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Tractor/Trailer Accident Statistics

PATRAM

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Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

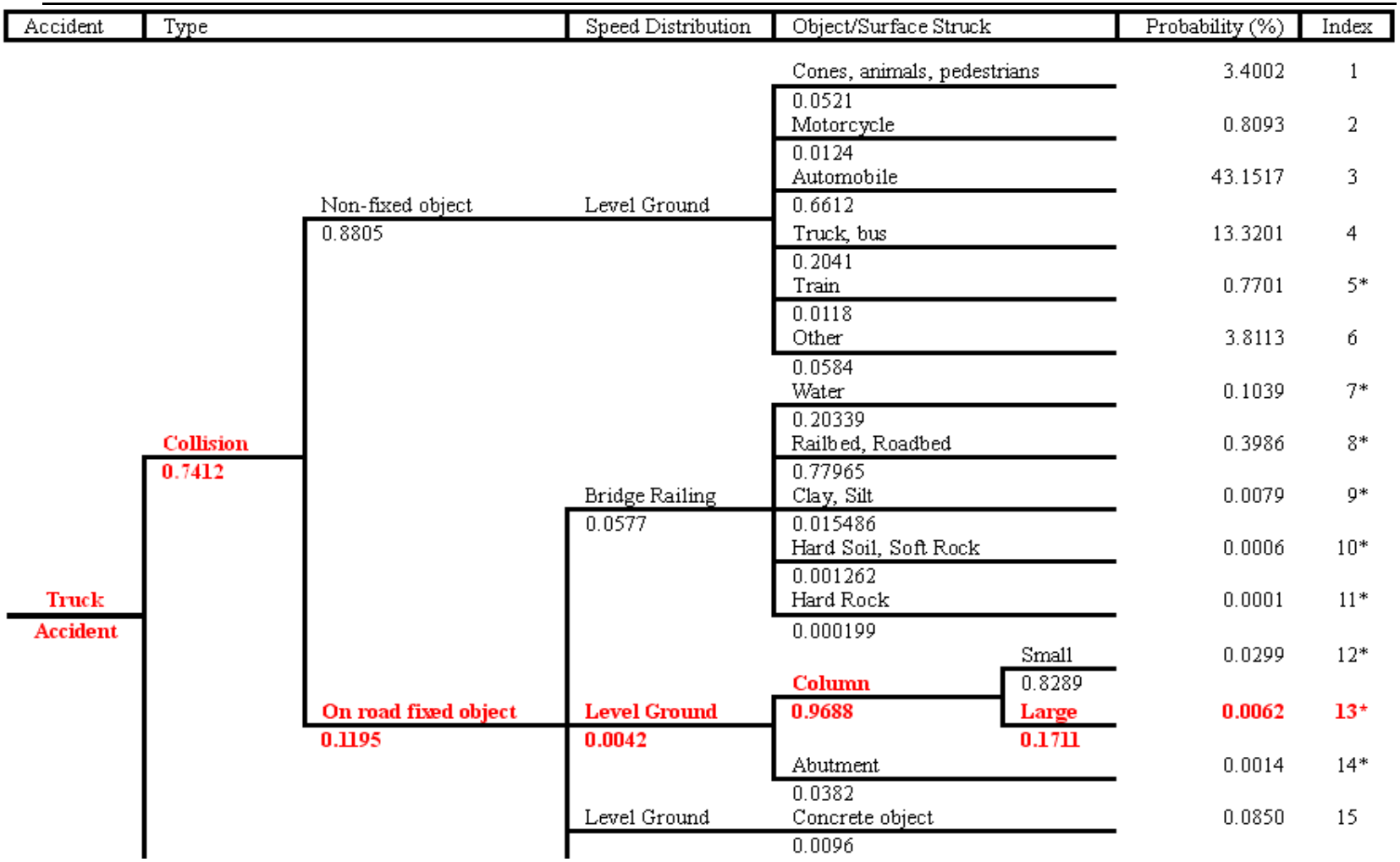
Background

- LLNL study, "Shipping Container Response to Severe Highway and Railway Accident Conditions"
  - Model Study
  - Truck accident data from 1973 through 1983
- Truck accident event tree first divides initiating events into:
  - Fires, mechanical failures, accidents where the truck overturns, or jackknife accidents where the truck leaves the road and then runs into or hits something.
  - Collisions where the truck runs into another vehicle or impacts an on-road structure.

Background

- The Modal Study used accident speed distributions to indicate whether an accident occurred:
  - At a highway/railway grade crossing,
  - On level ground (i.e., not on a steep grade),
  - Involved in a fall from a bridge, or
  - A plunge down an embankment.
- The event tree also specifies the type of object or surface struck, but does not indicate whether the impact initiates fire.
- 31 Scenarios

Modal Study Event Tree



*** Potentially significant accident scenarios.**

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Why Update the Modal Study

- During public meetings for NUREG/CR-6672 (June 2002)
  - Concerned citizens felt the study was outdated
  - Recommended event tree should be reconstructed using recent accident truck data
- As a result, a new analysis was performed to construct:
  - A new truck accident event tree, including the fractional occurrences of route wayside surfaces
  - New truck accident speed distributions and new estimates of truck accident fire probabilities

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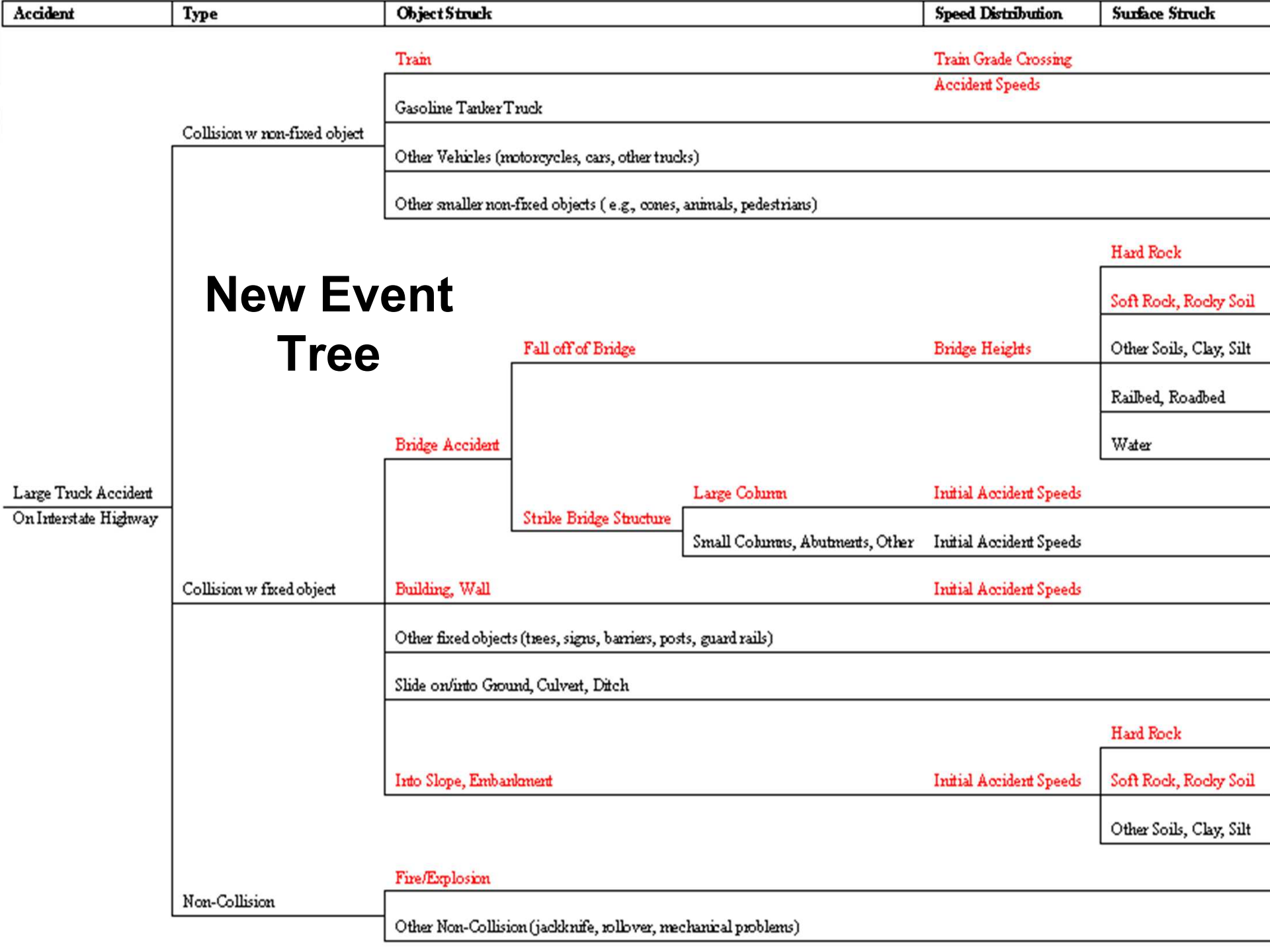
New Event Tree Structure

- Truck casks are massive and robust only high speed impacts into:
  - Train, hard rock outcrop, large steel reinforced concrete support column
- Reduction of Modal Study accident paths
  - A small and/or not very strong fixed object
  - A small and/or relatively soft non-fixed object
  - A yielding surface
  - Several non-collision paths
    - mechanical failures
    - truck jackknifes
    - truck overturns

New Event Tree



Database Review

- Three US DOT databases were considered:
  - Fatality Analysis Reporting System
  - Motor Carrier Management Information System (Analysis Division of FMCSA)
  - General Estimates System (NHTSA)
    - Most accurate data for this study

Accident Probability

The probability, P, that a truck carrying a SNF cask will be involved in an accident severe enough to release RAM:

$$P = P_{accident} \times F_{severity}$$

$$F_{severity} = P_{scenario,j} \times P_{speed}$$

$$P_{accident} = \sum_{i=1}^{n} L_i R_i$$

Where:

- L_i = the length (km) of the i^{th} segment on the shipment route
- R_i = the truck accident rate of the i^{th} segment on the shipment route
- $F_{severity}$ = the severity of the accident for collisions that don't initiate fires
- $P_{scenario,j}$ = the probability of collision accident "j"
- P_{speed} = the probability that this accident scenario occurs at a particular speed

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Accident Probabilities for Fire

Calculations indicated a partially engulfing fire regardless of duration can't fail SNF rods by burst rupture, but may fail elastomeric seals by thermal degradation. Thus:

$$P_{fire\_severity} = P_{colocated} \times P_{optically\_dense} \times P_{temperature} \times P_{duration}$$

Where:

$P_{colocated}$ = the probability that the fire and the cask are co-located

$P_{optically\_dense}$ = the probability that the fire diameter is just large enough to make the fire's flame envelope optically dense with respect to radiation of heat from the cask through the flame envelope to the atmosphere

$P_{temperature}$ = the probability that the fire fuel burns hot enough to raise the cask to temperatures of concern (seal failure or rod burst rupture temperatures)

$P_{duration}$ = the probability that the fire burns long enough for these temperatures to be reached.

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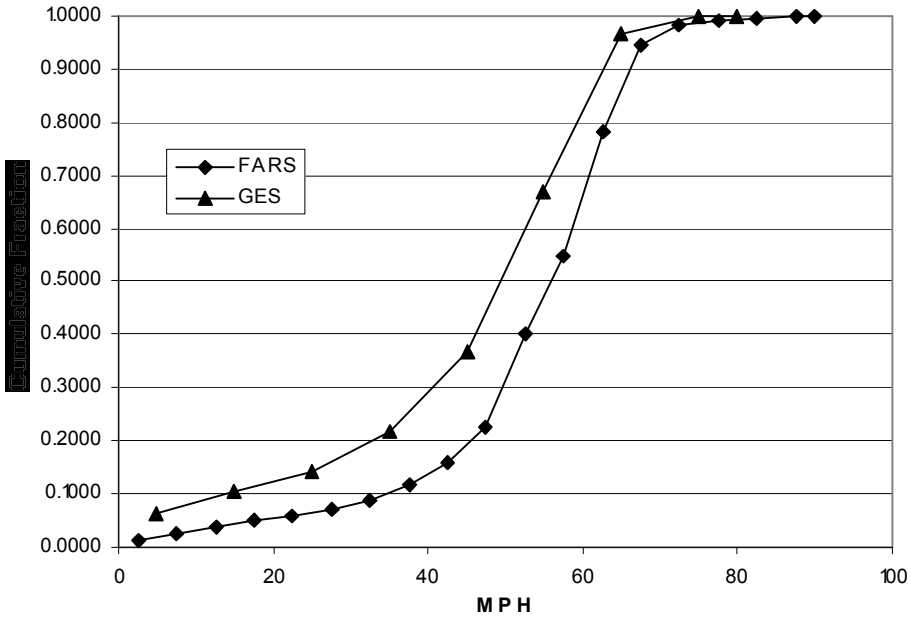
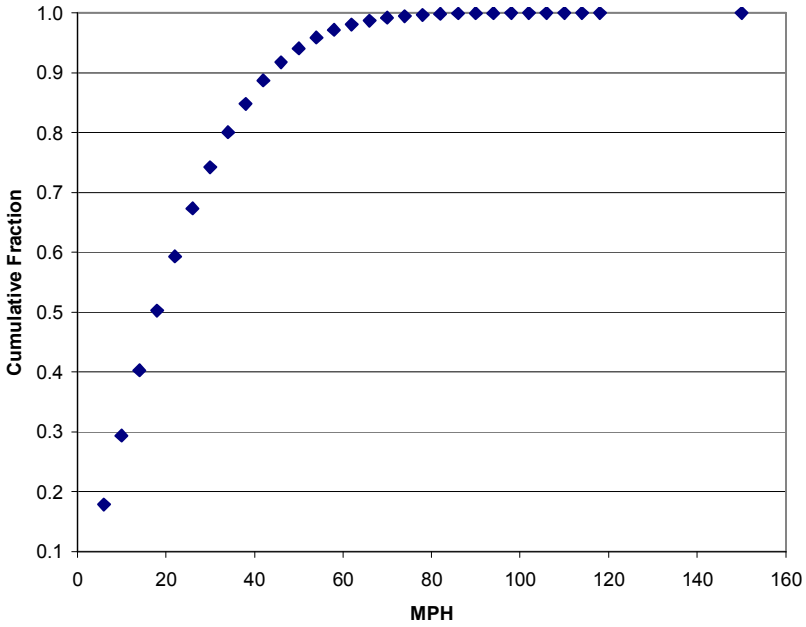
Speed Distributions



CDF - Truck Speeds at Accident Initiation



CDF - Highway/Railway Grade Crossing Accident Train Speeds

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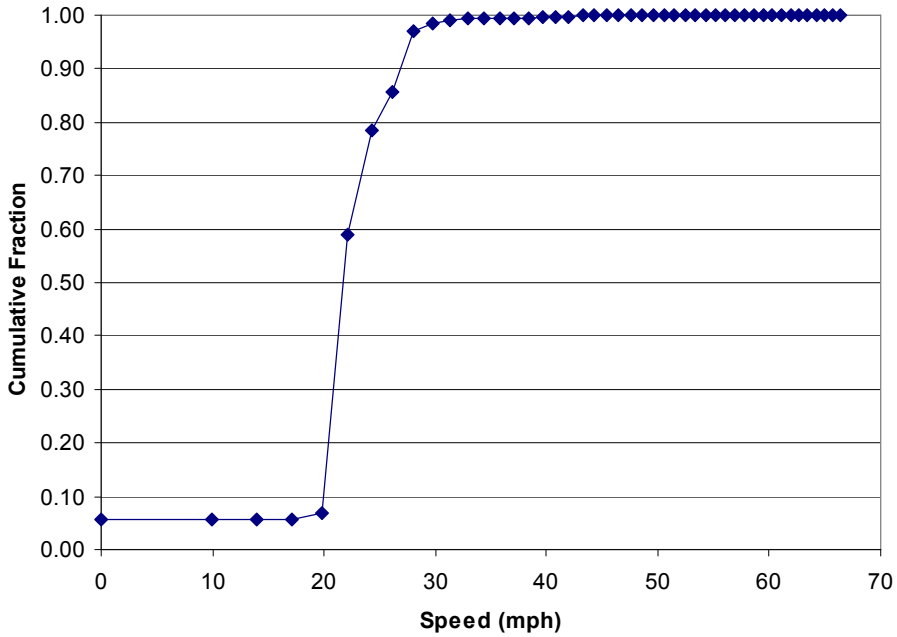
Speed Distributions Continued



CDF – Truck Impact Speed from Bridge Fall

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Fire Distributions

CDF - Fire Duration Distributions for Truck/Truck, Truck/Train, and Truck/Tanker Truck Fire Accidents

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Comparison

Object Struck	Surface Struck	Modal Study (MS)	This Study (TS)	TS/MS
Train		7.70×10^{-3}	8.20×10^{-4}	0.11
Bridge	Hard Rock	1.00×10^{-6}	3.46×10^{-6}	3.46
	Soft Rock/Rocky Soil	6.00×10^{-6}	3.18×10^{-6}	0.53
Large Column		6.20×10^{-5}	1.00×10^{-4}	1.61
Small Column, Abutment		2.99×10^{-4}	3.29×10^{-3}	11.00
Building, Wall		8.50×10^{-4}	5.90×10^{-4}	0.69
Slope, Embankment	Hard Rock	4.67×10^{-4}	1.40×10^{-4}	0.30
	Soft Rock/Rocky Soil	2.96×10^{-3}	1.20×10^{-4}	0.04
Fire/Explosion		9.71×10^{-3}	6.30×10^{-3}	0.65

Conclusions

- Severe accidents have not been found to be significantly greater than those estimated in the Modal Study
- Some of the branch-point fractions and scenario probabilities have been reconstructed
  - None of the differences are expected to significantly alter the risks posed by SNF truck cask accidents.
- Truck/Train collisions are estimated to be 100 times less probable in this study
  - Little effect since truck/train collisions are not likely to cause cask failure
- Accidents with large columns and hard rock slopes are estimated to be somewhat more likely (70% increase)
- Both studies found the chance of fire-only accidents to be about the same (0.63% vs. 0.97%)