In the first paper [1] we describe the influence of the road capacity on several strategies for evacuation and the relation with the decision making process. In the second paper [13] we focus on the models we used.

National emergency planning for evacuation

Compared to other countries, for example New Orleans in the United States, mass evacuation is less common in the Netherlands. In New Orleans, emergency planning for evacuation can be tested and evaluated by decision makers and public in real events (Hurricane Ivan, Katrina, Rita, Gustav) together with exercises (for example PAM). Because of the high safety standards in The Netherlands, we lack the experience and because of the high safety levels in the Netherlands, we have to use planning and exercises to be prepared while assuming a real-live exercise with about a million people to be impossible.

During the recent preparation of national (strategic) emergency planning for flood events, the question how often a government could decide on an evacuation and still be reliable was addressed. The national alarm system (early warning) for potential floods and the role of the National Coordination Commission Flooding had been updated every ten years in order to evaluate forecasts of possible extreme water levels. 1 in 10 situations is expected to be so extreme that a possible evacuation might

be evaluated. One in 10 (river) or 1 in 100 (coast) situations will result in a possible flood event [14]. For the public this means an evacuation will be a once in a lifetime experience. Experts evaluating forecasts will do it more often in their career because of analyzing forecasts. For decision makers it might be part of their career or not, depending on the period they are in charge. If decision making is required for a flood and evacuation event, the roles of national organizations are described in a national emergency planning for flooding [15], an emergency plan for evacuation [2] and translated to a operational timeline based on the scenario of Waterproef [16].

The National Operation Centre prepared an operation plan [17] for evacuation to support the Dutch situation with 'National Operational Staff'. It is important to state that the developed process of operational evacuation planning at the traffic management centre followed the processes of daily traffic management. The National Operational Staff is not an official part of the crisis structure, though they did participate in this exercise on an experimental base. The National Traffic Centre was part of this staff that directly informed the strategic crisis teams and the Minister of Interior.

As a part of a National Operational Emergency Plan for evacuation a National Concept Traffic Management was developed [18] by the National Traffic Centre which is part of the Ministry of Public Works, Transportation and Water Management. The National Operational Emergency Plan for evacuation was especially developed for the preparation of the exercise Waterproef, using the national strategic planning and existing regional planning which was still under construction [16].

National Concept Traffic Management

The National Concept Traffic Management only focuses on the Dutch Highway system. The entire highway system is predefined in connecting origin, route and destination. The Dutch complex road system with a lot of entry en exit points will be transformed to a more simple system for evacuation. This form of traffic management does not only focus on the threatened area itself but also on the surrounding areas. Experience from New Orleans where the contra flow system needed measures in the state of Louisiana and in Mississippi [19] to guarantee the outflow, shows that this is necessary. The routes in the National Concept Traffic Management are logical routes for evacuees because as they are close to normal circumstances (day to day use) but crossings are limited. Intersections between highway crossings and crossing of highways with local roads are closed or adapted so as to prevent congestion. Contra flow is only introduced for emergency services using the lanes of highways normally used to enter the threatened area (Fig. 2). The extra traffic load and extra crossing because of emergency services are not taken into account.

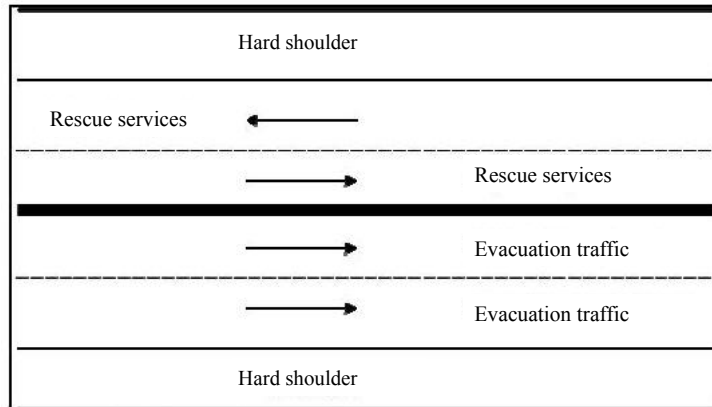


Fig. 2 Contra flow for emergency services using the lanes of highways normally used to enter the threatened area

The 'National Concept Traffic Management' describes the use of the highway system for evacuation. To prepare, support and decide on an evacuation, more activities need to be executed and decisions need to be made that does not fall under the responsibility of the National Traffic Centre. In addition, the decision to implement the 'National Concept Traffic Management' is a decision with mass impact; this decision will have to be made by the Minister of Interior and her crisis teams. These crisis teams will evaluate the consequences of the evacuation for the economy, vital infrastructure, social and political consequences using the risk assessment for flooding.

The National Concept Traffic Management has some characteristics:

- The concept is based on daily processes en daily operational handling
- Three zones: threatened zone, transport zone and destination zone
- The same configuration of highway-junction and ramps
- Logical routes (from the public's point of view) from threatened zone tot destination zone
- Concept can be phased and is scalable to larger and smaller evacuations
- Complete highway-traffic-network can be implemented in 8 hours during night-hours.
- The concept is communicated by mass media in a public-friendly manner

The entry points of the highway system are assumed to be controlled by regional governments (safety regions in cooperation with regional traffic centres). An amount of traffic is allowed up to the maximum level of road capacity. By regulation at entry points the likelihood of congestion can be minimized. This regulation and regional traffic management is a responsibility of safety regions.

At the start of the exercise, it was a known fact that the connection between national and regional planning was not finished yet. The exercise Waterproef was used the test existing planning and experience such a situation.

Implementation of the National Concept Traffic Management will be most efficient during night-time because roads are emptier. All measures can be implemented in a period of 8 hours. After decision making and during the implementation, the traffic strategy regarding routes etc. will be communicated by mass media, which is most effective during prime time in the evening. The message to the people will be combined with information from other organizations; the need for evacuation will also be addressed as well as the possibilities open to using public shelters. The total strategy of messages and communication is coordinated by the Ministry of Interior [20]. During implementation of traffic management the public will be able to prepare for evacuation and take preventive measures with regard to their belongings. Because the available time for preparation was communicated to the public, most of them will be at home at the start of an evacuation. If implementation during night-time and communication during prime time is not possible the whole process will take more time and will be less efficient.

To reach as many potential evacuees as possible, mass communication is needed and the optimal moment is assumed to be prime time in the evening. All measures can be implemented during the night, which also means the impact on traffic because of spontaneous evacuation could be kept to a minimum. Implementation during daytime will be less effective; more time is needed for transportation because of a higher density of traffic.

Case study 'Exercise Waterproof'

The objective of exercise Waterproof was to test the available emergency planning and organizations. During the exercise, several flood scenarios were tested for flooding in coastal, river and lake areas. Special attention was paid to reconstruction, aftercare and communication to the public. To total exercise took one complete week, together with preliminary exercises, it took about one and a half weeks.

The National Operational Staff in which The National Traffic Centre was involved participated in two scenarios (Fig. 3) on which this article is focussed:

- Storm surge: Potential extreme flooding in entire Dutch coastal area;
- Lake flood: Unexpected flood in Lake IJssel.

Waterproof, partners involved in the exercise

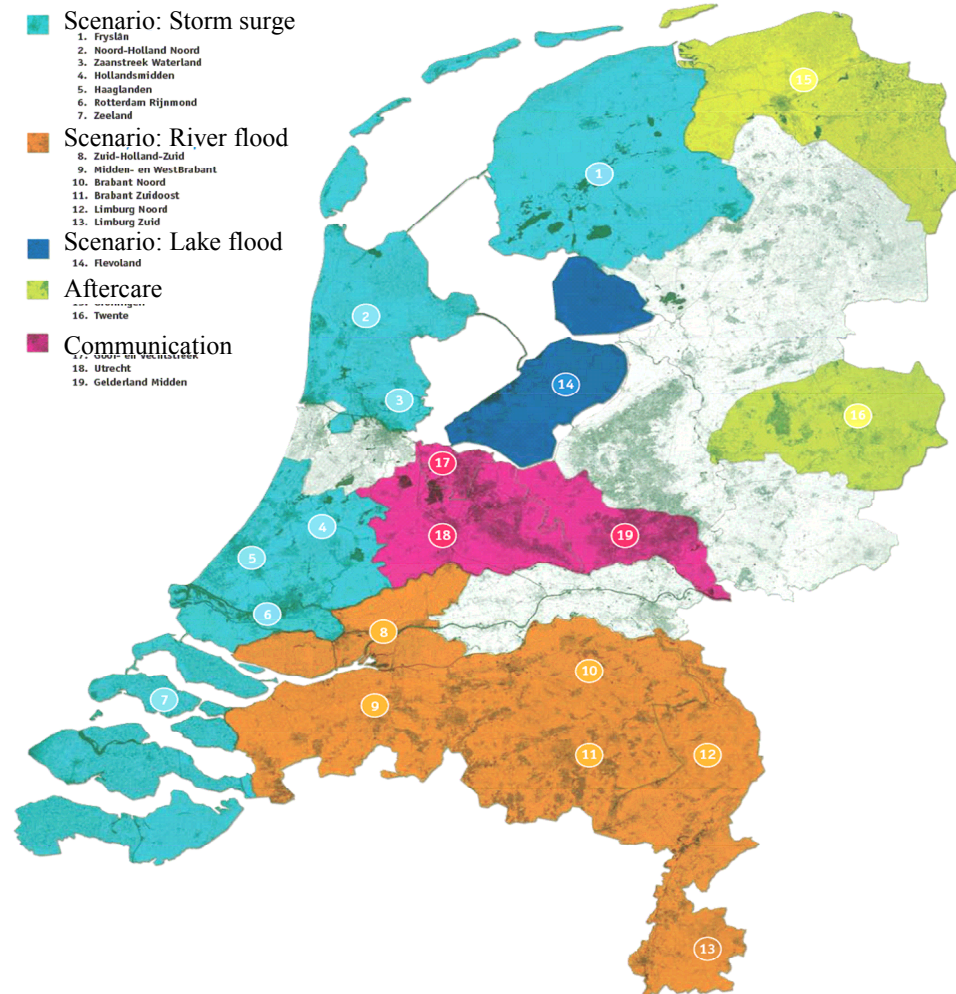


Fig. 3. Regions involved during all scenarios of exercise Waterproof

Scenario 1: Storm surge

A situation had been defined in which an approaching meteorological situation was identified 8 days in advance, which could end in a severe storm above the North Sea region. Although the probability was very low, the National Commission Flooding paid close attention to the situation. 2 days later the probability had increased to 10-15% and the Minister of Interior installed the National Planning Staff for evacuation

and requested that they, as well as the regions, start the emergency planning procedure. The exercise took place 2 days later, 4 days before a possible flood. The probability had increased up to 30% 5 days before possible flooding up to 40-45%¹ on the day of the exercise. At the start of the exercise the key question was if, and how they should evacuate. The threatened area at that moment in the exercise is presented in Fig. 4.

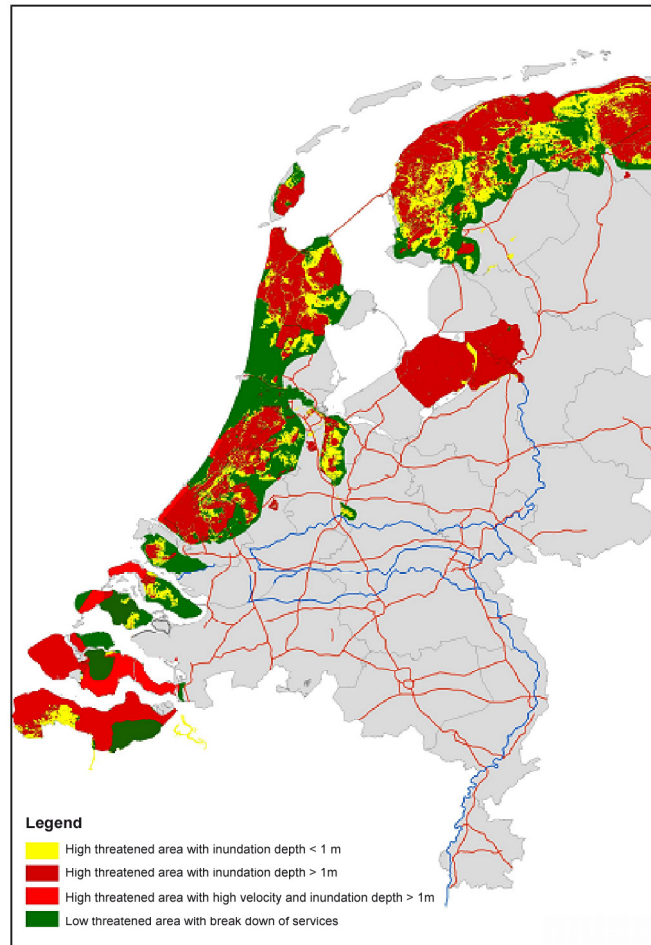


Fig. 4 Threatened area Waterproof, the red and yellow areas are the most threatened areas, the green area is not expected to flood but services will break down.

¹ For the exercise the probability had been upgraded to levels which are assumed to be higher than realistic. The available time was increased. This adjustment was made to make it possible for all participants to exercise a preventive evacuation and have the time needed for crisis management.

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During the exercise the National Traffic Centre advised the National Operational Staff about the potential capacity of the highway system (possible outflow but also consequences for other traffic outside the area which had to be evacuated the required resources and the subsequent consequences for the entire road system) and the National Operational Staff looked at different strategies for evacuation (from maximum preventive evacuation to minimum preventive evacuation).

The National Operational Staff presented three alternative strategies and their consequences for evacuation on a national scale. These were made using all available planning of safety regions that were threatened but also regions that were involved in facilitating transportation or offering public shelter. The consequences were estimated assuming decisions were made four days before a possible dike breach (with a 40-45% probability at that time)

1. Maximum preventive evacuation of most of the zone under the highest threat (Fig. 4); 2,000 casualties were expected in the event of dike breach; also the economy and society would be affected dramatically.
2. Minimum preventive evacuation of the zone under the highest threat if only the not self-supporting groups are evacuated (about 10% of the total population), others will hide. In the event of a flood 6,000 casualties are expected. Because of the visibility of the evacuation the strategy might be frustrated because of possible spontaneous evacuation. The consequences for the economy and society are expected to be less than those in the first alternative.
3. No preventive evacuation, everybody had to hide. In the event of a flood 10,000 casualties are expected.

By choosing for the first alternative, the National Concept Traffic Management also needed to be implemented. To implement the entire strategy before the next day (at a time of 05:00h) a decision had to be made before 17:00h. Implementation could start at 21:00 and would be combined with a public traffic alarm.

Safety regions inside the threatened area applied a lot of pressure to decide on evacuation as soon as possible. The different impact in each region, the different time requirements for evacuation (as shown by Kolen et al. [1]) and the controversies between regional and national interests caused a lot of discussion. The Minister of Interior organized a meeting during the exercise to explain the national strategy and reminded the regions to follow up agreements made in the national policy team of the Minister

During the exercise, the decision makers of the National Crisis Team decided to implement a preventive evacuation of only the non-self-supporting people inside the most threatened areas. A decision on evacuation of people who are assumed to be self-supporting or the evacuation of industrial animals was postponed to the next day. Actual forecasts showed that a few additional hours would be available before the start of the period with extreme wind speeds which was assumed to be the moment to end the evacuation.

Scenario 2: Unexpected flood in Lake IJssel

A scenario had been defined which led to high water levels caused by wind but flood risk was at a minimum. In the past days, a evacuation was a possible though no evacuation took place. Because of a weak spot in the Dike System alongside the deep polders next to the Lake IJssel, the Flevopolder flooded. During the exercise it took two hours from early warning to dike breach.

The National Traffic Centre took part to participate in the planning of the rescue operation and traffic management in the surroundings of the Flevopolder. The inflow of people to the Flevopolder could be reduced; so more space was available for rescue services.

Discussion

Decision making during crisis management is not conducive to creating the best opportunities for traffic management

A lot of stakeholders are part of the decision making process. Besides, to evacuate as many people as possible there are other elements to consider in the decision making process during a crises. Waterproof showed some clear examples:

- The National Concept Traffic Management is a 'best-case' scenario [1]. The decision to delay the total preventive evacuation because more time was available might be attractive from a political point of view. On the other hand, the risk that the strategy might not succeeded completely is accepted.
- Because of the delay, the implementation of the National Concept Traffic Management strategy might have to be implemented during daytime. This takes more time and is less efficient than it would be during night-time. Other consequences of implementation (traffic jams) might affect the preventive evacuation of non-self supporting people.
- Traffic measures only are not sufficient to evacuate all people. The mass-communication to the public is of great importance and needs to focus on behavioural aspects of public in threatened zone.

Almost every stakeholder depends on the transportation possibilities. If traffic jams occur, travel times will be longer, certainly where it concerns traffic management routes. This means that all stakeholders should think about the effects of these logistic problems related to business continuity (e.g. necessary equipment, employees for continuity of work processes, crisis teams, rubbish removal) and the effect off measures. New Orleans shows some good examples for electricity companies [21]. Possible measures should also be judged on opportunities for transportation.

In the Dutch situation, measures for continuity of vital services (Schiphol Airport, Rotterdam harbour, Supply of gas and electricity and Hospitals) equipment, supplies, waste removal and availability of employees might be needed for continuity. If they require transportation, they will be affected by evacuation. Adaptive measures can be taken to reduce the impact on business and the impact on the society. A (preventive) evacuation is such a measure to reduce possible loss of life. A Dutch example is the

(low scale) continuity of a glass-factory in [22] during the evacuation of the area of 'Rivierenland' during 1995. A New Orleans example in a hospital is described by Deichmann [23].

Because all stakeholders work in the same environment (they use the same roads) interaction is necessary. The actual and expected situations in traffic will be needed (decision making about several strategies requires this information for all these scenarios). Also the effects of measures and problems with business continuity should be translated in new expectations that should be basis for planning of all stakeholders.

Relation with public behaviour

Decisions to evacuate are made by the government but also by the public. The public will make the same evaluation using the information from the government as well as information from own resources. Decisions will be based on reflection to their own situation and their interpretation [12]. The government assumes that people (excluding the not self supporting) will drive to a safe place using their own transportation or public services. Whether the government's decision about evacuation succeeds depends largely on the response of the public. With Hurricane Katrina about 20% did not evacuate preventively from the city of New Orleans [19] where as in case the of Gustav, most people left the area (only 10,000 did not evacuate preventively [24]).

The evacuation strategy must be simple for road users, especially for The Netherlands where we lack experience with mass evacuation and such an event can be considered as a once in a life time experience. Road users will not be trained for such a situation in contrast with the example of the city of New Orleans with frequent evacuations. Strategies must be close to normal behaviour otherwise more people will choose their own path that may cause more traffic jams. The evacuation strategy is directly related to crisis communication and group dynamics.

The evacuation of only non-self supporting might trigger a spontaneous evacuation. This spontaneous evacuation could end in a situation that is already out of control because of giant traffic jams. Implementing an alternative strategy is difficult because time for transportation increases and communication to the public is more complex.

Decision making is to anticipate

To maximize the possible effect of traffic management, measures have to be taken before the start of an evacuation (whether is spontaneous, advised or obligatory). The decision maker will contentiously evaluate the uncertainty of the prediction and compare this with the possible impact of her decisions and possible public response. In cases of a delayed decision, for example when probability is very low, the response of business and public can create a new situation. This new situation will influence the necessary time required for each evacuation strategy and the possible outcome and loss of life in the event of flood.

The implementation of National Concept Traffic Management might be considered as a no regret measure that could be taken in an early stage, directly after detection.

Although implementation will result in an increase in traffic jams (for example equal to periods of road construction or snowfall in The Netherlands) it will also result in a better start situation in case of a real evacuation. Less time is needed for implementation after final decision making for preventive evacuation.

Framework of several prepared strategies for evacuation

Each strategy for evacuation needs a certain time frame; this is called the necessary or required time. The size of the threat also influences the necessary time because the size of the threat (high or extremely high water levels, one or multiple breaches) defines the area that is threatened. The available time is defined by the circumstances at that moment. Detection of the possible threat and assessment (sense making [25]) by decision makers is needed to start decision making or crisis management. Another element, which should be added, is the impact of roadwork which cannot be removed in time. During an evacuation less road capacity will be available.

Depending on the situation, flooding can occur with a lot of available time or almost no available time. The size of a flood can also be small or large. Several options for strategies of evacuation were defined During Waterproof. The consequences were calculated assuming decisions were made on D-4. In the case of a different threat or a different timeline, the consequences will be different. Other strategies might be more effective. Also the relation between the national strategy and the safety regions would result in different measures.

For use of scenarios during a crisis situation more scenarios are needed, combined in a framework that can be used during crisis. The consequences for uncertainties should also be taken in to account in a risk approach. This information can be used to develop more robust strategies that will be less affected by one or a few accidents.

Forecasting system for evacuation

Waterproof showed us that we have only made a start in preparation for evacuation. It also showed the relation between national en regional organisations. Both levels are necessary in the preparation and are related to each other. The Dutch highway system could be one of the common grounds for preparations because all stakeholders depend on these roads.

Crisis centres have information systems. Evacuation information systems (such as the 'National planning, monitor and training Module for Evacuation' [26]) will deliver better information about evacuation related parameters to the information centres of these crises centres but these systems have not been implemented yet. These evacuation information systems should be integrated with the information system of the crisis centres.

The possibility for developing forecasts for evacuation strategies on a national and regional scale (up to postcodes) during a crisis situation based on dynamic traffic (using dynamic traffic models) calculations and using actual information of the road network and the that, is a function that was addressed by the traffic and crisis managers as considered to be useful. This function is not available in models [27] which are used in the Netherlands as the macro scope models 'Evacuation calculator'

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[28], National planning, monitor and training Module for Evacuation, [26], DSS Escape [29] and more micro scope model BC Hydro [30]. The model which fits most close is the Evacuation training and exercise instrument SPOEL [31] but the current objective for this model is support in training and exercise or the experiment during Waterproef with the so called 'Warroom Rijkswaterstaat' [32] which combined flooding scenario's with the monitoring system for highways which is daily used.

Based on experiences gained during Waterproef, defined functionalities of evacuation forecast models are:

- Forecasting of the outcome and consequences of each strategy.
- Automatic comparison with alternative strategies (as defined by Kolen et al. in [1]) using different types of evacuation.
- Realistic planning assumptions have to be defined for evacuation. They should be based on a probabilistic approach, taking uncertainties into account.
- A presentation tool is needed to show results to non-experts.
- Calculation time should be limited
- Tools for analyses and reporting should be standardized and have to be customized for the role and responsibility of each user.
- Users should be able to define the consequences of lack of required external assistance.

Conclusion and Lessons learned

Further preparation is necessary to maximize the potential of traffic management and crisis management on national as well as regional scale. A connection should be made between regional and national organizations and the possibilities related to different strategies for evacuation should be investigated. A framework should be made using different scenarios (more or less time, small or large scale evacuation zone) and using different strategies for evacuation. Research is required to assess the impact of each strategy in a wider perspective than only infrastructure and resources. The consequences of perception (behaviour), crisis management, and cooperation between different organizations should also be taken into account as well as the influence of uncertainties.

Based on the experiences gained during the Waterproef exercise and the and preparation for the exercise, the knowledge of models and evacuation times for different strategies (with more or less available time [1]) the following lessons can be learned:

- The optimum of traffic management is not equal to the optimum of crisis management or the optimum of all actors involved.
- The evacuation strategy and traffic management must be clear to road users. Government decision makers should anticipate on public behaviour to make sure the implementation of measures is not affected.
- The traffic conditions (the actual, predicted future road capacity and possible measures which define travel times) have to be used by all stakeholders as basic information for planning and decision making.

- More alternative strategies for evacuation are necessary into a total framework that takes different sizes and timelines into account.
- More insight is needed into the effect of assumptions and the uncertainty of these assumptions.
- Evacuation forecast models should be developed and implemented to support decision making. These models should be connected to common information systems and exchange information.

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