Automatic Implementation of the KKL seismic PSA

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Contents

- Goal and processes of the KKL seismic PSA
- The challenges of the implementation
- Solutions developed
- Wink to PSA software developers
Seismic integrated model

- Seismic fragility of components is considered in the system fault trees
Process followed

- Grouping of components (type and elevation)
- Walkdown
- Finite element modelling
- Simulation => median capacity
- Screening

130 seismic groups retained
Group 001 => 26 basic events
Let’s calculate…

- 130 groups; 26 basic events per group:
  - 3380 basic events
  - + 3380 basic events descriptions
  - + 3380 parameters
  - + 3380 parameter descriptions

= ... lots of work...

1 per minute => 27 working days
Two challenges

1) How do we put all these objects in RiskSpectrum?
2) Once they are there, how do we put them in the Fault Trees? (3762 places)
Challenge 1

- Solved using Excel Import

Overview of the Excel document
Challenge 2

- How to prevent spending 2 months inserting basic events in fault tree pages?
Challenge 2

- In each Fault Tree:
Challenge 2

- [001, 002, 003, ..., 0130]
- For each group $gr$
  - Basic events = get_basicevents-associated($gr$)
  - For each basic events $be$
    - Fault trees = get_faulttrees-associated($be$)
      - For each fault trees $ft$
        - Create_OR_gate(name_gate)
        - Populate_gate(name_gate, gr, be)
        - Replace_be_by_gate(be, name_gate)
Challenges 1&2

- Challenge 1: cleared using VBA macro and the Excel Import functionality of RiskSpectrum

- Challenge 2: cleared using a script which automated the replacement of basic events by gates
What we have learnt from this

- **It works, but…**
  - There is a lot of dupplications
  - The use of an external program was necessary
  - Fault trees are more loaded

- **A more optimal solution should be available.**
Attribute related fragilities

- This feature does not exist in RiskSpectrum
- This feature is just an idea…

![Graph showing seismic failure probability versus peak ground acceleration.](image)
Explicit => Implicit

- Replacement performed in the background
- Less implementation work (Attribute ⇔ Basic Event)
- Lighter Fault Trees, more « System focused »
Multiple applications

Failure of PUMP A

Failure of PUMP A to start
Failure of PUMP A due to seismic
Failure of PUMP A due to fire
Failure of PUMP A due to flood
Failure of PUMP A due to airplane crash
Failure of PUMP A due to tornadoe

PUMP_A
SEIS_PUMP_A
FIRE_PUMP_A
FLOOD_PUMP_A
AIRCRA_PUMP_A
TOR_PUMP_A

Failure of PUMP A to start

ZA
PUMP_A

001 R123

Peak Ground Acceleration PGA [g]
Seismic Failure Probability [-]

Mean

0.05
0.50
0.95
Multiple applications

- Very similar to Exchange Events except that:
  - It is not necessary to define the exchanges for each basic event individually
  - It does not replace a basic event, it «adds» a contribution (equivalent to an OR gate)
Conclusions

- KKL seismic PSA has been efficiently implemented
- The model is easy to maintain (Excel Import)
- Improvements are possible in PSA softwares as requirements move more and more to integrated models