A practical Strategy to Reduce Earthquake Risk for Critical Infrastructure Systems

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Abstract

Unlike other natural hazards like slope instabilities, avalanches, floods etc., earthquakes affect large areas. Earthquakes happen unexpectedly, and all persons and structures in a whole region are affected at the same time. This leads to a widespread damage to the building stock and to human beings, as well to significant psychological stress also to those not physically harmed. This results in a lack of overview and confusions in the first hours to few days after an event.

For an efficient disaster response, emergency assistance and the following reconstruction efforts (and therefore for the economic recovery), an - at least partially - functioning infrastructure is mandatory. A first priority in the prevention activities should therefore be given to endeavours to protect the infrastructure system. As the experience show, authorities are aware of this fact, but do not know how to handle this task efficiently. That way prevention projects are started which often do not really lead to an fast and efficient improvement from the beginning.

Infrastructure systems like water supply and waste disposal, power supply, health systems and transport systems are wide and complex systems consisting of linear elements (e.g. main and distribution lines) and local elements (e.g. command centre, etc.) which are interconnected and with each element influencing the function of the others. The function of the whole system is influenced by all elements and depends not only on the behaviour of the structural elements, but also on power supply, communication, control systems, redundancies and the possibility of human intervention.

The individual infrastructure systems have different legal status. Some are directly government-owned (e.g. road systems), other are owned by utilities (which in turn are owned by individual or several Municipalities or private companies), other are directly controlled by local governments, and still other are private or belong to private/public partnerships. Often the result of this different legal status leads to unclear responsibilities and guidelines in respect of emergency requirements and of interfaces between the different infrastructure systems.

In case of an emergency, the public cannot expect that the infrastructure systems function as in normal times. Depending on the size of the emergency event, a so-called "reduced mode" of operation has to be accepted because of economic reasons. E.g., in case of a large event, it may be acceptable that the water supply will break down in low density residential areas, but it should still function in areas with high density (fire fighting) or industrial zones.

Generally, the utilities personnel has a very good knowledge and understanding of the characteristics of their systems with their weak and strong points, but are lacking the knowledge of the earthquake effects.

The following strategy has been successfully fully or partly implemented in several cases in practice. **It aims to enable a predefined functionality of the entire system in a predefined scenario event.** Based on a threefold triage, the elements of the system which need an improvement of their functional capacity are identified. Thus a substantial enhancement of the function in case of an earthquake event can be efficiently achieved from the beginning. With this concept the responsible authorities are able to prepare a long-term investment planning, taking into account their financial capabilities.

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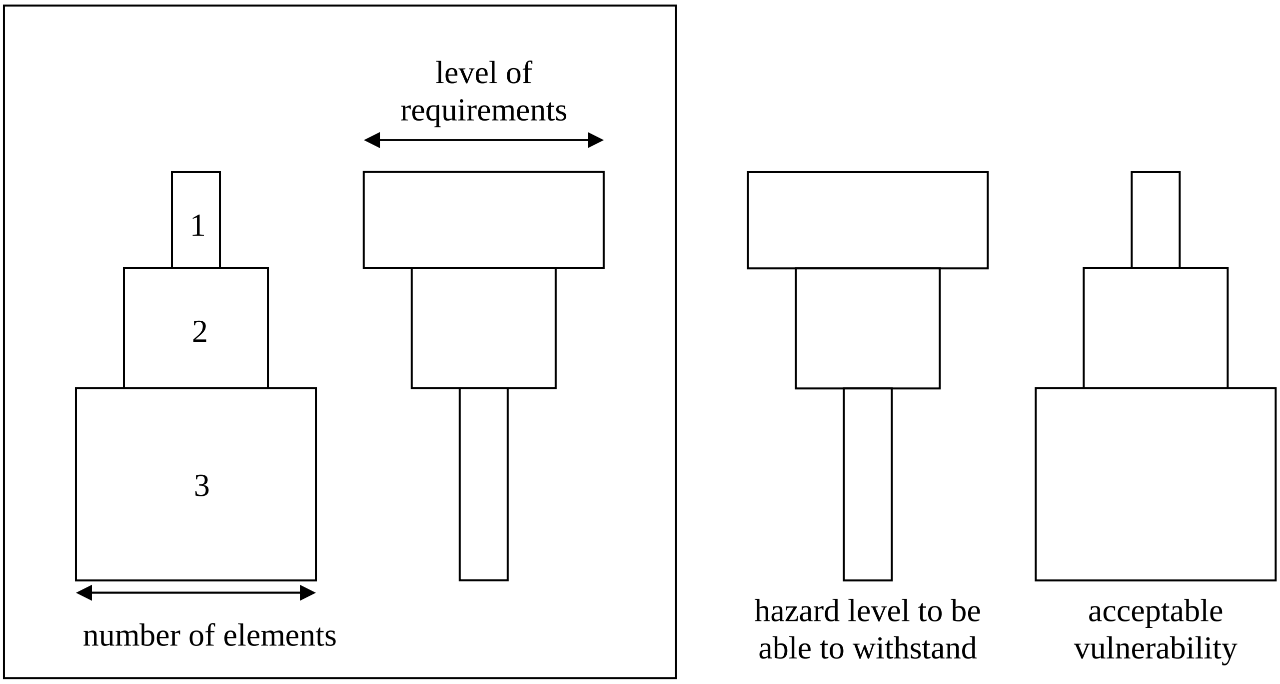
The paper describes in more detail the following procedure and the criteria for individual decisions:

1. The owner of the utility has to define an acceptable “reduced mode of operation” of its system for individual earthquake scenarios (e.g. event with return period of 500 years and a very seldom event). This is a political decision.
2. Segmenting the system in individual elements (linear and local elements) and defining their importance in respect to the functioning of the whole system (Triage 1). This will lead to few elements whose function will be mandatory for achieving the reduced mode, and a larger number of elements with lower importance. See also Figure 1 (importance classes).
3. Triage procedure 2 for the essential elements. Individual estimate of the local earthquake hazard (taking into account local geotechnical conditions and topography) and vulnerability of each element based on different indicators (geotechnical, structural, power communication related, etc.). Grouping in three classes "ok" (no further action needed", "not o.k." and "uncertain". See also Figure 2.
4. Triage procedure 3 for elements in the group "uncertain" and "not ok". Individual assessment of the local earthquake hazard (taking into account local geotechnical conditions and topography) and vulnerability of each element based on different checklists and simple calculations. Grouping in two classes "ok" (no further action needed" and "upgrade needed". See also Figure 2.
5. Upgrade concept for class “upgrade needed” and program for realisation.
6. Iterate the points 3 to 5 for the “important elements”.
7. If needed, also some investigations for selected “less important elements”.



Legend:
1 “essential elements”
2 “important elements”
3 “less important elements”

Figure 1: Importance classes and their acceptable vulnerabilities for a selected hazard level

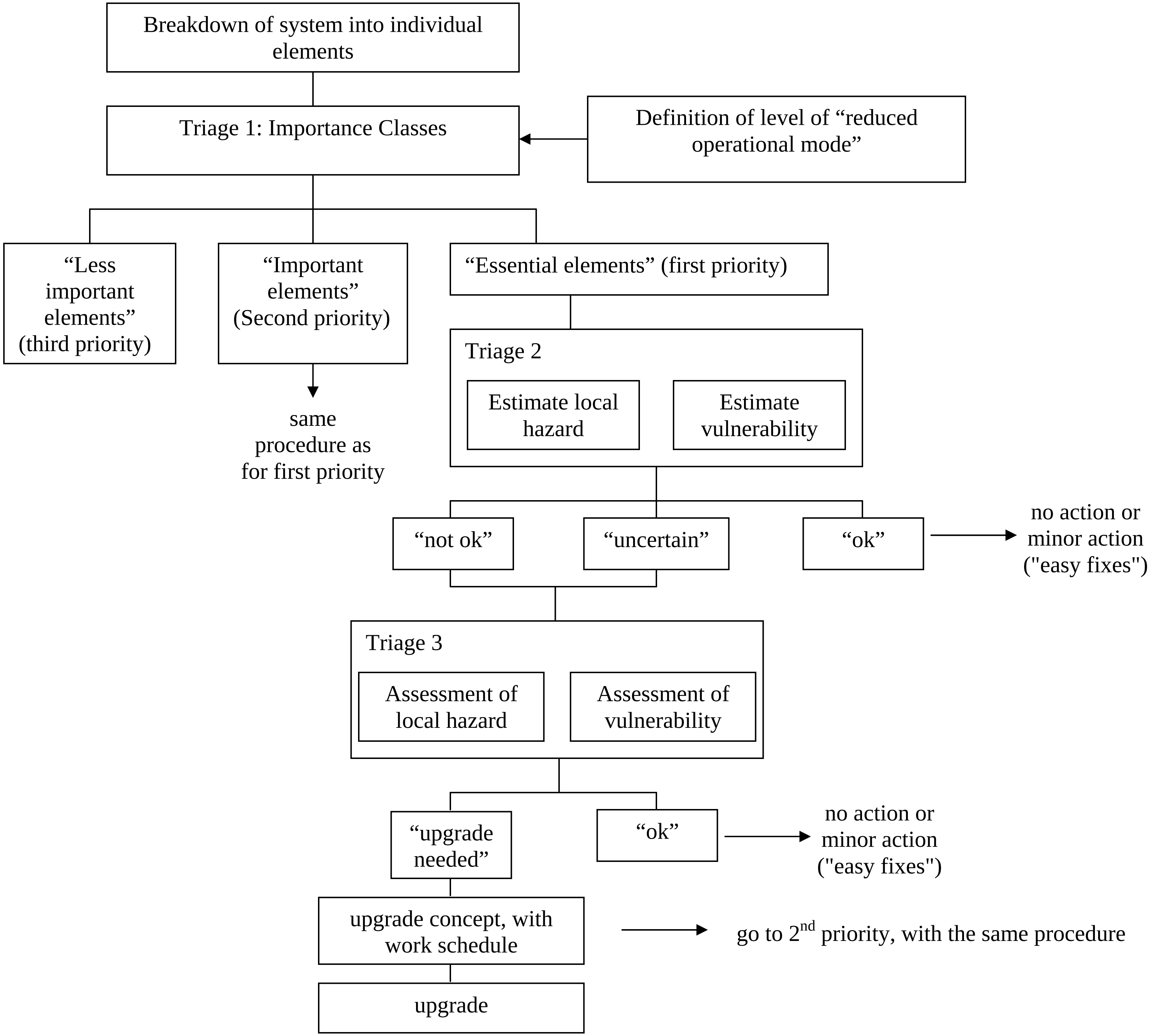


Figure 2: Triage procedure