EXTERNAL EVENTS ANALYSIS

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Purpose of this session

The purpose of this session is not to teach you how to perform an external events analysis, but to familiarize you with concepts behind external events analyses.

External events are important

- External events can initiate the undesired event

- External events can negate or compromise the systems or procedures used to prevent or mitigate the accident consequences

- External events have proved to be dominant in many risk assessments

What is an external event?

- **An external event is an event that is external to all systems used in normal operation and to all safety systems**

- **Examples:**
  - **Tornado**
  - **Earthquake**
  - **Fire**
  - **Flooding**

There are many external events that need to be considered in a PRA

These include

Aircraft crash
Earth movement (avalanche, landside)
Earthquake
Fire inside facility
Fires, external (forest fire, grass fires, etc.)
Flooding, external (to include Seiche, storm surge dam failure, and Tsunami)
Flooding, internal
Hazardous material release from on-site stroage
High winds, tornadoes

There are many external events that need to be considered in a PRA (Con't)

Hurricane
Industrial or military accident nearby
Lightning
Extraterrestrial acticity (meteorite strikes, satellite falls)
Pipeline accident
Sabotage
Ship impact
Toxic gas release
Transportation accident
Turbine missile
Volcanic activity
War

Other external events, which are generally excluded, may warrant some consideration

<u>These include</u>

- **Abrasive windstorms (duststorms, sandstorms)**
- **Drought**
- **Erosion**
- **Heavy rain**
- **River diversion or change in lake level**
- **Severe temperature transients (extreme heat, extreme cold**
- **Severe weather storms (icestorms, hailstorms, snowstorms)**

Earthquakes and fires have proved to be the dominant two external events

During this session we will discuss many of the external events listed, however, we will only discuss two in any depth. These include earthquakes and fires.

Industrial or military accident nearby

- Examples of such accidents are chemical plant fires and/or explosions, munitions plant explosions and/or fire, etc.

- Their effect on facilities should be similiar to that of a transportation accident involving hazardous material near a facility, e.g. fires, explosion overpressures, hazardous material release forcing station ventilation isolation or even control room evacuation, etc.

Hazardous material release from on-site storage

- Examples of hazardous materials stored on-site include diesel fuel for diesel generators, chlorine (sometimes in gaseous form) for water treatment, cleaning solvents, hydrogen gas for coolingmain turbine bearings, compressed gases such as nitrogen, oxygen, propane, compressed air.

- Accidents could include not only explosions, but the release of hazardous materials that could affect operation or force evacuation.

Severe temperature transients (extreme heat/cold)

- Severe temperature transients may effect your facility at one time or another. Effects include loss of offsite power.

- Other effects include freezing of water lines, freezing of instrument lines which could cause the loss of important sensors needed in the response to a severe accident.

Severe weather storms (ice, hail, snow)

- Ice and snow storms accompanied by strong winds can cause complete or partial loss of off-site power.

- Snow and ice may delay maintenance crews attempting to get to remote locations even for minor repairs.

- Other possible effects include degraded or complete loss of the ultimate heat sink and external flooding effects.

Lightning Strikes

- Most frequent cause of overvoltages on electrical distribution systems.

- Nonconductors are often shattered by lightning strikes, while conductors may be burned or vaporized entirely.

- Longest restoration times for lightning initiated events are those that result in grid instability.

External fires (forest, grass)

- **Potential effects could be loss of off-site power and forced plant ventilation isolation and possible control room evacuation.**

- **Off-site fires have the potential to travel long distances if left unchecked.**

Extraterrestrial Activity (Meteorite strikes, Satellite Falls)

- **Damage potential to objects on the earth being struck or even near-missed is enormous.**

- **Capability to design a structure to resist the effects of being struck by a meterorite or satellite is outside the realm of current or foreseeable technology.**

- **Probability of this event is very low (Probability of a meteorite weighing more than 100 lbs. striking a 100,000 square foot target is 6E-8/yr).**

Volcanic Activity

Effects include:

- Debris in waterways that threaten the ultimate heat sink water supply.

- Volcanic ash in air which can force facilities to isolate their ventilation systems and go to recirculation mode.

- Weight of accumulated ash on structures that could exceed design loads.

Earth movement (avalanche, landslide)

- May pose threat by their potential to damage safety-related structures or components.

- Have caused large loss of dollars and life (destroyed power plant in a 1955 Niagara Falls, New York rock slide; contruction problems with Panama Canal caused by slides).

Abrasive windstorms (duststorms, sandstorms)

- **Effects ventilation systems**
- **Could effect the ultimate heat sink water supply.**
- **May pose a threat to offsite power sources.**

There are currently two types of seismic analysis: Seismic Margin Reviews and Seismic PRAs

	Seismic Margin Review	Seismic PRA
Purpose	Estimate seismic capacity beyond SSE	Estimate seismic risk
Seismic hazard	Excluded	Important part of PRA
Seismic hazard uncertainty	Excluded from consideration	Has a major effort on results
Output	- Plant seismic capacity in terms of HCLPF (not related to specific probability distribution - Identifies lowest HCLPF elements	- Gives seismic risk, frequency of core damage - Identifies lowest capacity elements

Comparison of Seismic Margin Reviews and Seismic PRAs (cont'd)

	Seismic Margin Review	Seismic PRA
Plant walkdown	Two walkdowns - level of detail depends on the end use	As currently practiced, requires a less-detailed walkdown than a margin
Use of generic information	For screening out components	For "high" capacity components
Plant-specific evaluation	HCLPF calculations for components;doubles, triples	Fragility curves for "low" capacity components

Comparison of Seismic Margin Reviews and Seismic PRAs (cont'd)

	Seismic Margin Reviews	Seismic PRA
Safety measure decisions	Decided on HCLPF value of components and plant	Decided on frequency of core damage and/or consequences
	Estimation of HCLPF value is based on analysis, testing, experience, and judgement	Estimation of component fragility parameters is more judgemental than HCLPF estimation. Large uncertain-ties in seismic risk estimates make decisions difficult
Earthquake input	Needs the earthquake review level	Needs seismic hazard curves
Use of random	Care should be taken to identify this in estimating the HCLPF for cut sets	The PRA methodology includes consideration of this issue

Two seismic margin review methods have been developed: LLNL and EPRI

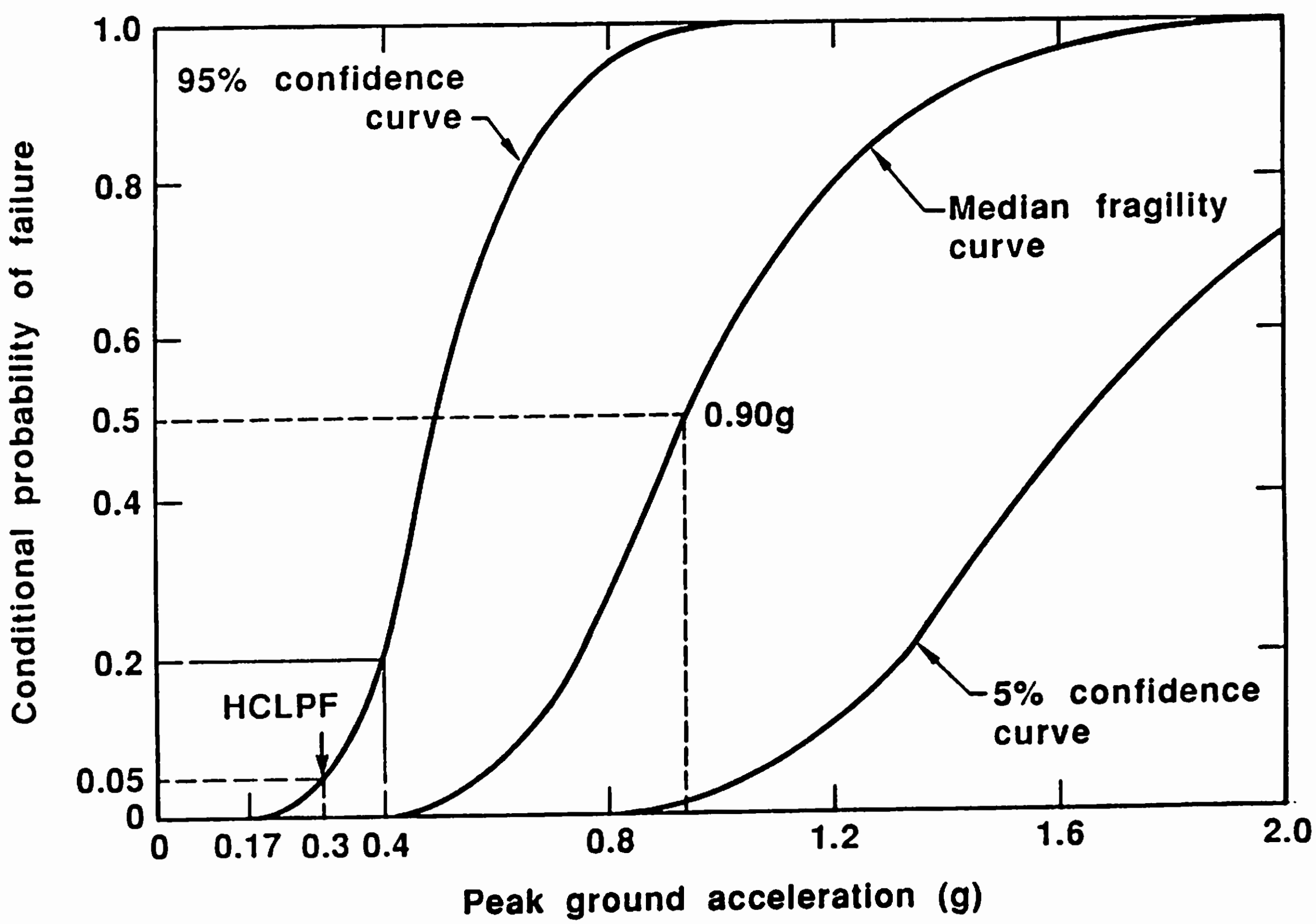
- **The major difference between the EPRI method and the LLNL method is in plant modeling and systems analysis. The EPRI method replaces the event tree and fault tree technique with a "success path" approach.**

- **The success path approach defines those components required for an operational sequence of plant systems that will bring the plant to a stable condition and maintain that condition. The set of components needed for success is called a "success path".**

The LLNL Seismic Margin Review contains 8 steps

1. **Selection of earthquake review level**
2. **Initial systems review**
3. **Initial components HCLPF categorization**
4. **First plant walkdown**
5. **System modeling**
6. **Second plant walkdown**
7. **System modeling analysis**
8. **Margin evaluation of components and plant**

HCLPF - High Confidence of Low Probability of Failure



Seismic PRAs have envolved and now include several methods

Four major methods include the following.

- **SSMRP method**
- **Simplified SSMRP method**
- **'Zion' method**
- **S_a approach**

The SSMRP method consists of five steps

1. Characterize the seismic hazard. This includes the likelihood and magnitude of potential earthquakes and the degree to which they transfer energy through the ground.

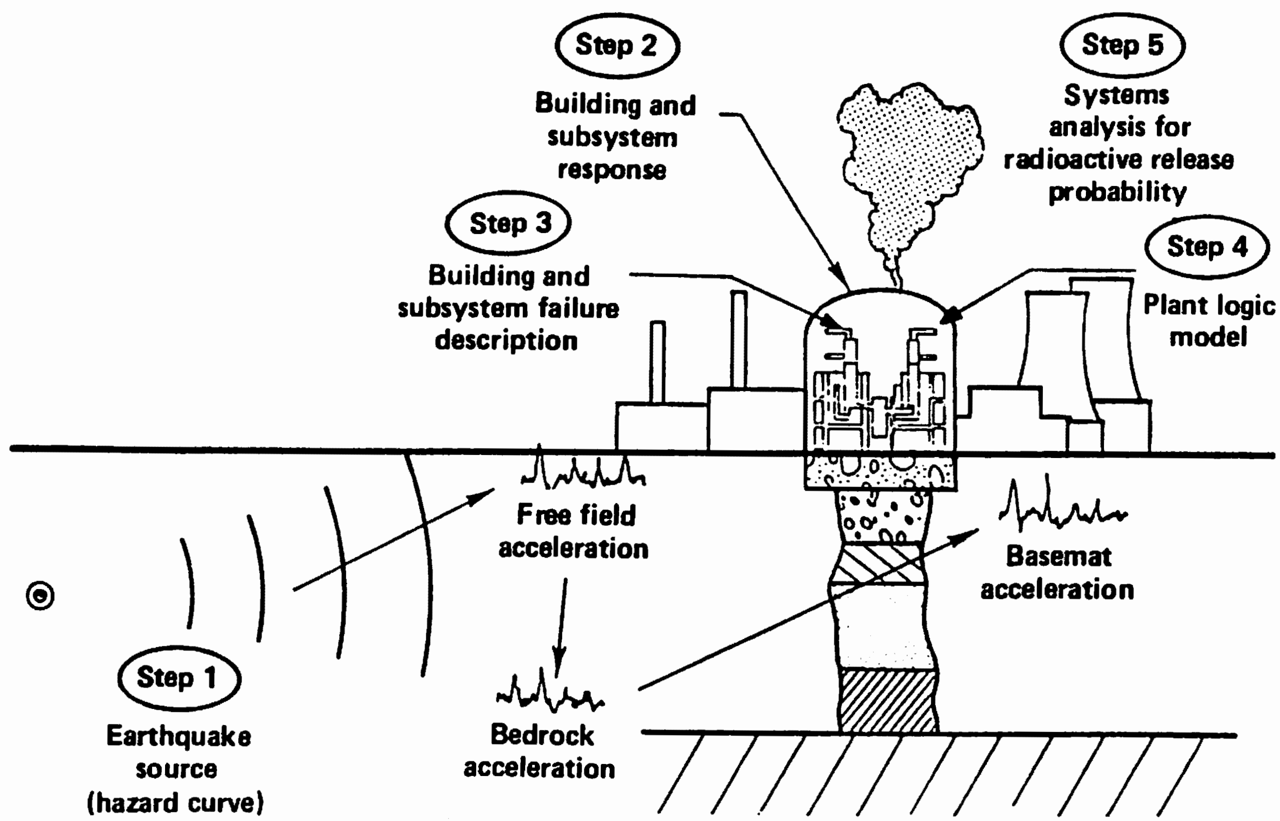
2. Determine response of structures and subsystems to seismic excitation including soil-structure interaction effects.

3. Determine fragility functions. A fragility function defines failure probabilities with respect to a given response.

4. Identify accident scenarios.

5. Calculate the frequency of the undesired event.

The SSMRP methodology can be graphically depicted

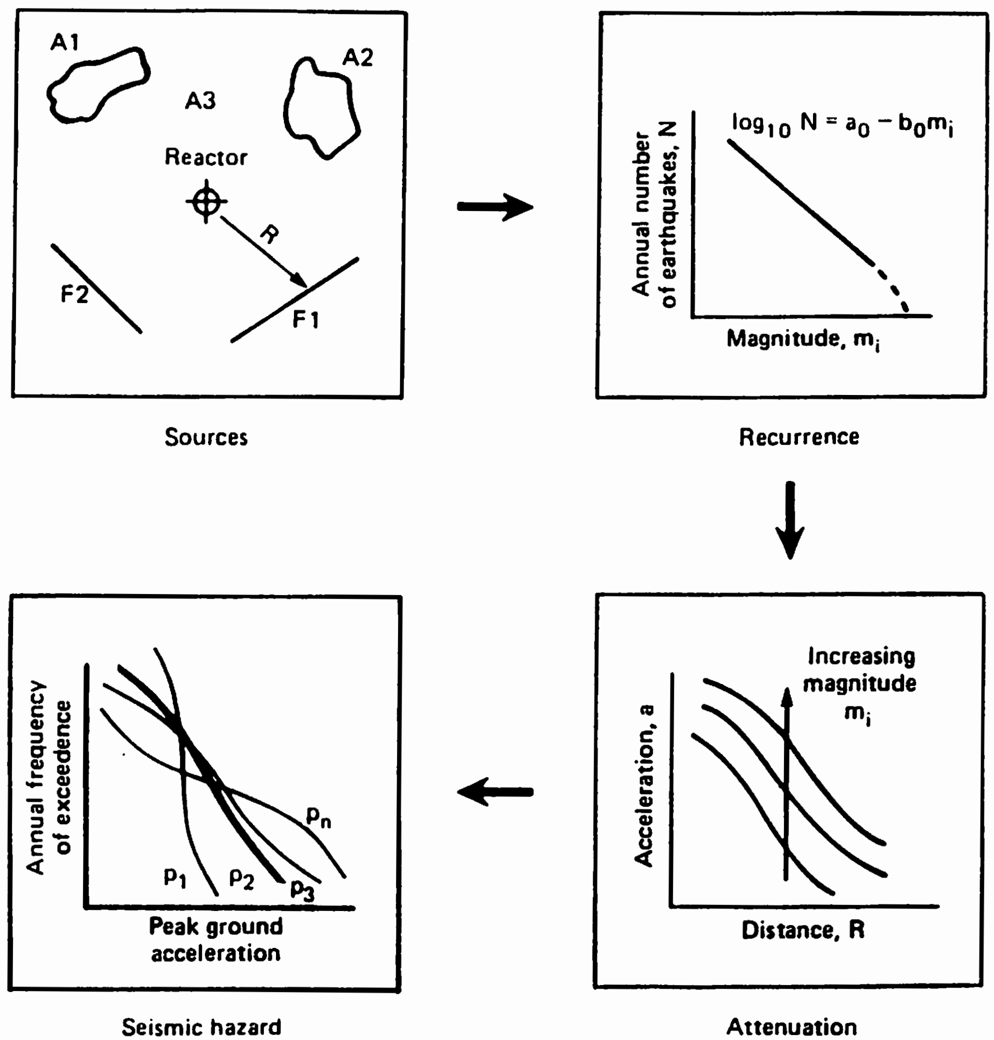


Step 1 - Characterize the seismic hazard

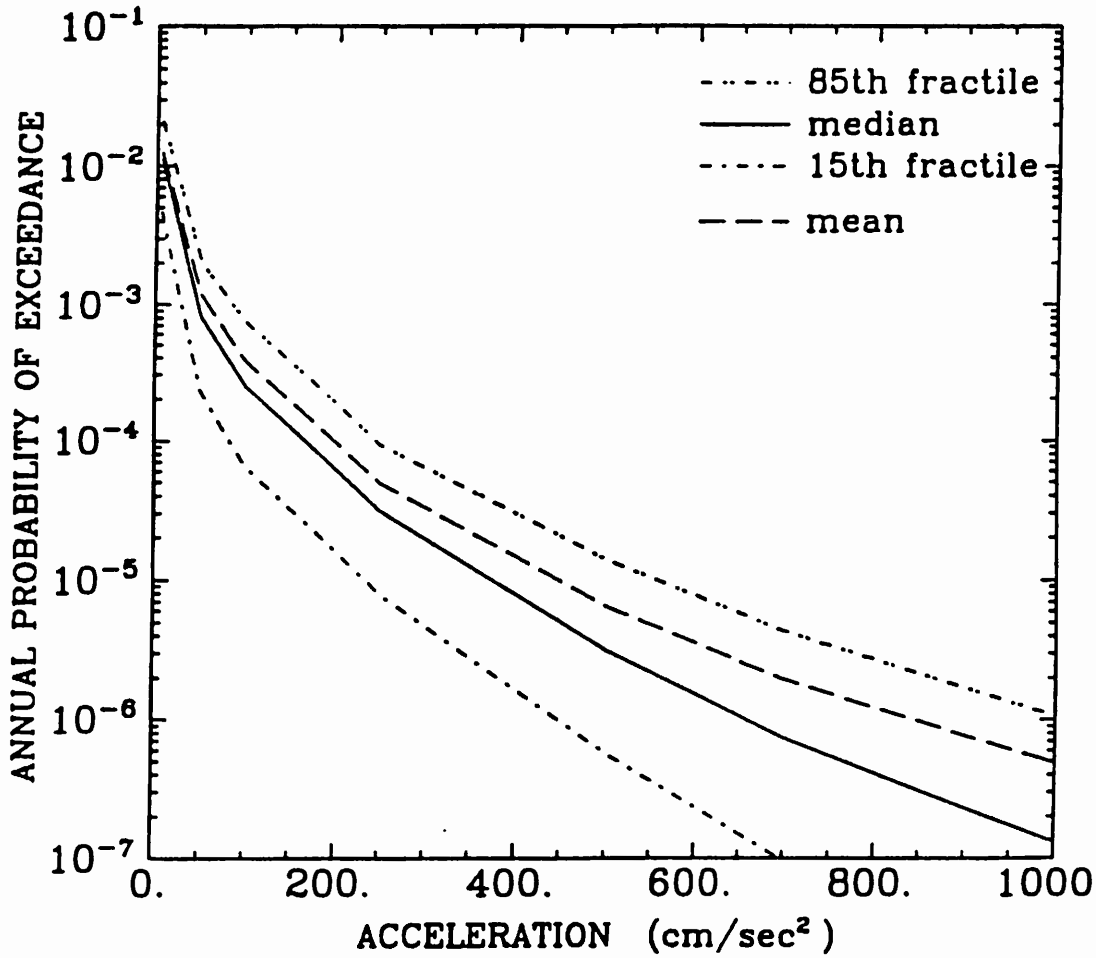
- The earthquake hazard at a given site is characterized by a hazard function giving the annual probability of exceedence of a ground motion parameter, i.e., peak acceleration, peak velocity, uniform hazard response spectrum.

- In addition to the seismic hazard curve, descriptions of the corresponding frequency characteristics of the motion are required. Response spectra and/or acceleration time histories usually serve this purpose.

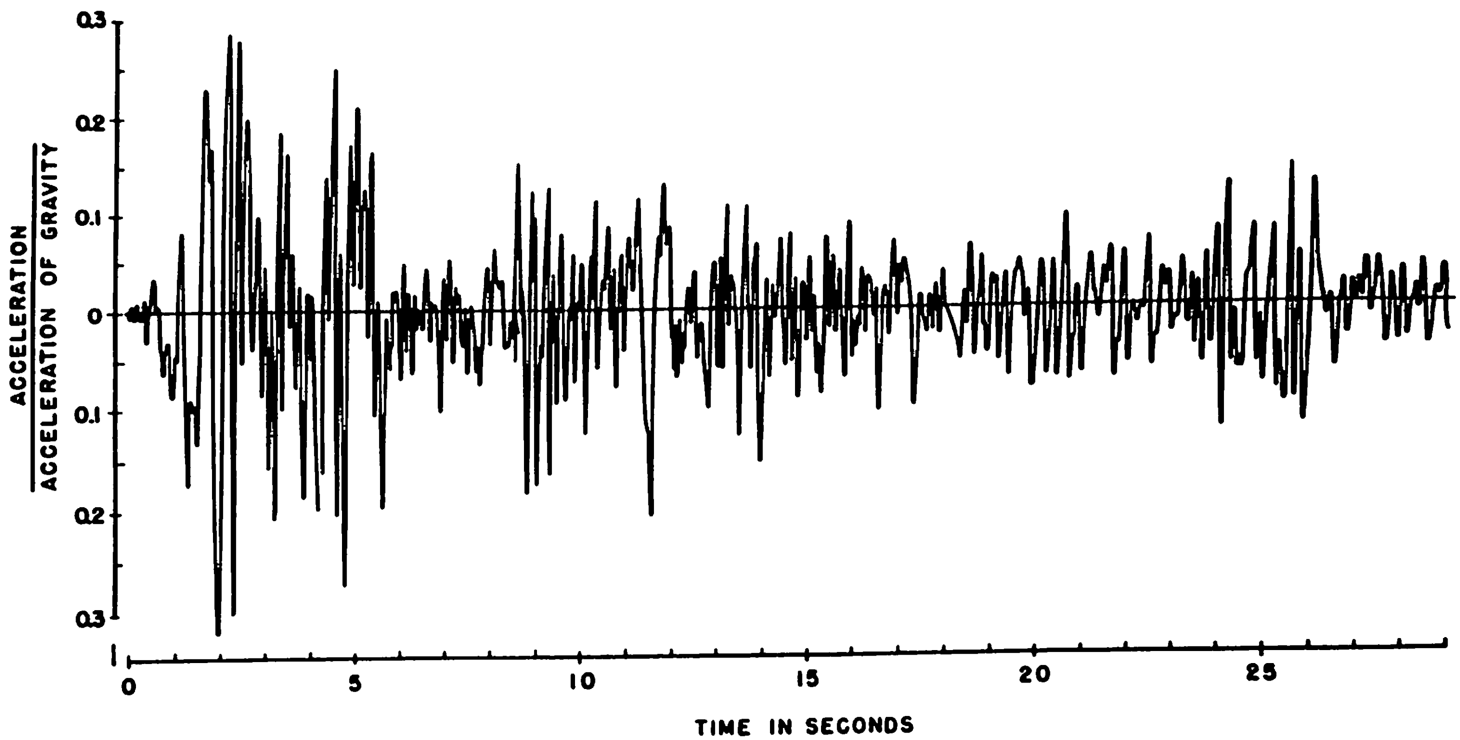
Seismic hazard analysis model



Example seismic hazard curve



Example time history

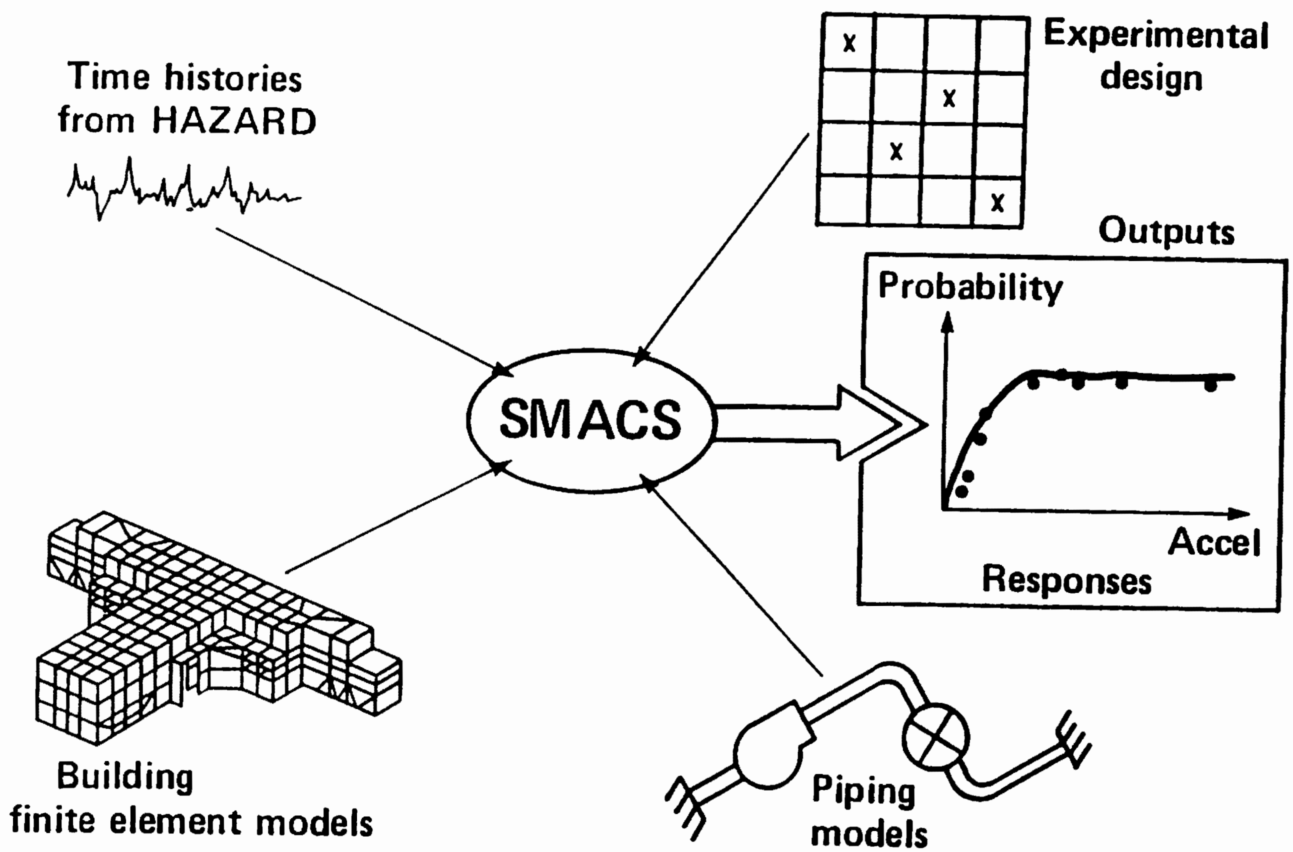


Step 2 - Determine response of structures and subsystems to seismic excitation

- For each level of earthquake described by the seismic hazard curve, three aspects of seismic response must be characterized to perform the seismic risk analysis: median response, variability of response, and correlation of responses.

- Seismic responses are required for all structures and components contained in the plant logic models (fault and event trees).

Responses were generated used the SMACS computer code



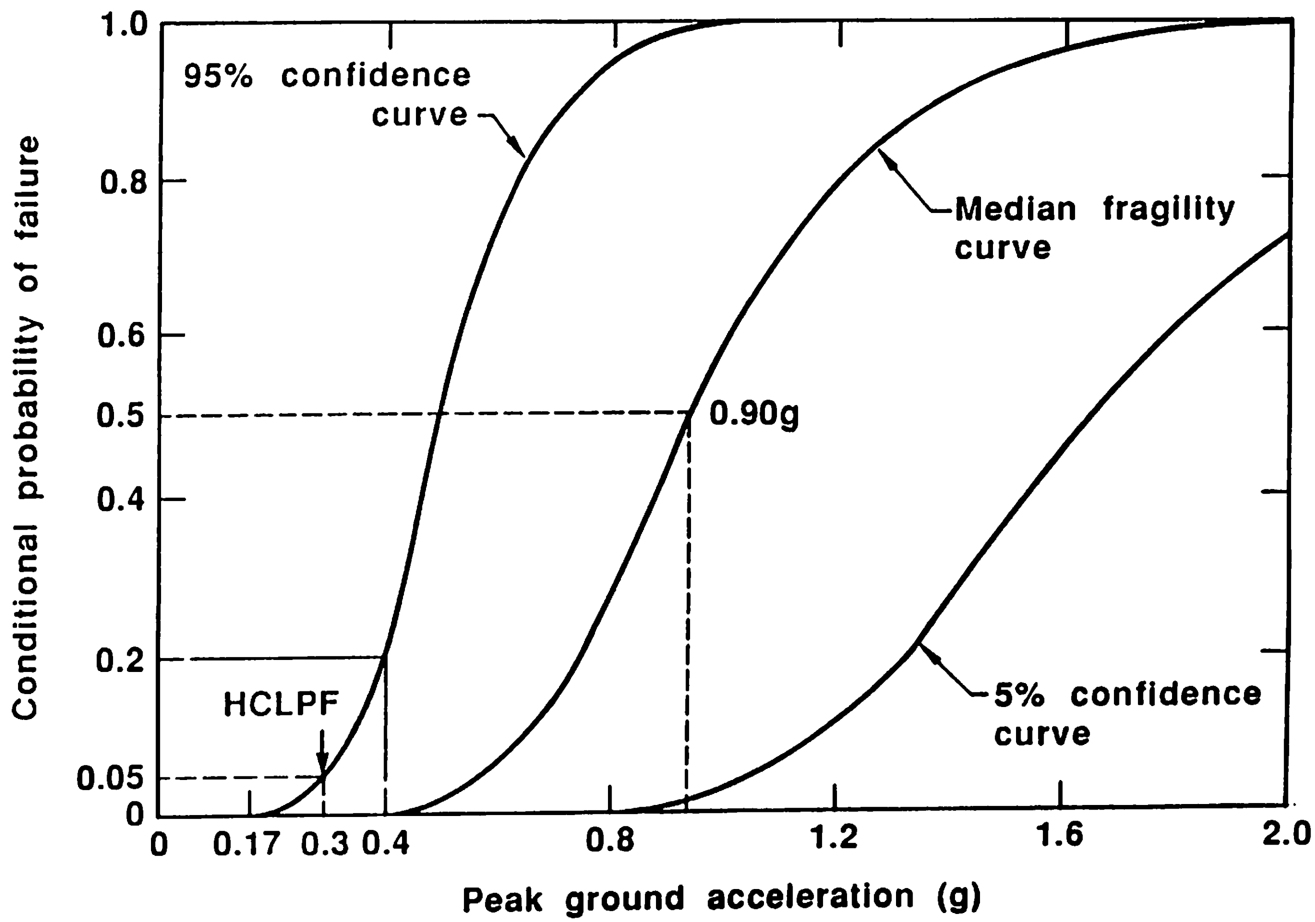
Step 3 - Determine fragility functions

- Failure (fragility) is characterized by a cumulative distribution function which describes the probability that failure has occurred given a value of loading.

- Loading may be described by local spectral acceleration, local peak acceleration, or an internal force resultant such as moment.

- SSMRP fragilities are related to the appropriate local response.

Example fragility curve



Step 4 - Identify accident scenarios

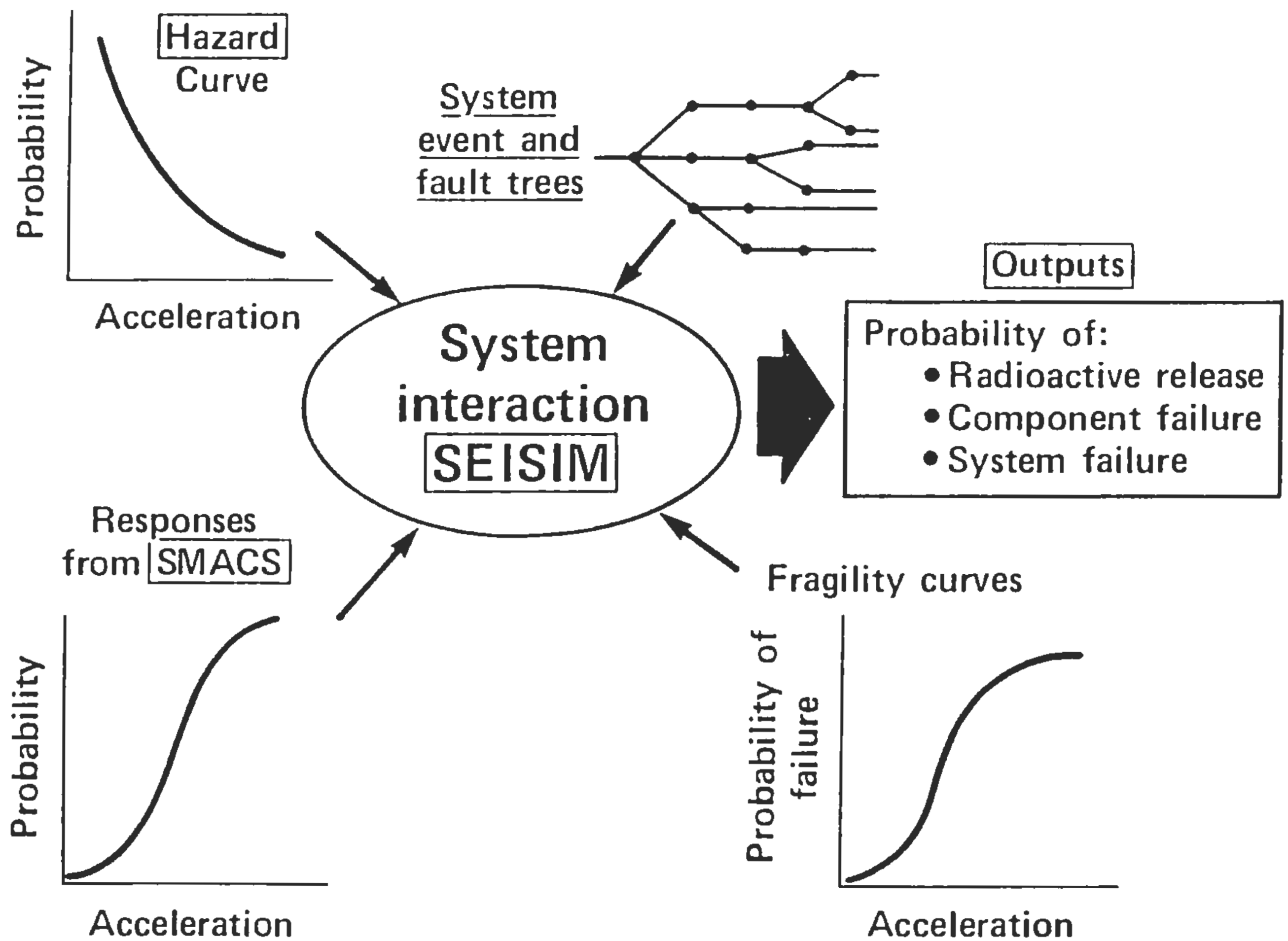
- **Possible paths that can cause the undesired event due to an earthquake-related event are identified.**

- **Events trees and fault trees can be used to determine the possible failure paths.**

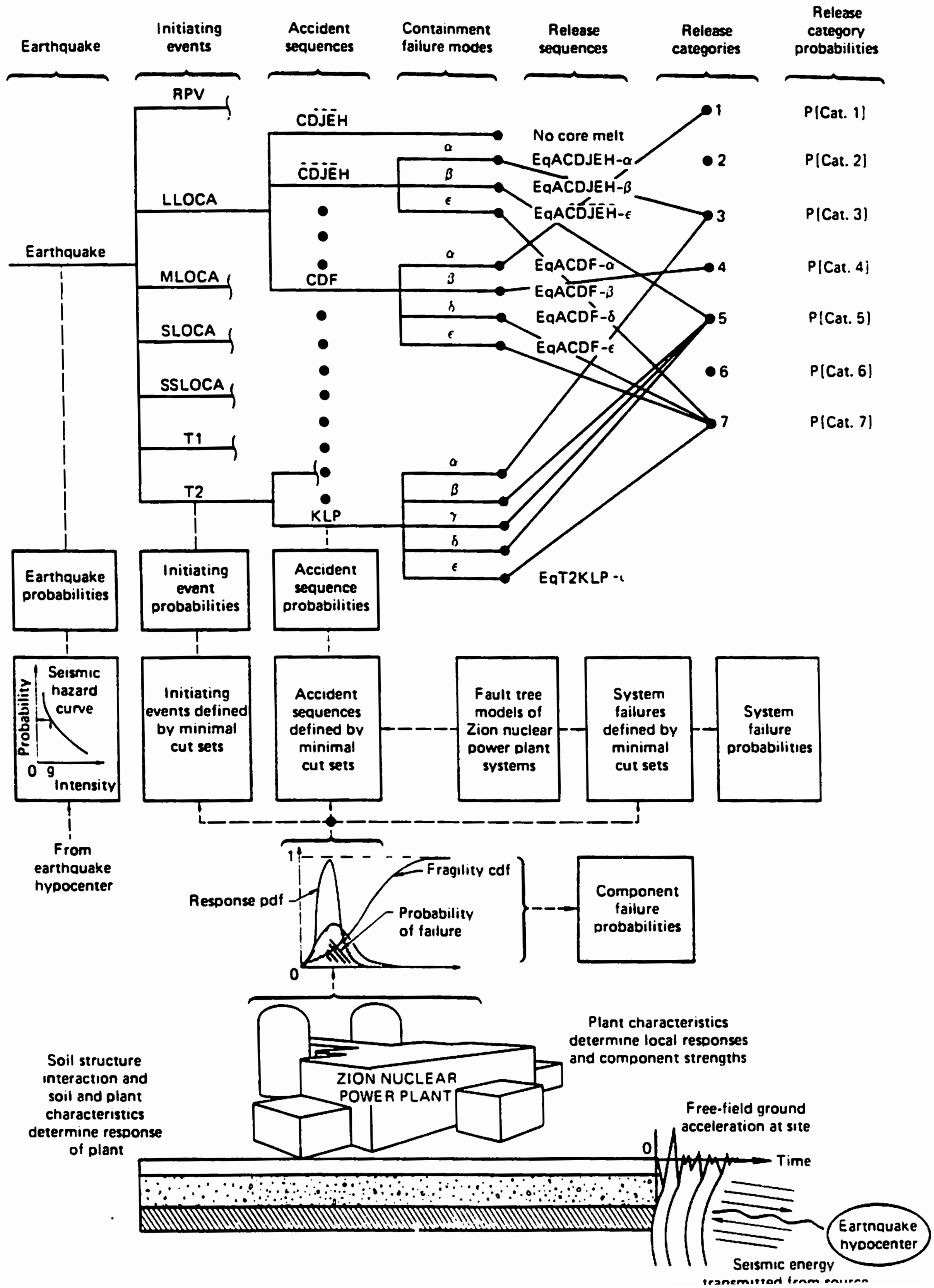
Step 5 - Calculate frequency of undesired event

- This step combines the results of steps 1-4.
- With respect to the seismic hazard at the site in question, this step calculates the following.
  - Structure and component failure probabilities.
  - Probability of failure of a group of structures and components, e.g., a system.
  - Frequency of the undesired event

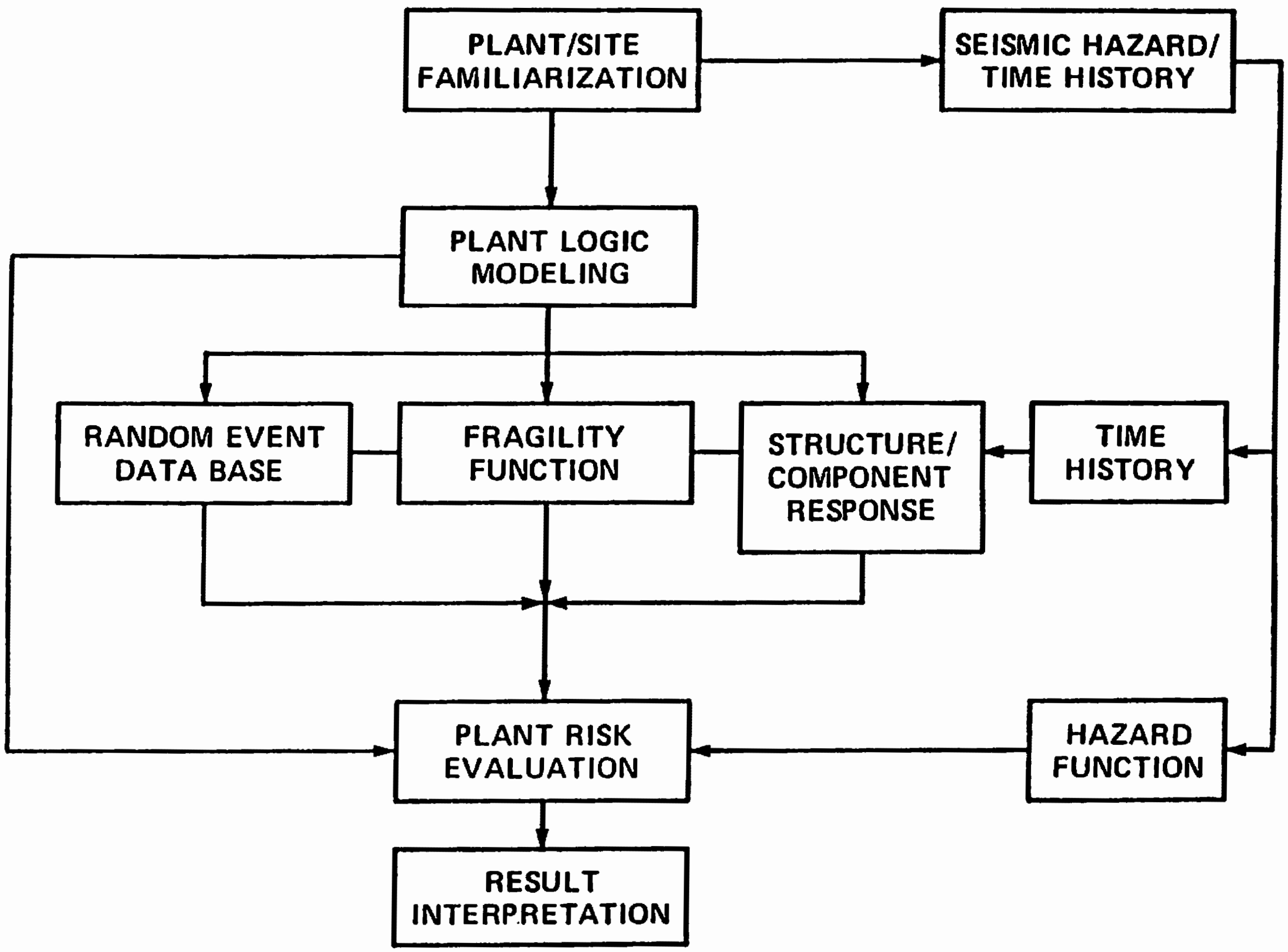
The SEISIM computer code can be used to compute system failure frequency



Description of the computational procedure embodied in SEISIM



A seismic risk assessment methodology



The 'Zion' method is an alternative to the SSMRP methodology

- Relies heavily on the use of engineering judgement to supplement sparse data and limited analysis

- Larger variabilities

- Fragilities relate to PGA rather than local acceleration

- Plant level fragilities used

- DPD arithmetic used

A simplified SSMRP seismic methodology was developed to reduce analysis time and costs

- **Eliminate need for time histories (rely on response spectra)**
- **Local responses and fragilities used**
- **Major difference is in generation of response data:**
  - **response calibration factor used (developed using design data)**
  - **correlations and response variability input rather than computed**

The S_a approach reduces some error in PGA approach transfer functions

- **Uses plant fragility approach**
- **Fragilities tied to a spectral acceleration rather than peak ground acceleration**

Fire risk has proved to be important in many facilities

- Fires have proved to be a potential initiator of multiple-system failures

- Considerable uncertainities exist in the current methodologies used in fire analyses

Fire risk methodology includes three basic tasks

These include:

1. **Identify 'critical' locations and assess frequency of fires.**

2. **Estimate fire growth times and compute detection and suppression times.**

3. **Determine response of the plant.**

Task 1: Identify 'critical' locations and assess frequency of fires

This task includes five basic steps. These include:

1. **Construct simple systems model of facility.**
2. **Identify locations of safety equipment.**
3. **Identify critical fire-impact locations, using a simple FMEA.**
4. **Identify locations adjacent to critical locations containing large quantities of combustibles.**
5. **Evaluate the distribution for fire frequency for each location.**

Task 2: Estimate fire growth times and compute detection and suppression times

This task includes four basic steps. These include:

1. **Define representative fire-growth scenarios for each location.**

2. **Determine distribution for fire-growth time for each scenario.**

3. **Determine distributions for fire detection and suppression times for each scenario.**

4. **Compute distribution of frequency of growth.**

Task 3: Determine response of the plant

This task includes three basic steps. These include:

1. **Develop event or fault tree logic that links component damage to one or more damage states.**

2. **Apply component and system failure boundary conditions to the event or fault tree logic.**

3. **Develop the distributions for the frequency of fires resulting in each damage state.**

This process requires information about several important aspects of a fire

These include:

- **ignition**
- **progression**
- **detection and suppression**
- **characteristics of materials under fire conditions**
- **plant safety functions**
- **behavior under accident conditions**

Additional research is needed in many areas

- Determining the frequency of fires
- Evaluate treatment of room-to-room spreading
- Study the effect of hot gases
- Evaluate the vulnerability of control circuitry
- Study the accuracy of suppression models
- Evaluate how to assess damage of nearby equipment
- Evaluate equipment damage due to suppression
- Study smoke control issues
- Review evaluation of manual fire-fightning effectiveness
- Study fire-earthquake linkages