

# Quantifying Functionality of Buildings to Natural Hazards

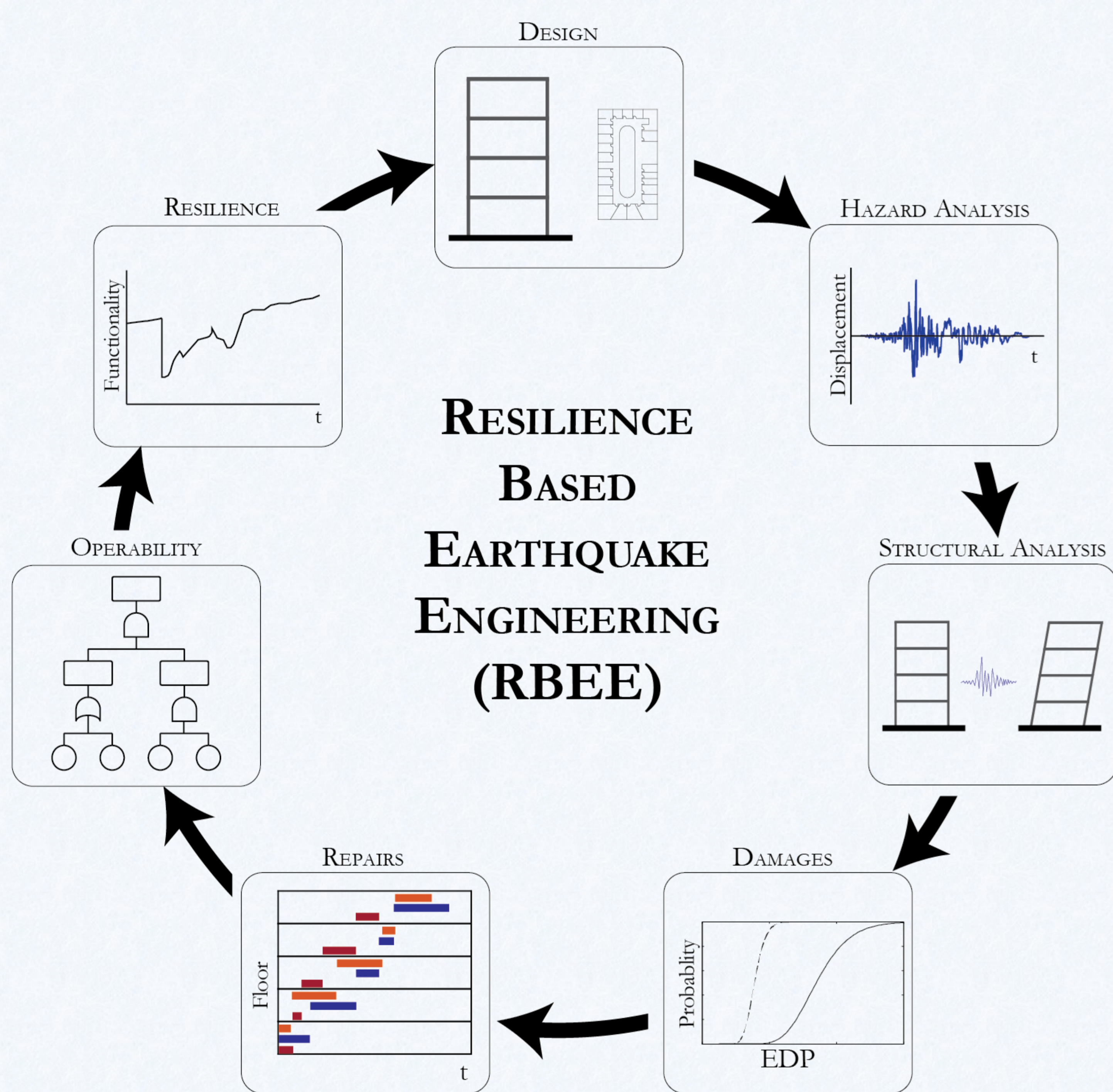


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## Introduction

Continued functionality of critical infrastructure systems shortly after an earthquake is expected. However, experience has shown that this is often not the case. Buildings with limited or no structural damage may still experience significant non-structural damage or be impacted by surrounding and interconnected infrastructural failures that can cause a sustained and substantial impact on the operability of the building. A method to rapidly identify how damage, outages, or blockages are linked to drops in functional performance measures for the people and organisations is being developed for hospitals and will be further expanded to other building occupancies and infrastructure including commercial buildings, critical facilities, and housing.

## Building Functionality



Resilience Based Earthquake Engineering Design Framework. Follows the initial steps for a performance based design methodology and then uses the damage and repair estimates to predict the operability of the social and organisational systems that occupy the building and provides an estimate of the overall building functionality (in terms of intended use) over the recovery period.

**Performance:** How the structural and non-structural components handle shocks or excitement from natural disaster. What type of damage occurs? How severe is the damage? How long will it take to repair the damage?

**Operability:** How the damage affects the ability of the structure to be used for its intended purpose. Is the building still about to operate according to it's intended purpose? Are the organisations and other units able to continue as they did prior to the shock event? If not, at what level are they about to operate?

**Functionality:** How well the building is able to provide for occupants and organisations housed with in for the duration of the recovery period. To what level is the building able to serve for it's intended function? What level of service will be available? How long will the disruption be?

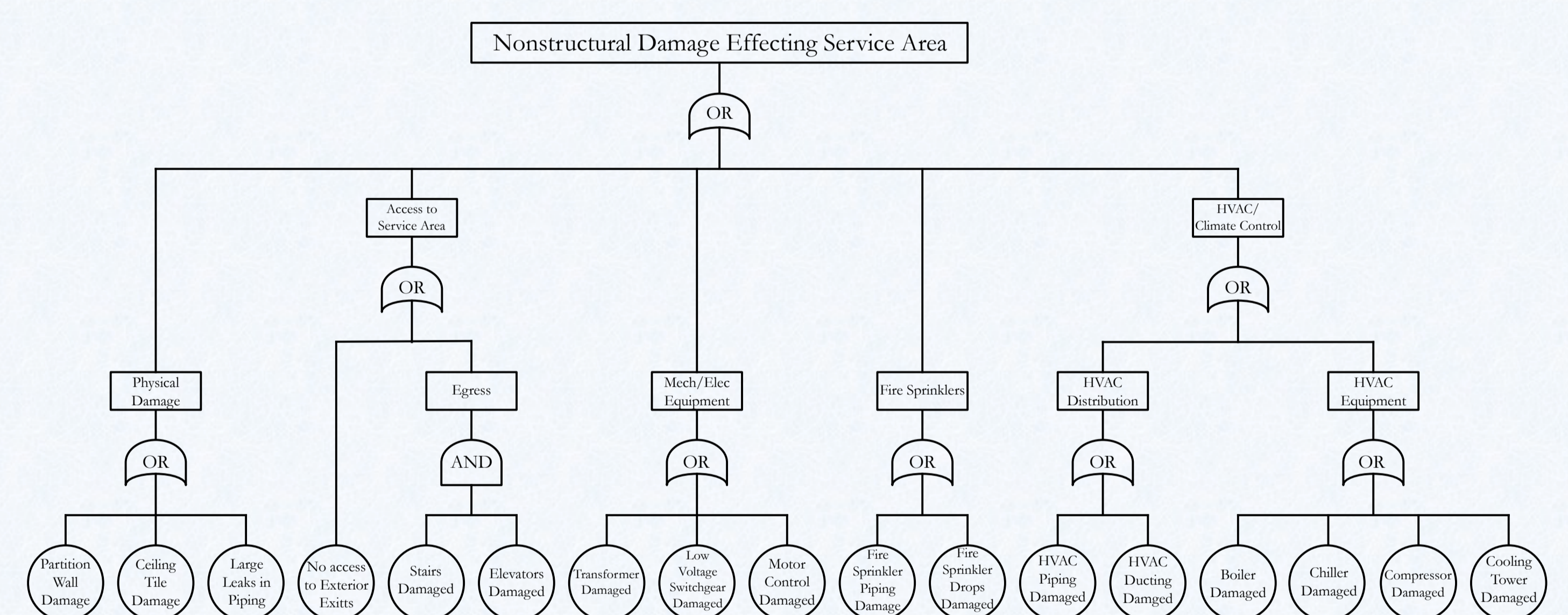
## Design Methodology

**Data Collection:** Data is collected from past earthquakes to determine what types of structural and non-structural damage impacts hospital performance. Interviews with hospital personnel are used to determine specific hospital service needs and requirements for patient safety and ability to continue providing various types of medical services.

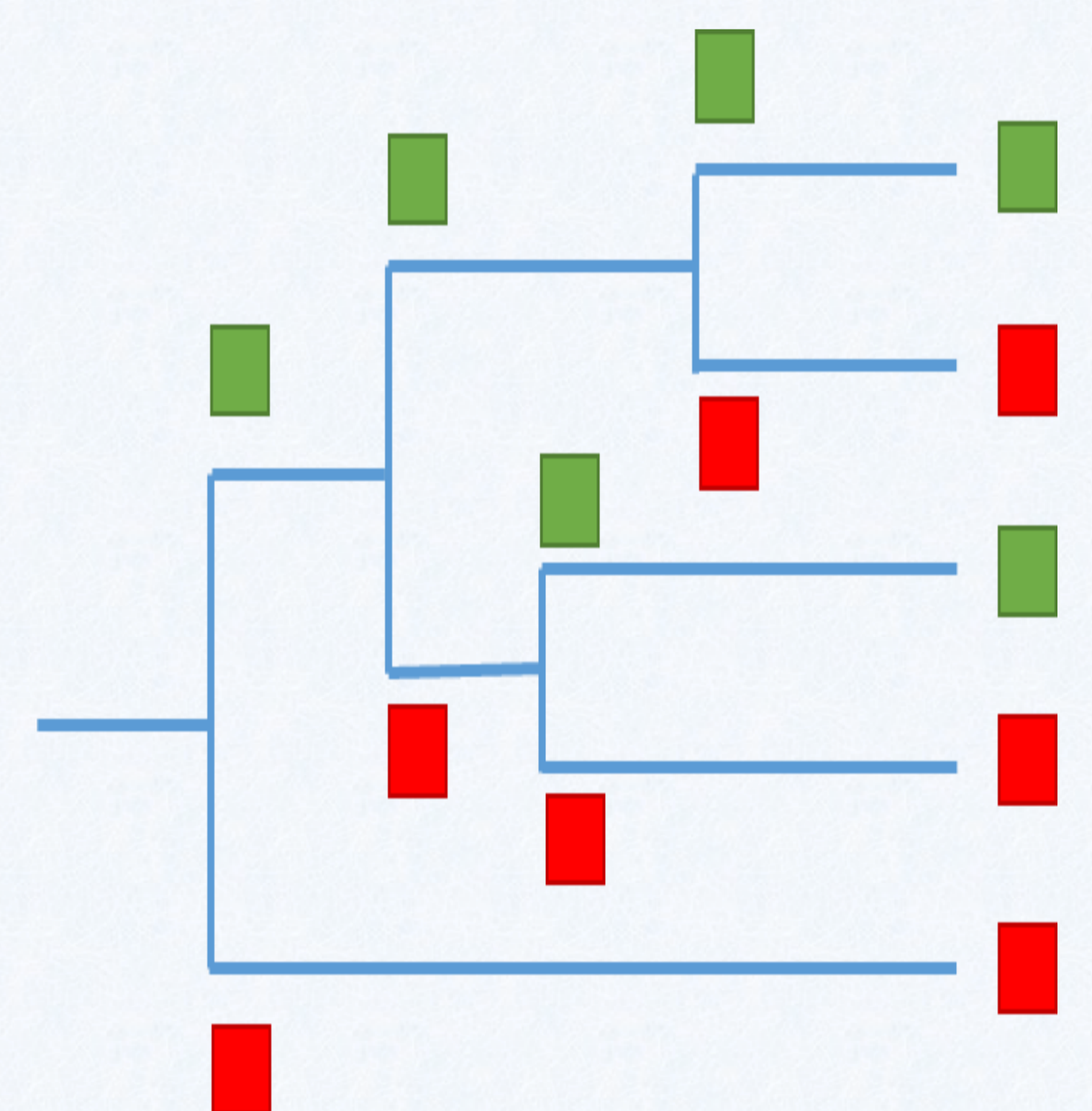


Damage to non-structural components can compromise hospital services. For example they can create unsterile environments or unsafe conditions for patients and staff. Damage does not need to be directly in the service area. For example, damage to the HVAC system could hinder level of operability across all hospital services. (Images from EERI Earthquake Reconnaissance Report, M7.1 Anchorage Earthquake November 30, 2018)

**Risk Analysis:** Immediate understanding of damage and the subsequent effects of the damage can provide instant feedback on the level of operational functionality. Fault trees are used to determine if a certain service area or procedure will be available for use immediately after a shock event. Fault trees can be deterministic (it works or it doesn't) or probabilistic (probability of failure).

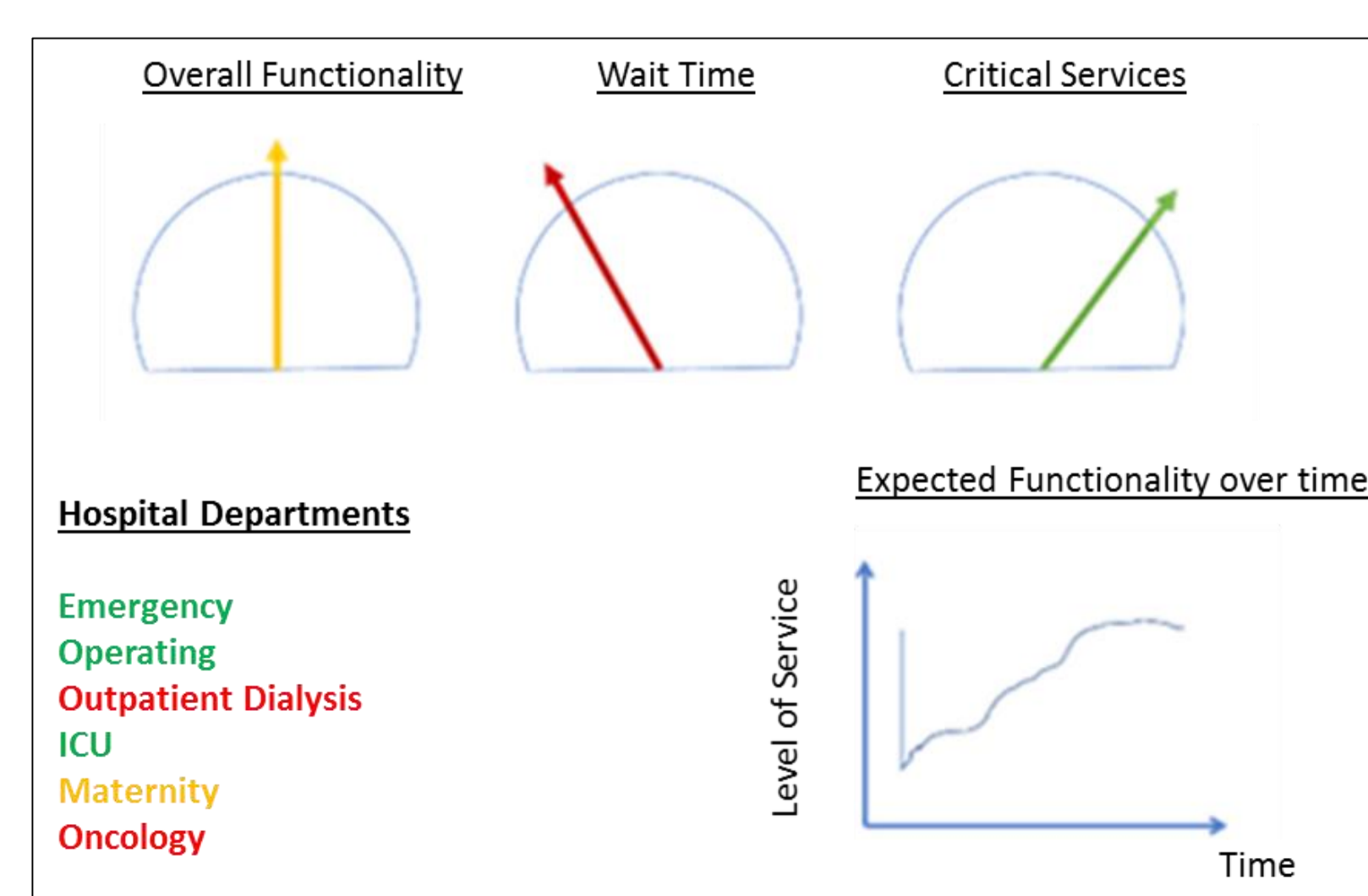


**Operability Prediction:** Level of operability is predicted through an event tree. By organising sequences of events that led to full or partial failures the level of operability for the hospital can be determined. The event tree takes the outputs of the fault trees, where each junction is based on an individual fault tree.



## Application

### Functionality Dashboard:



Functionality Dashboard that provides real-time information on the current operability and functionality levels of the building based on the building's intended use.

Dashboard provides information on level of service and an estimate of the time for full recovery.