Event Tree Analysis of Accidents During Transport of Radioactive Materials in Japan: The Assessment of A Tunnel Fire

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INTRODUCTION

Construction of a nuclear-cycle facility at Rokkasho-mura in Japan's Aomori Pref. is being planned. Its uranium enrichment plant is already operating. Motor carriers and ships are being used to transport SF, UF6, LLW, etc., in Japan and from overseas. As Japan is very mountainous, it is necessary to investigate the possibility of a tunnel fire and a fall from a bridge in evaluating the safety of transporting radioactive materials (RAM). Accident scenario probabilities and their environmental effects should be investigated, particularly since some routes pass through urban areas.

To establish Probabilistic Safety Assessment (PSA) for transport of RAM in Japan, effective methods and assessment examples were investigated and discussed, and accident data were collected and evaluated.

CONCEPTS OF PSA

Our PSA approach for transport of RAM has two views, one all-inclusive and the other local. The all-inclusive PSA examines the entire route to assess latent risks. The local PSA checks critical sites to discuss emergency plans. Table 1 describes the comparison between them.

Table 1. Comparison Between All-inclusive and Local

	TARGET	PURPOSE	MAIN METHODS
All-inclusive PSA	Whole route	Assess latent risks	Fault Tree Analysis
Local PSA	Critical sites	Check emergency plans	Event Tree Analysis Fault Tree Analysis

LOCAL PSA

CONCEPTS OF LOCAL PSA

The local PSA checks specific events at critical sites in order to discuss whether emergency plans are sufficient. Event Tree Analysis is used for this purpose. Event Tree Analysis evaluates accident probabilities under various safeguards.

A specific incident at a specific point is set up as an initial event. An Event Tree is drawn up with due regard to possible safeguards and scenarios. The development key events are expanded by Fault Trees. Probability assignment to basic events of the Fault Tree decides the value of the development key of the Event Tree.

On the Safety Assessment, MIT Risk and Protection Level are used for Risk Indexes. MIT Risk and Protection Level are defined as follows:

$$\text{(MIT RISK)} = \frac{\text{(POTENTIAL HAZARD)}}{\text{(SAFETYGUARD EFFECT)}}$$

$$= \frac{\text{(INITIAL EVENT)}}{\text{(INITIAL EVENT)} - \text{(TARGET EVENT)}}$$

$$\text{(PROTECTION LEVEL)} = \frac{1}{\text{(MIT RISK)}}$$

AN EXAMPLE APPLICATION - THE TUNNEL FIRE

Background

In 1979, a large fire occurred in Nihonzaka tunnel (length: 2050 meters) on Tomei Highway (Tokyo - Nagoya) due to a severe car accident. The fire kept burning for 130 hours and the temperature was estimated between 600 ℃ ～ 1000℃ on the wall. As there are many tunnels in Japan, tunnel fires become the object of public attention.
In this example, local PSA is applied to the tunnel fire.

Analysis Conditions

Local PSA is attempted on the follow conditions:

INITIAL EVENT : a car engine fire in the tunnel

ACCIDENT TYPE: car fire, tunnel fire, more severe fire than design standard (800℃ -30minutes), injury or death

SUBJECT: driver of other cars, staff, firemen, neighbors

DEVELOPMENT KEY: fire-fighting, evacuation, influence on environment (Figure 1 includes only fire-fighting.)

Event Tree

Figure 1 shows the Event Tree whose initial event is "A fire of the car engine in the tunnel". The probability that the fire exceeds the design standard is calculated. The Fault Tree determined the probability of the Development Key.

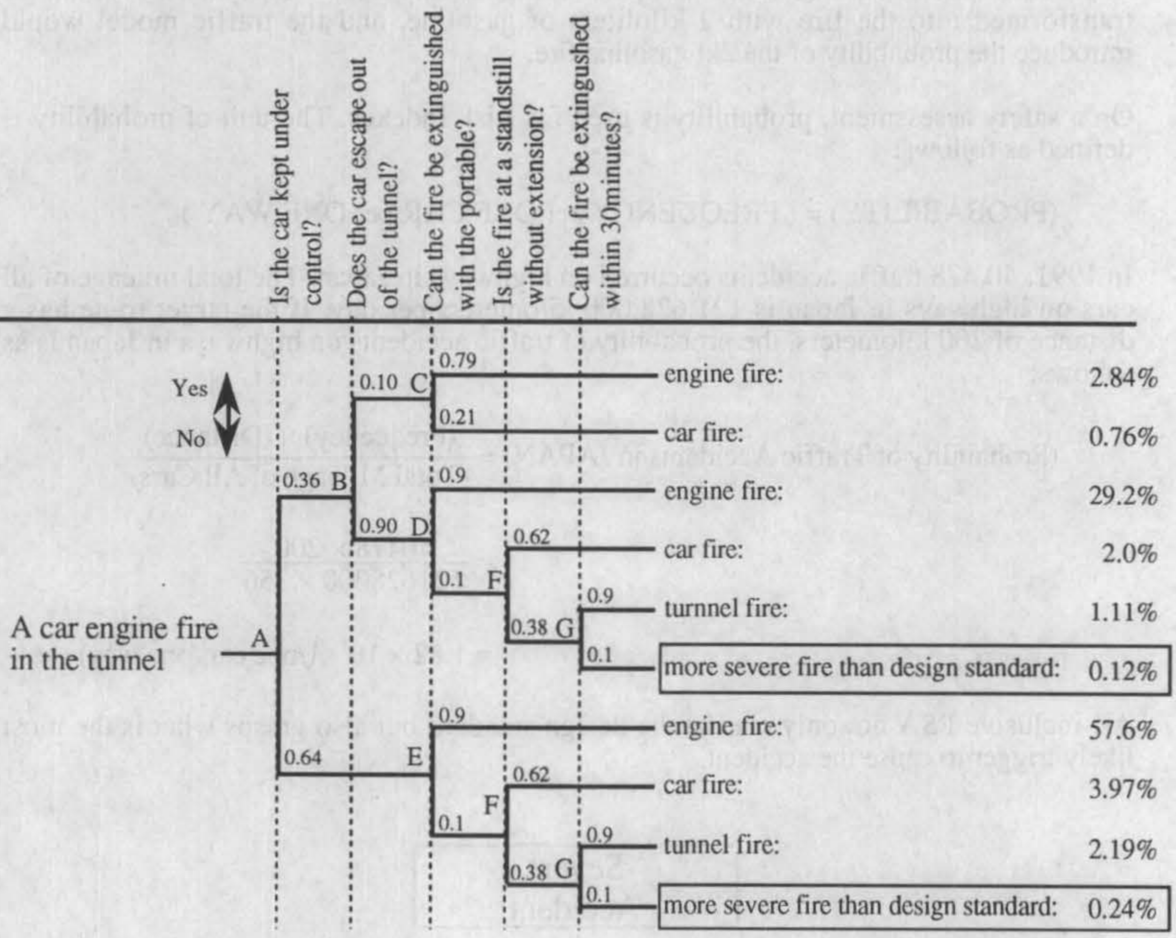

Figure 1 The Event Tree for Local PSA

Safety Assessment

MIT Risk and Protection Level is as follows;

$$(\text{MIT RISK}) = \frac{(\text{INITIAL EVENT})}{(\text{INITIAL EVENT}) - (\text{TARGET EVENT})}$$

$$= 1.0037$$

(PROTECTION LEVEL) = 99.6%

ALL-INCLUSIVE PSA

All-inclusive PSA examines whole routes because of Regulatory Review and Risk Level Assurance. The origins of the accident exceeding the design standard are pursued through Fault Tree Analysis. The latent risk on the transport of RAM is measured through statistical data (traffic accidents, traffic volume, fire, et al.).

The Fault Tree should be tuned to statistical data. The 800℃ -30min. fire would be transformed into the fire with 2 kiloliters of gasoline, and the traffic model would introduce the probability of the 2kl gasoline fire.

On a safety assessment, probability is used for Risk Indexes. The unit of probability is defined as follows:

(PROBABILITY) = (FREQUENCY per ONE CAR per ONE WAY)

In 1991, 40,478 traffic accidents occurred on highways in Japan. The total mileage of all cars on highways in Japan is 121,628,000 kilometers per day. If the target route has a distance of 200 kilometers, the probability of traffic accidents on highways in Japan is as follows:

$$\text{(Probability of Traffic Accidents in JAPAN)} = \frac{\text{(Frequency)} \times \text{(Distance)}}{\text{(Total Mileage of All Cars)}}$$

$$= \frac{40478 \times 200}{121628000 \times 356}$$

$$= 1.82 \times 10^{-4} \text{(/one car /one way)}$$

All-inclusive PSA not only checks the design standard but also grasps what is the most likely trigger to cause the accident.

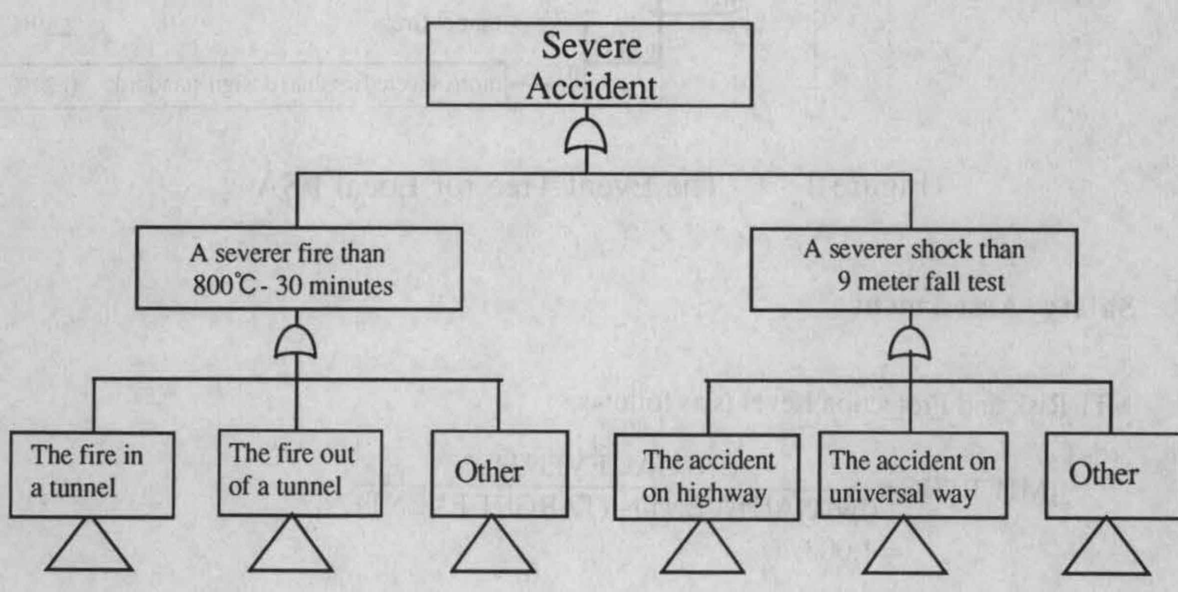

Figure 2 Fault Tree for All-inclusive PSA

CONCLUSION

Two views were proposed for PSA on the transport of RAM. One is the all-inclusive PSA, which studies the entire route to determine the latent risk. Another is the local PSA, which checks the key point to discuss the emergency plan.

For the example of local PSA, tunnel fire safety probabilities are determined. This Event Tree finds these suggestions:

(1) It is important to extinguish the fire at first step.

(2) If a severe accident happens, the scene should be promptly sealed off.

In this paper the example of all-inclusive PSA could not be determined. In the next paper, a comparison between Japan and other countries will be made to determine Japan's specific latent risk.

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