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Spatially Informed Plant PRA Models for Security Assessment

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Outline

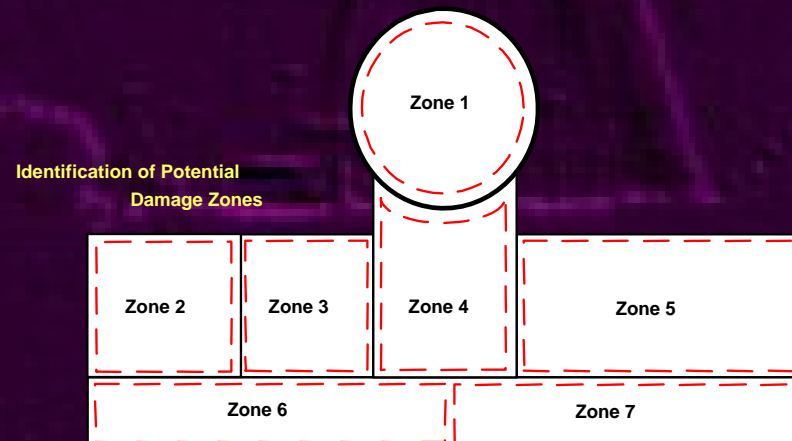
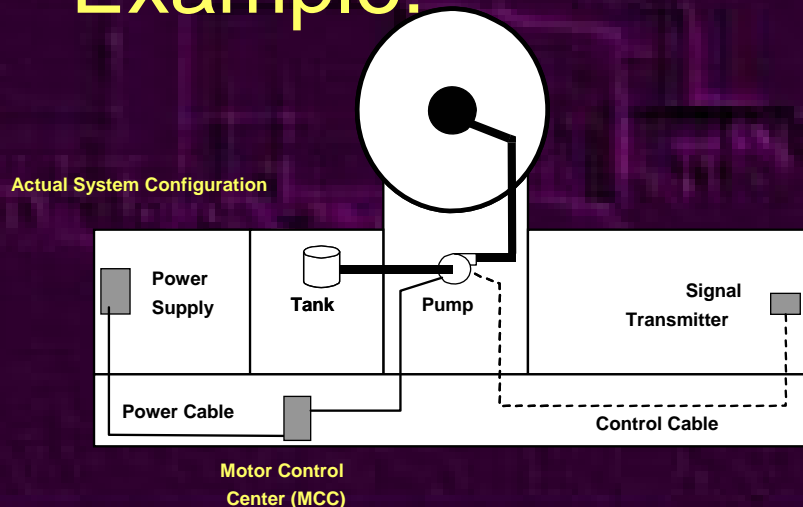
- Introduction & Background
- Damage Footprint Concept
- Method for Spatially Informed PRA
 - Zone identification
 - Spatial dependencies
 - Transformation
 - Solutions
- Additional Modeling Issues
- Conclusions

Background

- Purpose: Adapt traditional PRA models to account for the spatial dependencies of structures, systems, & components for evaluation of the potential effects of security-related events
- Modeling Challenges
 - Multiple types of damage mechanisms
 - Potential widespread effects
 - Varying susceptibilities
 - Passive component failures

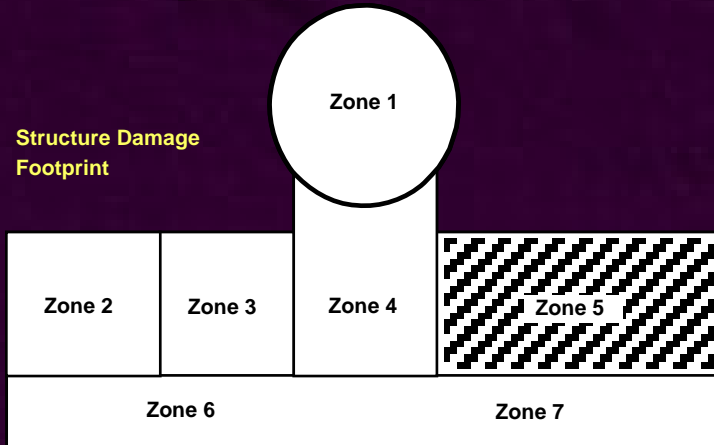
Damage Footprint

- Need: Assess the effects of a security-related event
- Solution: Spatial mapping of potential damage mechanisms onto plant areas
- Example:

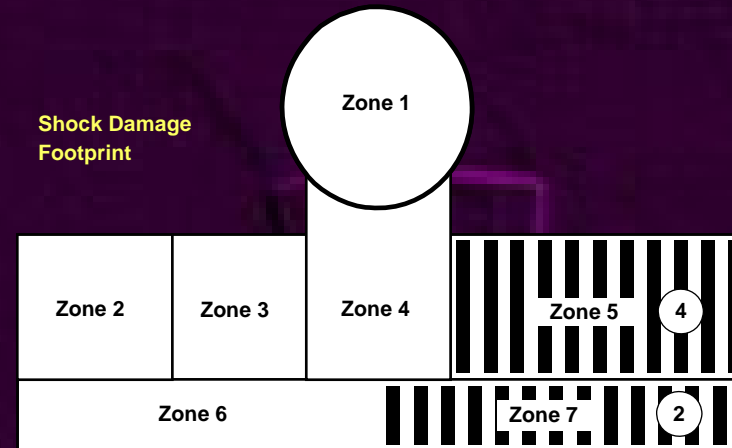


Damage Footprint

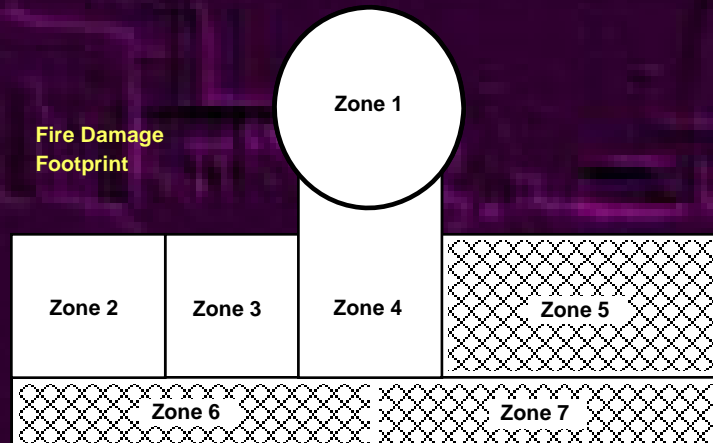
Structure Damage Footprint



Shock Damage Footprint

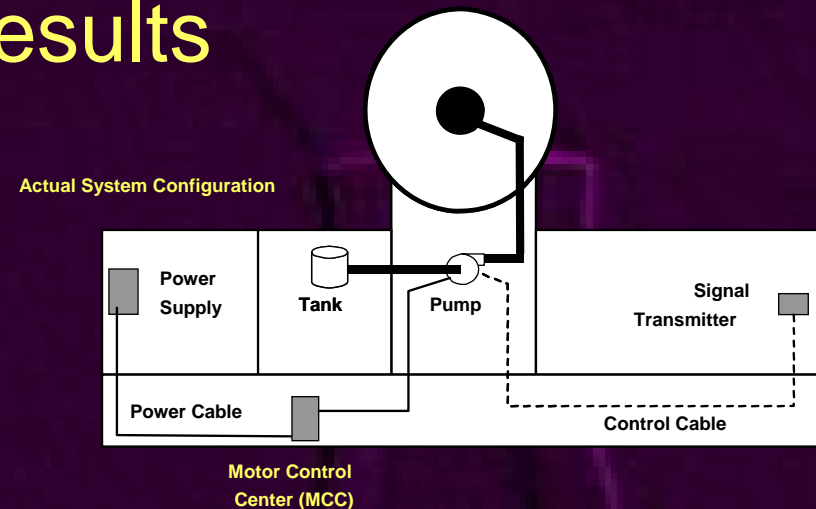


Fire Damage Footprint



Damage Footprint

- Composite footprint results
 - Surviving equipment
 - Pump
 - Piping
 - Tank
 - Failed equipment
 - Actuation signal transmitter (Zone 5 structural)
 - Control cables (Zone 7 fire)
 - Motive power (Zone 6 fire)
- System fails though primary equipment survives



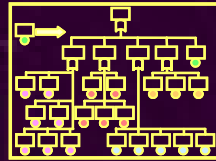
Method

- Zone identification
 - Subdivide all buildings and elevations that house important equipment and support systems
 - Plant firefighting plans provide good basis
- Spatial dependencies
 - Identify zones with physical equipment
 - Remember piping, power cabling, & control cabling
 - Use P&IDs, equipment databases, staff knowledge

Method

- Transformation

- PRA basic events are expanded to incorporate all spatial dependencies
- Software such as SAPHIRE can perform transformations automatically

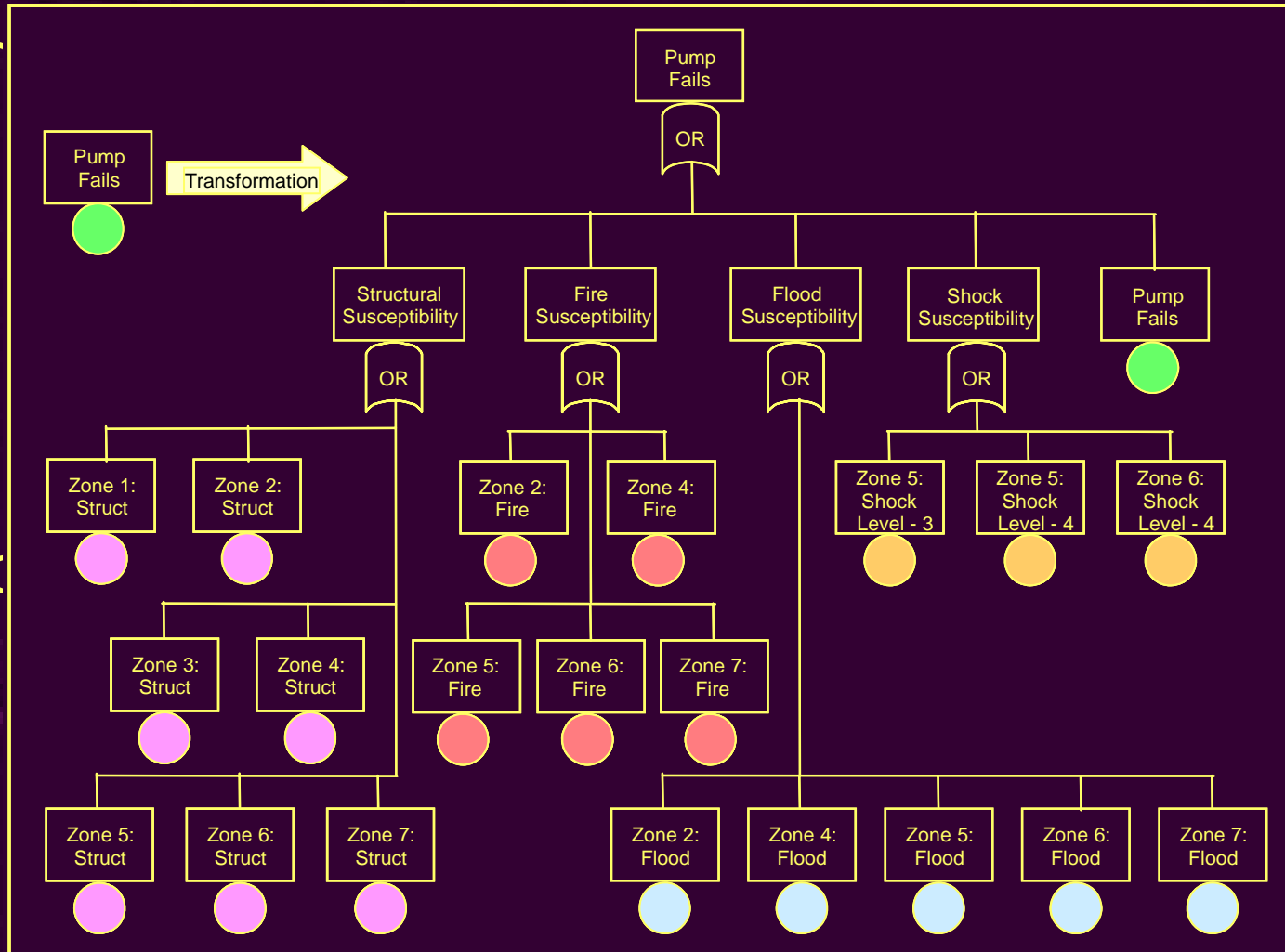


- Solution

- Damage footprints incorporated as failed zone basic events – $P(\text{fail}) = 1$
- Solution expressed as cut sets composed of zones rather than random failure events

Method

- Tr



- Sc

Method

- Event Tree Solution
 - Intent is to identify safe shutdown capability
 - System fault trees produce pass/fail results
 - Straightforward, manual solution of event trees
- Human Reliability Considerations
 - Failure due to damage to components
 - Failure due to an inaccessible environment
 - Consideration of both action locations and access routes

Additional Modeling Issues

- Incomplete information
 - Lots of basic events
 - Lots of components, including cables and pipes
 - Best-estimate or conservative assumptions
- Timing of failures
 - Some damage mechanisms not instantaneous
 - Components may only need to function for short period of time
- Instrumentation and control failures
 - Need to assess failure modes of I&C
 - Works in combination with timing of failure

Conclusions

- Security-related events are likely to be location-driven
- Mapping of damage mechanisms onto plant areas produces a “damage footprint”
- Applying the damage footprint to a spatially-informed PRA evaluates safety system functions
- Straightforward, but labor-intensive process