Options For NRC To Advance Level 3 PRA Technology

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Discussion Topics

- Lessons learned from Seabrook PRA
- PRA challenges from Fukushima accident
- Modular reactor licensing considerations
- PRA practitioners perspective on Options

Note:

The information presented in Slides No. 4 through 10 is taken from the 1983 Seabrook PRA and is used only to identify relative risk insights. The risk levels in the current PRA are significantly lower due to improvements in plant design and plant performance as reflected in plant specific data. The current mean core damage frequency at Seabrook Station is less than 2×10^{-5} per reactor year.

Lessons from Seabrook PRA

- Performed in mid to late 1980's
- Contractual requirement to include integrated risk of then-planned two-unit Seabrook Station
- Need to address emergency planning (EP) issues required full scope PRA
  - Internal and external hazards
  - Level 3 with extensive EP sensitivity studies
  - All modes and states
  - Likely most comprehensive scope among industry PRAs
- Results should be taken with grain of salt – only relative risk insights are meaningful today

Initiating Event Analysis

Category	Initiating Events
Events Impacting Both Units	• Loss of Offsite Power • Seismic Events • Tornado and Wind • External Flooding • Truck Crash in Switchyard
Events Impacting Both Units under certain conditions	• Loss of Condenser Vacuum • Loss of Service Water • Turbine Missile
Events impacting each unit independently	• Loss of Coolant • General Transients • Loss of Component Cooling • Loss of one DC bus • Internal fires • Internal floods • Aircraft crashes

Integrated Plant Risk Metrics*

Model Type	Risk Metric	Core Damage Frequency Uncertainty Distribution			
		Mean Value	5%	50%	95%
Single Reactor PRA	CDF per reactor year	2.3x10-4	6.90E-05	1.78E-04	5.41E-04
Integrated Site PRA of both Units	Single reactor CDF per site year	4.0x10-4	1.20E-04	3.10E-04	9.40E-04
	Dual reactor CDF per site year	3.2x10-5	1.10E-06	1.50E-05	1.20E-04
	Total CDF per site year	4.3x10-4	1.40E-04	3.40E-04	1.00E-03

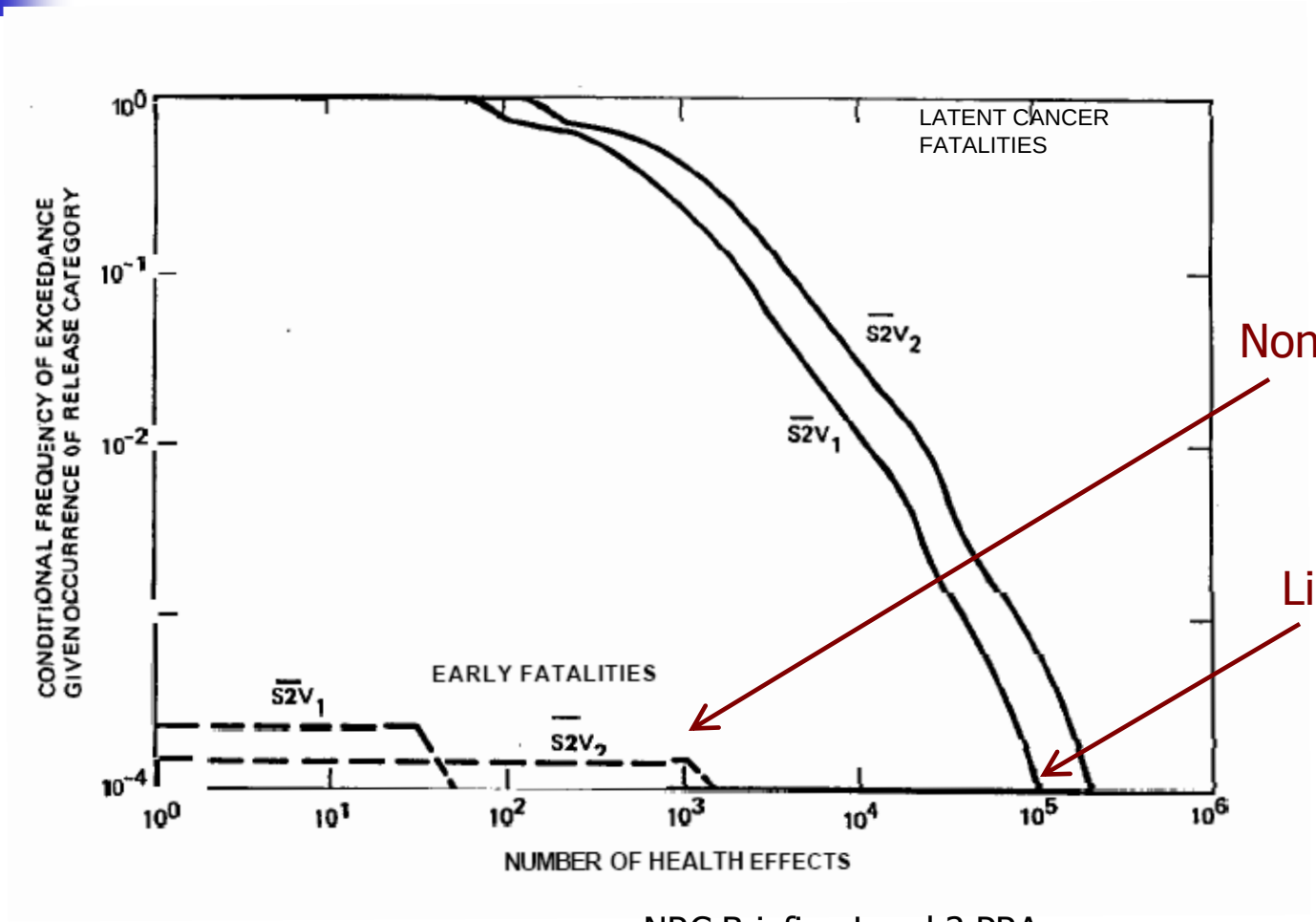
* Values listed are from 1983 study; current CDF at Seabrook is less than $2x10^{-5}$ per reactor year

Dual Reactor CDF Contributions*

Initiating Event	Dual Unit CDF Per Site Year	% of Total
Seismic Events	2.80E-05	88%
Loss of Offsite Power	2.80E-06	9%
External Flooding	1.60E-06	5%
Truck Crash into Transmission Lines	1.00E-07	0.3%
Total	3.20E-05	100%

* Values listed are from 1983 study; current CDF at Seabrook is less than $2x10^{-5}$ per reactor year

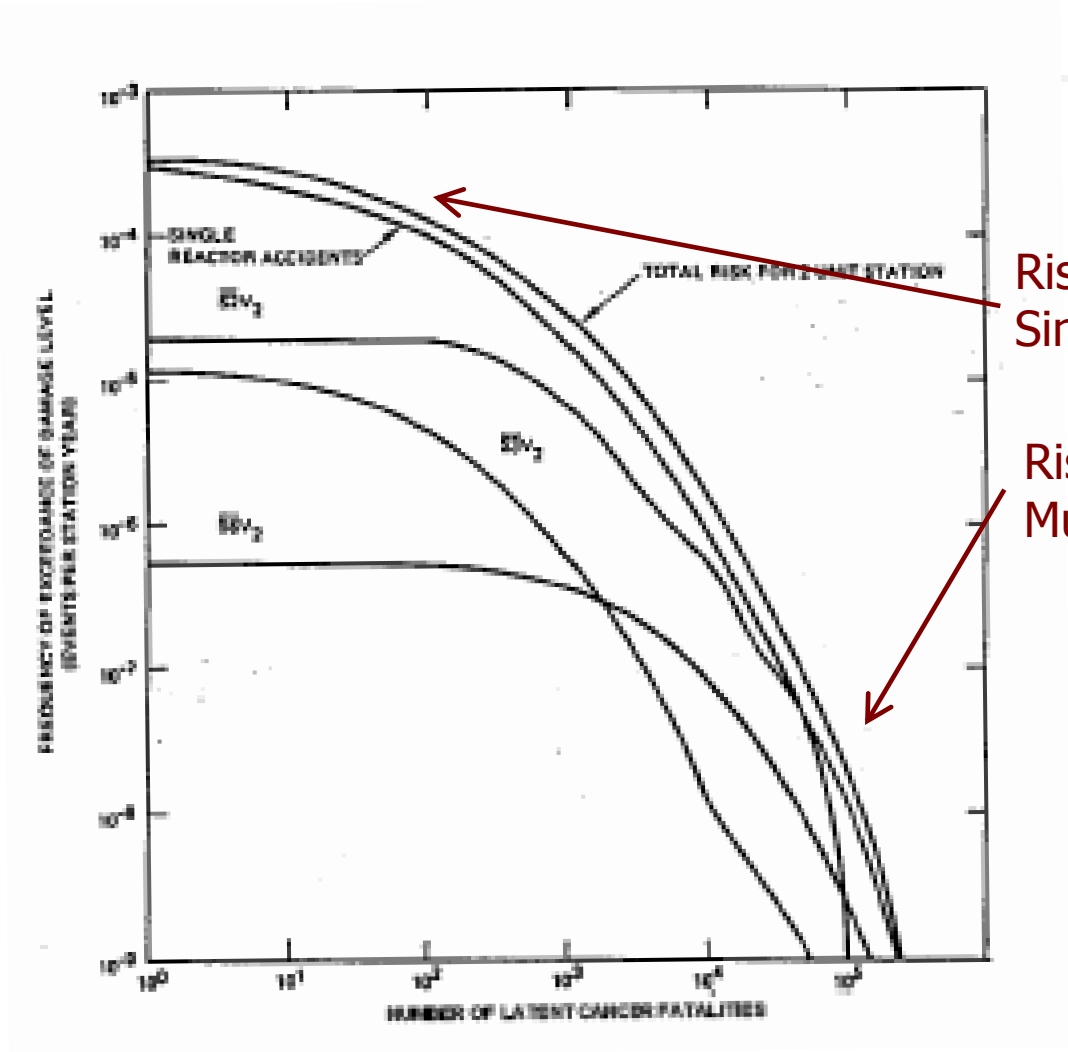
Comparison Of Consequences
Small Unscrubbed Bypasses (1983 Study)



Non-linear increase

Linear increase

Results For Latent Cancer Fatality Risk (1983 Study)



Risk Dominated by Single Reactor Events

Risk Dominated by Multi-Reactor Events

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Author's Seabrook Insights

- One cannot manipulate single reactor risk metrics to represent integrated site risk
- Technical basis for linking single reactor risk metrics to QHOs is questionable given number of multi-unit sites
- Contribution of multi-reactor events at Seabrook significant despite lack of highly integrated support systems
- Seismic events dominated multi-reactor events
  - Seismic correlation important for low intensity events
  - Seismic correlation not important for high intensity events
- Although there are unique challenges to integrated site PRA, this is more of a willingness to do it issue rather than a state of the art limitation issue

Fukushima Insights for PRA

- Standard PRA models assume plant conditions would lead core damage
- Multi-reactor event and multi-source issues
- Tsunami hazard analysis issue
- Seismic and flood PRA issue
- Accident management issues
  - Competing resource requirements
  - Radiation hazard impacts on HRA
  - Core damage prevention vs. mitigation tradeoffs

Modular Reactor PRA Insights

- Integrated risk issue for licensing modular reactors (PBMR, NGNP, SMRs)
- Technology neutral PRA standard for advanced non-LWR plants
  - Plant level risk metrics
  - Event sequences involving single or multiple reactors
  - Event sequences involving non-core sources

Recommendations

- Resources should be focused on areas of greatest uncertainty unless we have no way to reduce it
- Should avoid letting existing PRA Standards inhibit PRA development
- Some version of Option 3 has merit if sufficient resources are available
- ACRS recommendation of phased approach to Option 3 makes sense.