Comparing and contrasting infrastructure resilience

– *Analyzing Swedish critical infrastructures with one approach*

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Critical Infrastructure Resilience **is becoming a hot topic, highlighting the importance of resilient infrastructures and its effect on societal safety. A large amount of the research published on this topic is trying to figure out how to measure it. So are we! We have analysed and compared the resilience levels of different types of infrastructures in Sweden by utilising interruption data. A generic resilience assessment approach has been successfully developed and applied on collected interruption data from six infrastructures with promising results.**

Today's modern societies are critically *dependent* on vital societal functions, e.g. availability of *electricity, tap water* and *internet*. Some of these functions are so important that if interruptions occur, the consequences can be devastating; thus, the infrastructures providing these functions are of equal importance. *Critical infrastructures* are infrastructures which a nation's economy, security and social well-being are critically dependent on and makes up the backbone of societies. So, it is of great importance to ensure their functioning and to make them *resilient,* i.e. improving 'a system's ability to cope with and recover from stress'.

To operationalize a concept such as resilience, one way is to develop a quantitative method to measure it. Quantification enables objective discussions and comparisons, which can be used as information for policymakers or public bodies as a basis for discussions and decision making. In this work, an approach is developed to assess and compare *Critical Infrastructure Resilience* by analysing empirical interruption data from Swedish critical infrastructures. Two properties typically associated with the resilience of engineered systems are: loss of system functionality and duration of this loss. These properties can be derived from empirical interruption data. Hence, this type of real-life data was collected for six different types of technical critical infrastructures: Electricity Transmission, Electricity Distribution, Transport Road, Transport Railway, Telecommunication and Water Supply. Some of the data spans over a time period of over 10 years and stems from a large amount of sub-infrastructures. We also tried to attain data from several other infrastructures, but this type of data is not systematically gathered by all infrastructures in a structured way. Hence, we hope that incentives for data gathering of interruptions will be implemented for more infrastructures, enabling assessing their resilience in the future with the developed approach.

In the resilience assessment approach, this interruption data is aggregated to a 'national system level', i.e. summing up individual sub-infrastructure into one 'national infrastructure', where all interruptions are evaluated equally and results in functionality loss for the overall infrastructure. This total sum of interruptions is used to depict the functionality loss and the duration for unmet service delivery over time. This is then used as a basis to analyse and evaluate the resilience for the different critical infrastructures.

The results reveal that the Electricity Transmission is most resilient (see Figure 1). While the least resilient, with a great margin, is Transport Railway. Second least is Electricity Distribution. The rest of the studied infrastructures are slightly less resilient than Electricity Transmission, but rank all on a similar level. In general, it can be concluded that the level of resilience for the studied infrastructures is very high. In future work, the approach can be combined with other resilience oriented methods for further analyses to enable more in-depth conclusions. The results could also potentially be used assess the degree of interdependencies between critical infrastructures. In summary, the approach can be used, in a unified manner, to measure and compare resilience for critical technical infrastructures. With more specific data and additional analyses, we believe the opportunities for further uses of the method are plenty.

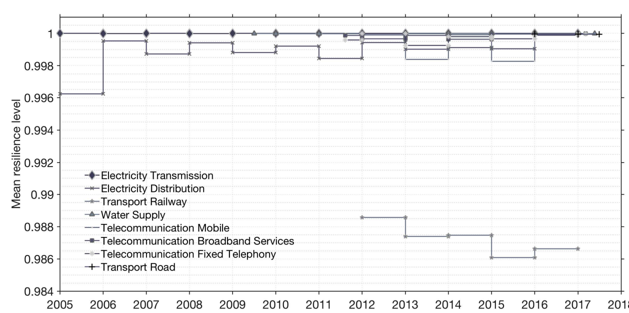

Figure 1 Annual resilience level of studied infrastructures

A popular science summary of the master thesis *Critical Infrastructure Resilience – Comparing Swedish critical infrastructures based on interruption data*, at the Division of Risk Management and Societal Safety, Faculty of Engineering, Lund University.