KEM Research Question (max. 4 pages + annex)	
TITLE	**Vulnerability of infrastructures and the potential use of sensor information**

Objective

Information on the earthquake (location, intensity) and on the impact of it on (Infra-)structures is essential to asset owners and authorities in Groningen. Now this information is limited to KNMI shake maps produced within minutes of the earthquake. In the current HRA toolbox no infrastructures are taken into account. Information on the state and vulnerability of infrastructures is lacking for Groningen or at least scattered around between different owners. It is assumed furthermore that having sensors on infrastructures can improve the assessment of the impact of a future earthquake.

This project investigates the possibilities of including the infrastructures in the HRA model by assessing methods to determine the vulnerability of the infrastructures as well as investigates the potential of receiving relevant information from connecting (low cost) sensors to infrastructures. All together this will provide (near) real time information to stakeholders regarding the essential infrastructures in Groningen.

State of the art, background

Infrastructure vulnerability

For asset owners and authorities, it is important to have a full picture of the state of the infrastructures in the region of the earthquakes. This includes roads and bridges for transportation as well as underground structures such as gas pipes and other cables and pipelines that could be responsible for outbreaks of fires or that are necessary for communication purposes.

The vulnerability of the infrastructures in Groningen has previously been assessed on incidental basis for roads and bridges and on a more systematic basis for underground infrastructures such as pipelines. Also, vulnerability curves are available from world wide databases. What is currently missing is a Groningen specific overview of critical infrastructures necessary for the authorities to be able to respond efficiently to a potential earthquake. At the moment it is not possible to get a quick insight in the actual performance of the infrastructures and or the damages they might have suffered.

Seismic sensor networks

Groningen is covered by numerous high-quality seismic networks, managed mainly by KNMI and TNO. The network comprises of a mixture of broadband, short-period and strong-motion sensors of a wide variety of types. At this moment, the KNMI network is used to determine the ground response after a seismic event. Ground-motion fields, often referred to as shake-maps, are produced by interpolating the ground-motion parameters from observations (seismic records and macro seismic intensities). This data can be used by authorities to assess the amount of damage expected, but only in an indirect way, as no damage estimates are being determined automatically. Such shake-maps however can be fed into loss assessment tools to generate rapidly updated damage and loss maps of the affected area, using simplified and robust exposure models. Several new low-cost sensors are/have been developed recently, that could eventually increase the inputs and the resolution of the existing network and extend the network to detect the state of (infra)structures directly after an earthquake event.

Rapid Response to Earthquakes (RRE)

By combining a better insight in the vulnerability of infrastructures with sensor information, it is possible to detect the state of infrastructures directly after the earthquake. This information can be used by authorities in charge of disaster management to act rapidly and efficiently. Currently this is done based on a partial, qualitative and emotionally-biased knowledge of the situation in the field. RRE relies heavily on the near-real-time estimates of the earthquake location and characteristics (e.g. magnitude) to estimate the potential losses and the areas most affected by the event. At present, several loss estimation tools capable of estimating damage and possible casualties in near real-time already exist in the Euro-Mediterranean region, e.g. for Istanbul, Romania and Italy. In some cases, e.g. the port of Gioia Tauro in Italy, the system is set up also to support the functionality of the entire system of infrastructural elements. Potential disruptions of one (or more) elements due to an earthquake event may trigger a cascading (or domino) effects affecting the whole system. In Groningen, a real-time Rapid Response System is currently not in place. The potential for implementation of such a system is expected to be present, however the specific conditions of Groningen and its needs are currently unknown.

Research Question

Maximum 400 characters (what to be addressed and what not AND Link to KEM Research Agenda)

The potential to provide better information on the state and vulnerability of infrastructures to stakeholders in Groningen can only be realized if the following questions can be sufficiently answered:

1) Which infrastructures are most critical for authorities / first responders?
2) What are the most probable damage scenarios for infrastructures in Groningen?
3) What is the vulnerability of the relevant infrastructures in the area that are necessary for the first period (minutes, hours, days) after a large earthquake has occurred? This includes gas pipes, water, electricity cables and telecommunication.
4) How to integrate information about vulnerability of infrastructures to tackle cascading effects in the Groningen system?
5) Is it possible to gain relevant information from existing or specifically placed (low cost) sensors on infrastructural objects?
6) What kind of information related to the infrastructure is necessary, for whom (e.g. first responders and other operational parties), at what moment (after the event) and in which form?
7) How can infrastructures be taken into the HRA toolbox?

The focus of these questions is on the infrastructures, not on the other structures in Groningen. The hazard information and stakeholder needs include only those relevant for the infrastructure assessments. Additional research questions could be studied outside KEM34 related the hazard concerning the use of different types of sensors and the risk and scenario analysis for the stakeholder needs in wider sense. These are not part of the KEM34 questions.

Deliverables expected

Yearly progress reporting.

A) A report will be delivered on the vulnerability of a selection of the most critical infrastructures in Groningen (at this moment a bridge and a sluice are foreseen). The report will include recommendations on how to integrate and communicate the information on vulnerability of infrastructures in the Groningen systems (HRA toolbox) to authorities. Answers questions 2, 3 & 4.

B) Sensors will be installed on the pilot locations with critical infrastructures that are present within the main earthquake region. The sensors will be placed, and readings made publicly available through the KNMI network. The performance of the sensors will be followed for 1-2 years and a report on the performance will be delivered after this period. Answers questions 5.

C) A study will be performed into the needs of the stakeholders related to the availability of infrastructures in Groningen and towards the information needed for a rapid and efficient response. The study will be reported in a short memo that includes the needs of different stakeholders, the current systems in place and the potential for improving the systems for rapid response information. Answers questions 1, 6 & 7.

Timeline

Duration of the project is 3 years.

Expected use

The results of the study will be the basis for Groningen authorities (with main focus on the Veiligheidsregio Groningen) to improve their insight in the performance of infrastructures during and after an earthquake. The results will be linked to outcomes of the European TURNKEY project.

Expertise and tools preferred for the team

Technical knowledge on Dutch infrastructure safety assessments and regulations,
Technical knowledge of asset owners for the (structural) conditions of the pilot structures (RWS, Province of Groningen)
Experience in Dutch safety regions (Veiligheidsregio Groningen) and its organisation

Quality assurance, Organisational and communication requirements

Maximum 200 characters qc process, (review level, location, collaboration and meeting schedule wishes)
2 presentations per year for KEM