SPRA Alternate Screening Method

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Why screening & prioritization is an important step in SPRA

- Seismic Equipment List (SEL)
  - List of all the equipment that will be given consideration in the SPRA
  - SEL is typically greater than 1000 individual SSC’s
- The number of SSC’s that must be considered in the SEL is a challenge for SPRA project:
  - Calculating realistic, median centered fragilities for all the SSC’s can be a significant T&M burden on a SPRA project.
    - Providing realistic fragilities for all the SSCs in the SEL is not feasible
    - Attempting to provide realistic fragilities for too many SSCs may reduce overall model quality
  - Including all the SSC’s without screening in the SEL in the PRA model can “bloat” the SPRA model without adding much safety insight other value.
    - Model becomes more challenging to use and maintain
- ANS/ASME standard allows for screening components out of the PRA model based upon seismic capacity
  - Screening criteria must be clearly identified

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Screening timing: When to apply screening?

- Optimally, identifying which equipment can be screened out of inclusion in the PRA model should be done as early as possible
  - Early screening allows effort to be focused on those SSC's that are more significant
- Screening can start post walkdown using preliminary conservative fragility data
  - Walkdown will provide some screening
  - Conservative fragility estimates can be made prior to finishing in-structure response evaluations
  - Slightly less conservative fragility estimates can be made after finishing in-structure response evaluations
- Screening and Prioritization is an iterative process that takes place throughout the project

Screening using Fussell-Vessely

- Example general form:

$$FV_{x_i} = \frac{CDF_{base} - CDF_{\ x_{i=true}}}{CDF_{base}}$$

- Screening FV values calculated for a preliminary model using early conservative fragility data:
  - Relative to CDF based on preliminary conservative fragility data.
    - CDF calculated using preliminary fragility data will be conservatively high with respect to final CDF
    - Preliminary FV calculated in this way can under estimate the significance of components with respect to the final model if there is a significance difference between preliminary and final CDF values
  - Median capacities for preliminary fragilities will not all improve in a linear/scalar way with fragility refinement
    - Relative significance of components will change with fragility refinement
- It can be problematic to use FV and/or other traditional Risk significance measures to determine individual component significance for the purpose of early component screening

Alternate screening method

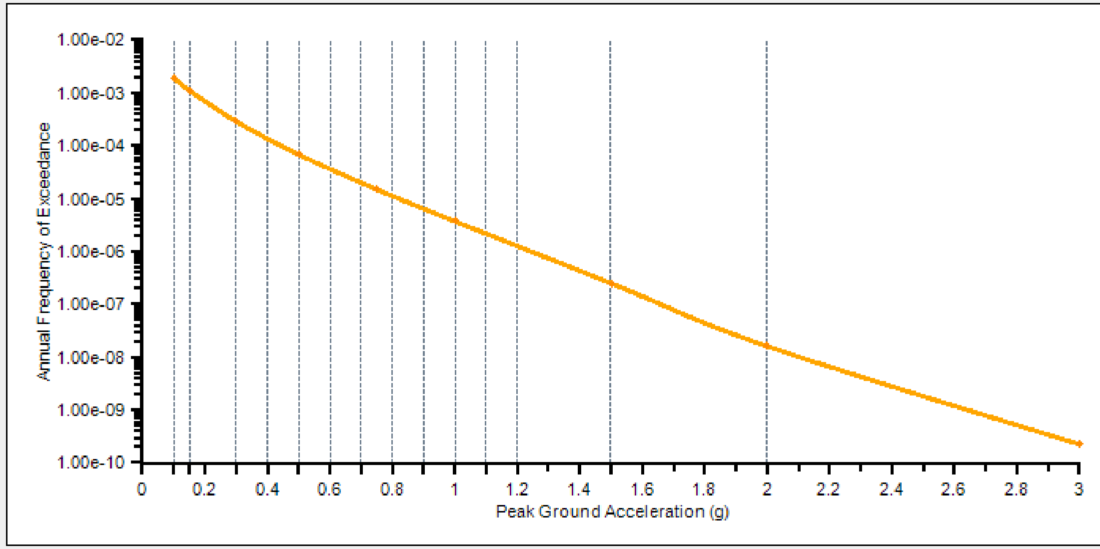
- Builds upon existing screening approach described in EPRI *Seismic Probabilistic Risk Assessment Implementation Guide* TR 1002989
- Develop an screening HCLPF estimate for 1% maximum target CDF/LERF contribution in the final PRA model
  - Conservatively based upon direct to core damage seismic failure
  - Possible to extend the method to non-direct failure in limited cases
  - Screening HCLPF level can be refined iteratively throughout the SPRA project

Building a screening & prioritization HCLPF assessment

- Developing a screening HCLPF requires three major inputs
  - Target CDF/LERF
  - "binned" control point seismic hazard
    - Hazard data that will be used in FRANX
  - Reasonable estimates of the fragility uncertainties
- Target CDF/LERF values
  - Anticipated CDF & LERF for the final model
  - Based on expert knowledge, seismic hazard, and existing seismic evaluations for the site
  - Should not be "conservatively high"
    - The lower the target CDF & LERF, the higher the screening value.

Seismic Hazard

- "Binned" seismic hazard from FRANX
  - OK if it does not reflect the final number of bins
  - Sufficient bins are necessary to not underestimate CDF contribution



ID	Description	Lower	Upper	Representative Ground Motion (g PGA)	Mean Frequency	Error Factor
%G01	Seismic Initiating Event (0.1g to <0.15g)	0.1	0.15	0.1225	8.20e-04	2.1875
%G02	Seismic Initiating Event (0.15g to <0.3g)	0.15	0.3	0.2121	8.23e-04	3.9662
%G03	Seismic Initiating Event (0.3g to <0.4g)	0.3	0.4	0.3464	1.52e-04	6.1093
%G04	Seismic Initiating Event (0.4g to <0.5g)	0.4	0.5	0.4472	6.71e-05	6.0095
%G05	Seismic Initiating Event (0.5g to <0.6g)	0.5	0.6	0.5477	3.18e-05	5.2244
%G06	Seismic Initiating Event (0.6g to <0.7g)	0.6	0.7	0.6481	1.61e-05	4.6757
%G07	Seismic Initiating Event (0.7g to <0.8g)	0.7	0.8	0.7483	8.64e-06	4.4482
%G08	Seismic Initiating Event (0.8g to <0.9g)	0.8	0.9	0.8485	4.79e-06	4.3807
%G09	Seismic Initiating Event (0.9g to <1g)	0.9	1	0.9487	2.71e-06	4.3647
%G10	Seismic Initiating Event (1g to <1.1g)	1	1.1	1.0488	1.55e-06	4.3922
%G11	Seismic Initiating Event (1.1g to <1.2g)	1.1	1.2	1.1489	9.00e-07	4.4645
%G12	Seismic Initiating Event (1.2g to <1.5g)	1.2	1.5	1.3416	1.02e-06	4.6505
%G13	Seismic Initiating Event (1.5g to <2g)	1.5	2	1.7321	2.34e-07	4.8933
%G14	Seismic Initiating Event (>2g)	2		2.2	1.60e-08	4.281

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Fragility uncertainties

- Recommend using the fragility uncertainties in the SPID (Table 6-2) proposed for the hybrid approach for fragility evaluation
- Screening HCLPFs will be generated for each of the SSC categories

Type SSC	Composite β_c	Random β_R	Uncertainty β_U	$C_{50\%}/C_{1\%}$
Structures & Major Passive Mechanical Components Mounted on Ground or at Low Elevation Within Structures	0.35	0.24	0.26	2.26
Active Components Mounted at High Elevation in Structures	0.45	0.24	0.38	2.85
Other SSCs	0.40	0.24	0.32	2.54

*uncertainty table above is directly from table 6-2 of EPRI, *Seismic Evaluation Guidance: Screening, Prioritization and Implementation Details (SPID) for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic*, TR 1025287,

Calculating ΔCDF_{max}

- Calculate conditional failure probabilities for HCLPF and uncertainty combinations for each of the seismic hazard bins
- Sum up to get the ΔCDF_{max} corresponding to a given HCLPF & uncertainty combination for the seismic hazard
- ΔCDF_{max} is the maximum direct to core damage or diret to LERF contribution for a given HCLPF and uncertainty combination

Interval	Rep. GM PGA (g)	Mean freq (/y)	Mean failure prob	Mean failure freq (/y)
1	0.12	8.20E-04	1.46E-12	1.19E-15
2	0.21	8.23E-04	1.01E-08	8.34E-12
3	0.35	1.52E-04	5.85E-06	8.89E-10
4	0.45	6.71E-05	9.03E-05	6.06E-09
5	0.55	3.18E-05	6.02E-04	1.91E-08
6	0.65	1.61E-05	2.42E-03	3.90E-08
7	0.75	8.64E-06	6.99E-03	6.04E-08
8	0.85	4.79E-06	1.60E-02	7.68E-08
9	0.95	2.71E-06	3.11E-02	8.43E-08
10	1.05	1.55E-06	5.33E-02	8.26E-08
11	1.15	9.00E-07	8.29E-02	7.46E-08
12	1.34	1.02E-06	1.59E-01	1.62E-07
13	1.73	2.34E-07	3.60E-01	8.41E-08
14	2.20	1.60E-08	5.94E-01	9.51E-09
A_m	**Bc**		**HCLPF**	**ΔCDF_{max}**
2	0.40		0.79	7.00E-07

ΔCDF_{max}

- Obtain ΔCDF_{max} for a range of HCLPF values and for each of the uncertainty combinations

Median Capacity (g)	0.35 βc		0.45 βc		0.40 βc	
	HCLPF	ΔCDF_{max}	HCLPF	ΔCDF_{max}	HCLPF	ΔCDF_{max}
1.00	0.44	1.10E-05	0.35	1.73E-05	0.39	1.38E-05
1.50	0.66	1.91E-06	0.53	3.82E-06	0.59	2.72E-06
1.75	0.77	8.90E-07	0.61	2.00E-06	0.69	1.35E-06
2.00	0.88	4.35E-07	0.70	1.10E-06	0.79	7.00E-07
2.25	1.00	2.22E-07	0.79	6.27E-07	0.89	3.79E-07
2.50	1.11	1.17E-07	0.88	3.71E-07	0.98	2.13E-07
2.75	1.22	6.31E-08	0.96	2.26E-07	1.08	1.23E-07
3.00	1.33	3.50E-08	1.05	1.41E-07	1.18	7.29E-08
3.25	1.44	1.97E-08	1.14	9.01E-08	1.28	4.41E-08
3.50	1.55	1.14E-08	1.23	5.86E-08	1.38	2.72E-08
3.75	1.66	6.64E-09	1.31	3.88E-08	1.48	1.71E-08
4.00	1.77	3.93E-09	1.40	2.61E-08	1.58	1.09E-08
4.25	1.88	2.36E-09	1.49	1.78E-08	1.67	7.02E-09
4.50	1.99	1.44E-09	1.58	1.22E-08	1.77	4.59E-09

Screening HCLPF values

- For the following examples the target CDF & LERF values are:
  - $SCDF_{target}$ = 5E-6/yr
  - $SLERF_{target}$ = 5E-7/yr
- 1% of target values are recommended for use for screening comparisons

		0.35 βc	0.45 βc	0.40 βc
% $SCDF_{target}$	ΔCDF_{max}	$A_{m\ (approx.)}$	$A_{m\ (approx.)}$	$A_{m\ (approx.)}$
1%	5.00E-08	2.85	3.60	3.20
10%	5.00E-07	1.95	2.40	2.18
50%	2.50E-06	1.42	1.65	1.53

		0.35 βc	0.45 βc	0.40 βc
% $SLERF_{target}$	ΔCDF_{max}	$A_{m\ (approx.)}$	$A_{m\ (approx.)}$	$A_{m\ (approx.)}$
1%	5.00E-09	3.87	5.15	4.45
10%	5.00E-08	2.81	3.59	3.19
50%	2.50E-07	1.58	2.70	2.43

Application of the screening criteria

- SCC fragilities can be compared to screening HCLPF values to evaluate screening potential. Works for:
  - Conservative fragility values
  - More realistic fragility values (SOV, CDFM, Hybrid, etc.)
- Screening should be validated on the final SPRA model
  - Applying screening HCLPF using the final CDF/LERF
  - Other risk importance measures (FV, etc.)

Extending the alternate screening method beyond a direct to core damage assumption

- For SSCs whose failure does not result directly in core damage the seismic failure combinations can be evaluated.
  - For a given SSC and fragility group:
    - What seismic failure combinations is the SSC/fragility group involved in?
    - Does the SSC show up in multiple cutsets combinations?
  - Recommend preliminary modeling of the seismic failure with an arbitrarily low median capacity
    - Use the results to identify the failure combinations for the given SSC
  - For components with limited failure contributions to CDF/LERF
    - Adjust the ΔCDF_{max} calculation to reflect an appropriate failure combination.

Examples where adjusting the ΔCDF_{max} calculation for compound failure should make sense

- SSCs whose failure is only significant with loss of offsite power
- Subcomponents in systems that redundant in purpose and a backup to primary safety response
  - Two valves in series for containment isolation

Conclusion

- Screening and Prioritization is a significant aspect of SPRA
  - Focusing effort on those SSCs that are most significant contributors to SPRA is critical
  - The earlier the screening and prioritization can occur the better
  - All in-process screening needs to be re-verified and documented using the final SPRA model