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A Systemic Approach to a Railway Accident Scenario Analysis Using a Quality Function Deployment

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Background

- Risk assessment of Railway system

Accident Risk Analysis

Frequency Analysis

Consequence Analysis

Interaction analysis between hazardous events and hazardous condition

Hazard Identification / Preliminary Hazard Analysis (PHA)

Accident Analysis

Safety regulations, Published sources

Accident related reports

√ Prerequisite to understanding how hazardous events and hazardous condition contributes to an accident

√ Examining the etiology of accidents and analyzing the detailed sequence of events

√ Provide a clear picture of accidents

Background

- **Accident Analysis Method**

○ FMEA (**Failure Mode and Effect Analysis)**
○ **FTA (Fault Tree Analysis)**
○ **MORT (Management Oversight and Risk Tree)**
○ **Fault Hazard Analysis**
○ **STEP (Sequentially Time Event Plotting)**
○ **SCAT (Systemic Casual Analysis Technique)**

"At the early stage of risk assessment,
These method can be subjective depending on analysts' personal experience
and be difficult to make a systematic analysis in a general view"

- **Accident Scenario Analysis Method**

" Process of understanding, analyzing, and describing accidents and the behavior patterns of hazardous conditions" - Cushman and Rosenberg, Human Factors in product design, 1991-

" Devise a limited number of accident scenarios with descriptions of victims, products, environment, and task" - Drury and Brill, Human Factors, 1983-

Research Objectives

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"Although much work has been done to apply scenario analysis to railway accidents, there is still no systematic and formal methodology which identifies generates, analyzes, and verifies accident scenarios, in our view. "

The absence of such a methodology raises questions regarding accuracy and objectivity

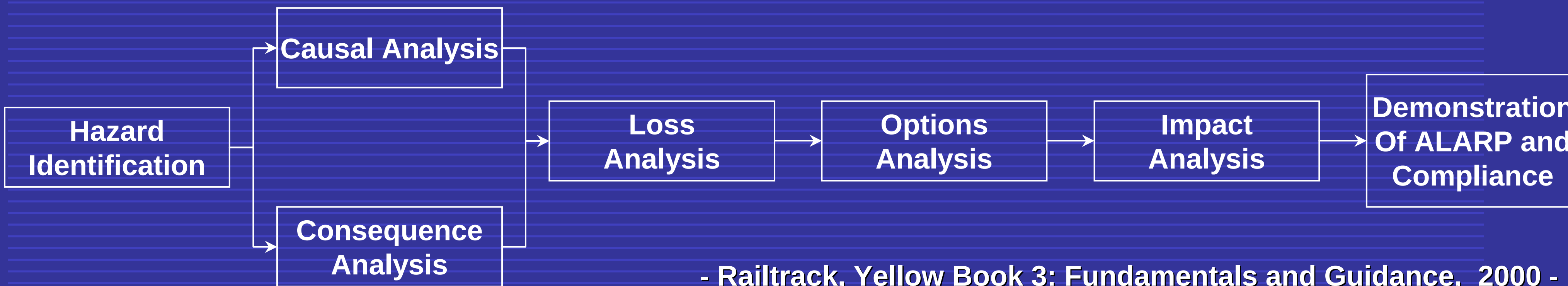
Research Objectives

Devise an accident scenario analysis method for creating Railway accident scenarios at the PHA step of a hazard analysis for railway system

- **Inspired by the Quality Function Deployment (QFD) method**
  - **conventionally used in quality management**
  - **used at the systematic accident scenario analysis (SASA) for the design of safer products**
- **The QFD provides a formal and systematic schema to devise accident scenarios while maintaining the objectivity.**

Risk Assessment Process

"Risk assessment entails a systematic analysis of the potential losses associated with the change and of the measures for reducing the likelihood or severity of the losses. "



- Railtrack, Yellow Book 3: Fundamentals and Guidance, 2000 -

"Risk assessment is tightly coupled with hazard identification and risk reduction"

- The PHA, often called hazard identification, is used in the early life cycle state

  - Identifying critical system functions and system hazard factors.

  - Understanding how hazard factors contribute to railway accidents

  - Understanding, analyzing, and describing the accident process

  - This can be accomplished by applying the accident analysis method

Preliminary Hazard Analysis (PHA)

Input Data for Analysis

- ○ Hazardous event lists generally considered for railway system
- ○ Hazard analysis scope
- ○ Definition of severity and frequency levels for hazardous conditions
- ○ System Description

Preliminary Hazard Analysis

- ○ Selection of a hazardous event from hazardous event lists
- ○ Evaluation of the frequency and the severity for the hazardous event
- ○ Definition of hazardous conditions to initiate the hazardous event
- ○ Description of hazardous conditions
- ○ Analysis of influence on the hazardous event for each hazardous condition
- ○ Evaluation of hazard levels for each hazardous condition
- ○ Definition of control measures for each hazardous condition
  - Corrective or preventive measures, possible safeguard, and recommended action
- ○ Verifying that control measures effectively control hazardous conditions

Expected Output

- ○ Severity and frequency levels of hazardous conditions related to a hazardous event
- ○ Potential hazard factors
- ○ Risk reduction alternatives

Quality Function Deployment (QFD)

is conventionally used in quality management

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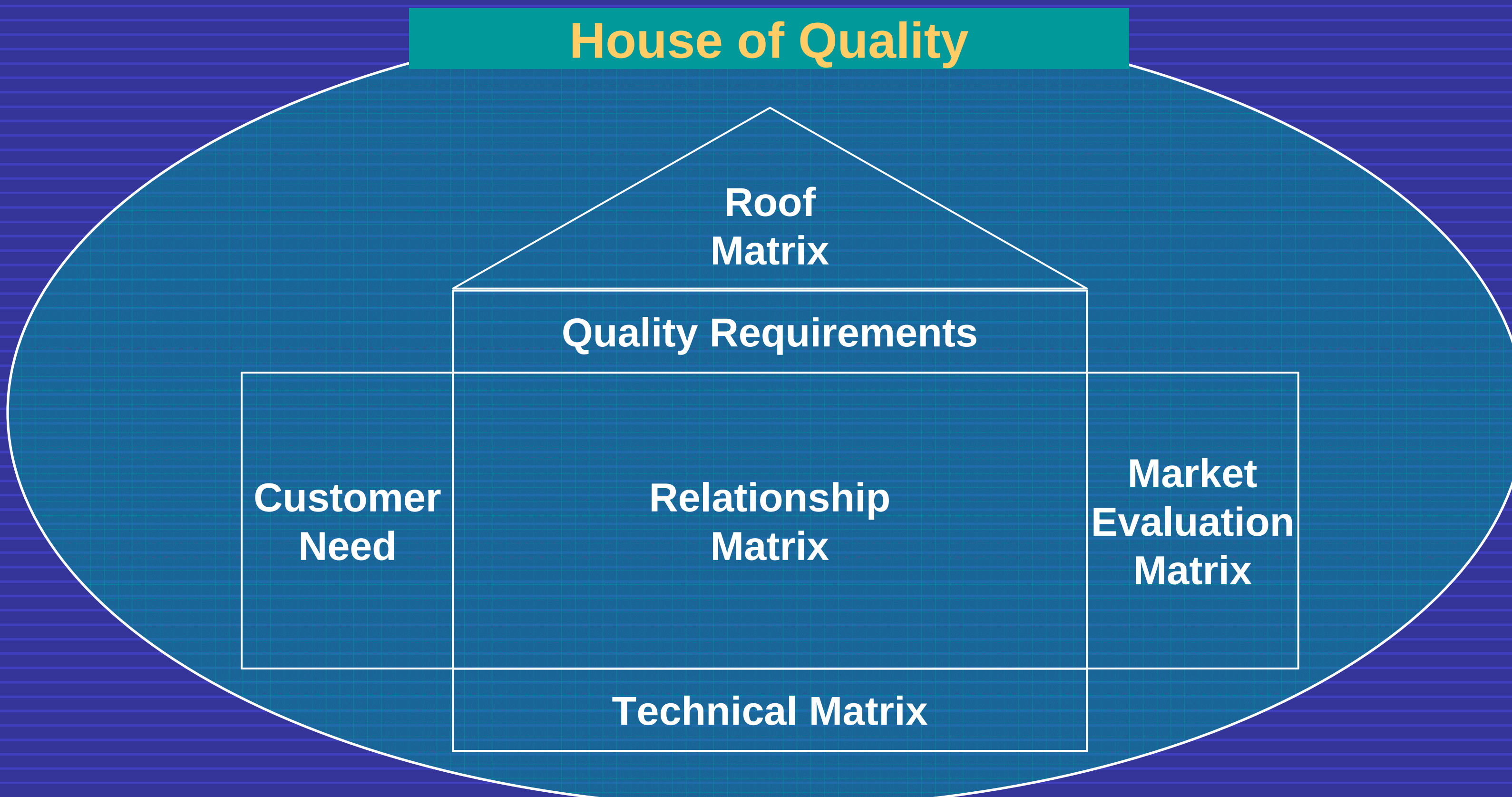
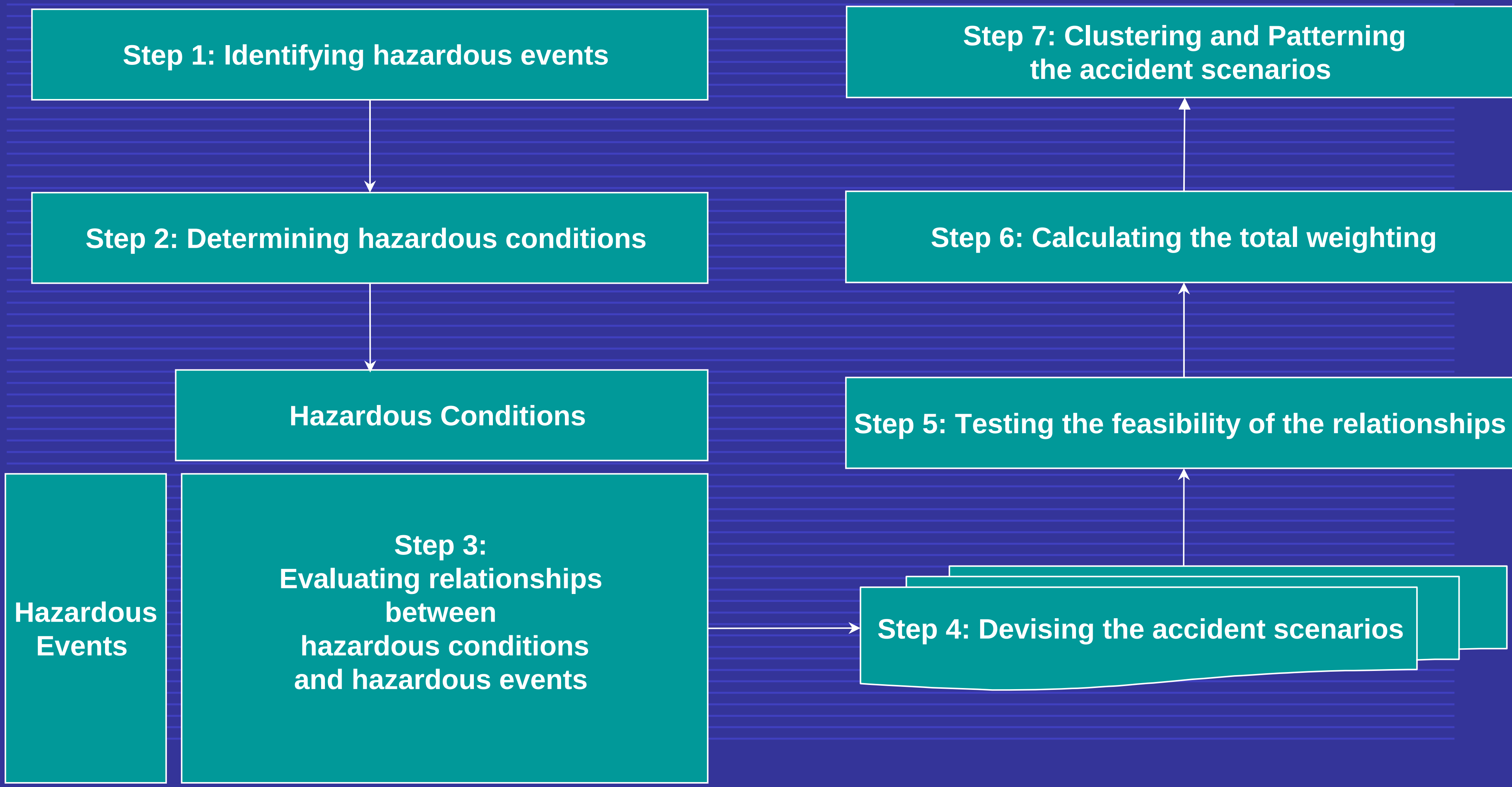
"The QFD method is conventionally used in quality management .

The QFD method provides a way to incorporate customer needs into product development and production. "



In QFD, the relationship between customer needs and the quality requirements necessary to produce those needs are charted as House of Quality (HOQ).

Railway Accident Scenario Analysis Approach



Identifying hazardous events & Determining Hazardous Conditions

Step 1: Hazardous events Identification

- ○ This step is probably the most important in that it can pinpoint the safety problems
- ○ Carried out mainly by gathering various accident-related reports and information to define hazardous events such as collisions, derailments, explosions, etc.
- ○ A series of hazard evaluation approaches as FMEA, FTA can be also used.

Step 2: Hazardous Conditions Determination

- ○ characteristics and circumstances surrounding a railway accident.
- ○ In case of a product use accident, Drury and Brill makes hazardous conditions composed of a product, a user, a task and an environment.
- ○ For railway accidents, this study makes hazardous conditions composed of the four parts: (1) victim, (2) task, (2) environment, and (4) cause.

		Hazardous Conditions											
		Victim Characteristics			Task Characteristics			Environment Characteristics			Cause Characteristics		
Hazardous Events	Importance	1	2	••	1	2	••	1	2	••	1	2	••
Hazardous Event 1													
Hazardous Event 2													
.													
.													
Hazardous Event N													

Relationship Rating Indication

◎: Strong relationship (5)
△: Moderate relationship (3)
○: Slight or possible relationship (1)

Evaluating Relationships

		Hazardous Conditions											
		Victim Characteristics			Task Characteristics			Environment Characteristics			Cause Characteristics		
Hazardous Events	Importance	1	2	••	1	2	••	1	2	••	1	2	••
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·													
·													
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Step 3: Evaluating Relationships

○ The QFD method is rated based on the results of questionnaires and the direct experience of the QFD development team

○ The proposed method

- rates the importance of a hazardous event by computing the severity of the hazardous event (e.g. equivalent fatality per year)
- evaluates relationship by computing the frequency.
- the ratings are generally weighted with 1 to 5 or 1 to 9 scales with the larger number indicating greater importance or stronger relationship.

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Devising the accident scenarios & Testing the feasibility of the relationships

Step 4: Devising the accident scenarios

- ○ The scheme, ‘railway accident analysis tableau’, creates scenarios from a matrix of all the possible relationships
- ○ For example, if any hazardous event is related to
  - four victim characteristics, two task characteristics, three environment characteristics, and one cause characteristic,
  - devise a total of 4×2×3×1 = 24 accident scenarios.

Step 5: Testing the feasibility of the relationships

- ○ filter out infeasible relationships between elements of the hazardous conditions
  - mitigating the need to devise and analyse the accident scenarios

		Hazardous Conditions											
		Victim Characteristics			Task Characteristics			Environment Characteristics			Cause Characteristics		
Hazardous Events	Importance	1	2	••	1	2	••	1	2	••	1	2	••
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Calculating the total weighting & Clustering and Patterning the accident scenarios

		Hazardous Conditions											
		Victim Characteristics			Task Characteristics			Environment Characteristics			Cause Characteristics		
Hazardous Events	Importance	1	2	••	1	2	••	1	2	••	1	2	••
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Step 6: Calculating the total weighting

- ○ To calculate the total weight for each railway accident scenario,
  - The importance of the hazardous event is multiplied by each of its corresponding hazardous conditions,
  - then added together to get the total.
- ○ The highest ranked railway scenario describes the most hazardous case.

Step 7: Clustering and Patterning the accident scenarios

- ○ The process may create too many railway accident scenarios to be dealt with.
- ○ In order to understand the hazardous condition thoroughly, the clustering and pattering processes are introduced.
- ○ These processes make the proposed method an easier and simpler railway accident analysis method.

Conclusions

"devise an accident scenario analysis method for creating accident scenarios at the PHA step of a hazard analysis for railway system"

- This approach was inspired by the QFD method.
- In this study, the QFD method provides a formal and systematic schema to devise accident scenarios while maintaining the objectivity.
- The accident scenario analysis method first identifies the hazardous events and explains the hazardous conditions

"Since this method enables an accident scenario analysis to be performed systematically as well as objectively, this method is useful in building better accident prevention strategies"

○ This method is useful in building better accident prevention strategies.

○ This study could serve to reduce railway accidents and could be an effective tool for a hazard analysis.

Thanks for the attention!