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Risk and Security Assessment of Container Supply Chains

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Agenda

- **Introduction**
  i) Necessity of the study
  ii) Aim of the study
- **Operational process of container supply chains (CSCs)**
- **Historical failure data analysis**
- **Risk characteristics of CSCs (problem analysis)**
- **Advanced risk and security assessment models**
  i) Fuzzy rule based Bayesian reasoning for assessing hazards
  ii) Threat-based Bayesian reasoning
  iii) A method of modelling both hazards and threats with dependency.
  iv) Multiple dynamic attribute decision making

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Introduction

Necessity of the study

- Over the past several years there has been a growing international recognition that security and risk issues of marine systems, such as CSCs, need to be reviewed urgently.
- Serious accidents prompted this urgency including:
  - 9/11 terrorist attacks in 2001,
  - Lock-out of the American West Coast Ports in 2002,
  - Blast on the Madrid commuter trains in 2004
  - Blast on the London commuter buses and underground trains in 2005.
- Safety and security in the chains are facing an unprecedented challenge.
- Traditional engineering-based risk assessment methods and safety protective measures may be inadequate to deal with the threats from uncertain environments, especially in the era of terrorism rampancy.

Aim of the study

To propose a preliminary study of developing novel and feasible risk and security models for the improvement of reliability performance of CSC operations.

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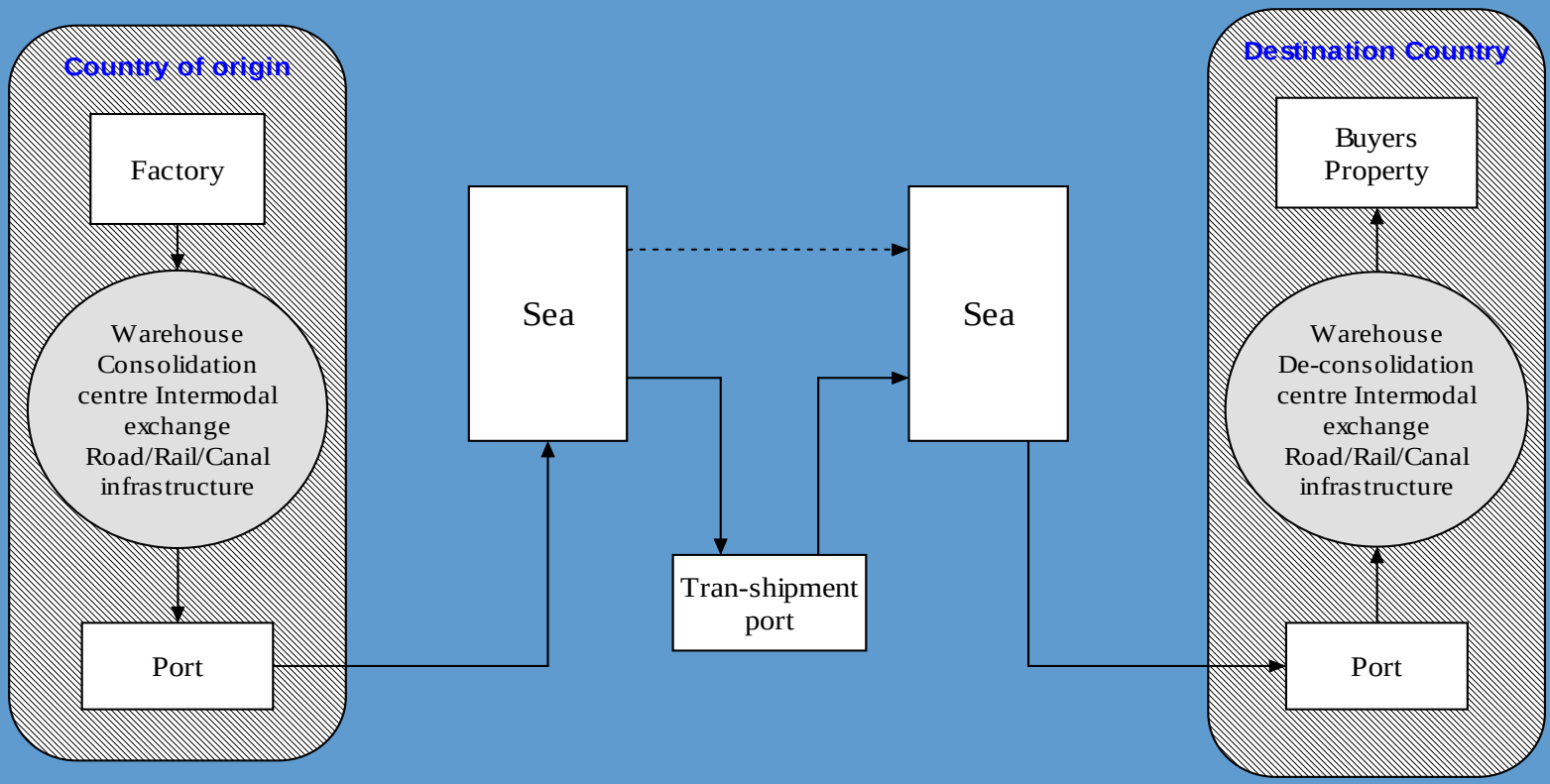
Operational process – Physical cargo flow



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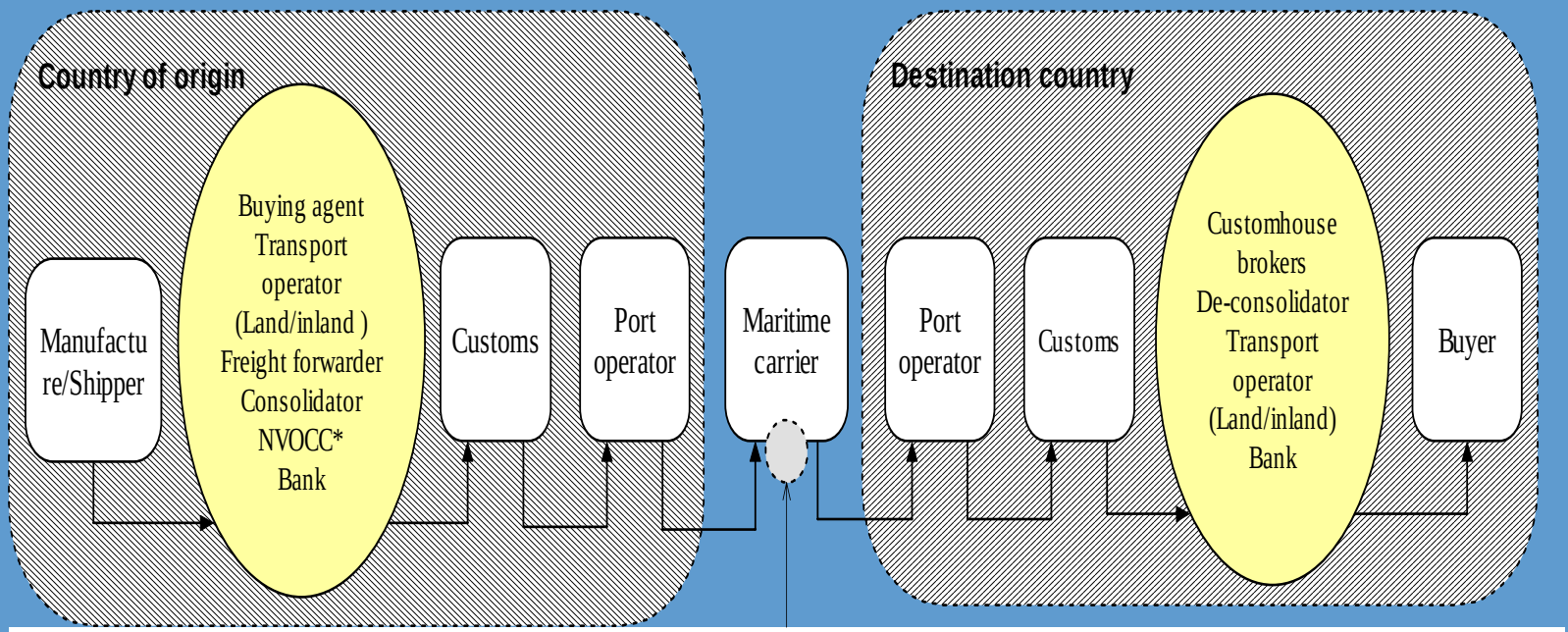
Operational process – Custody flow



Note: NOVCC (Non-Vessel Operating Common Carrier)

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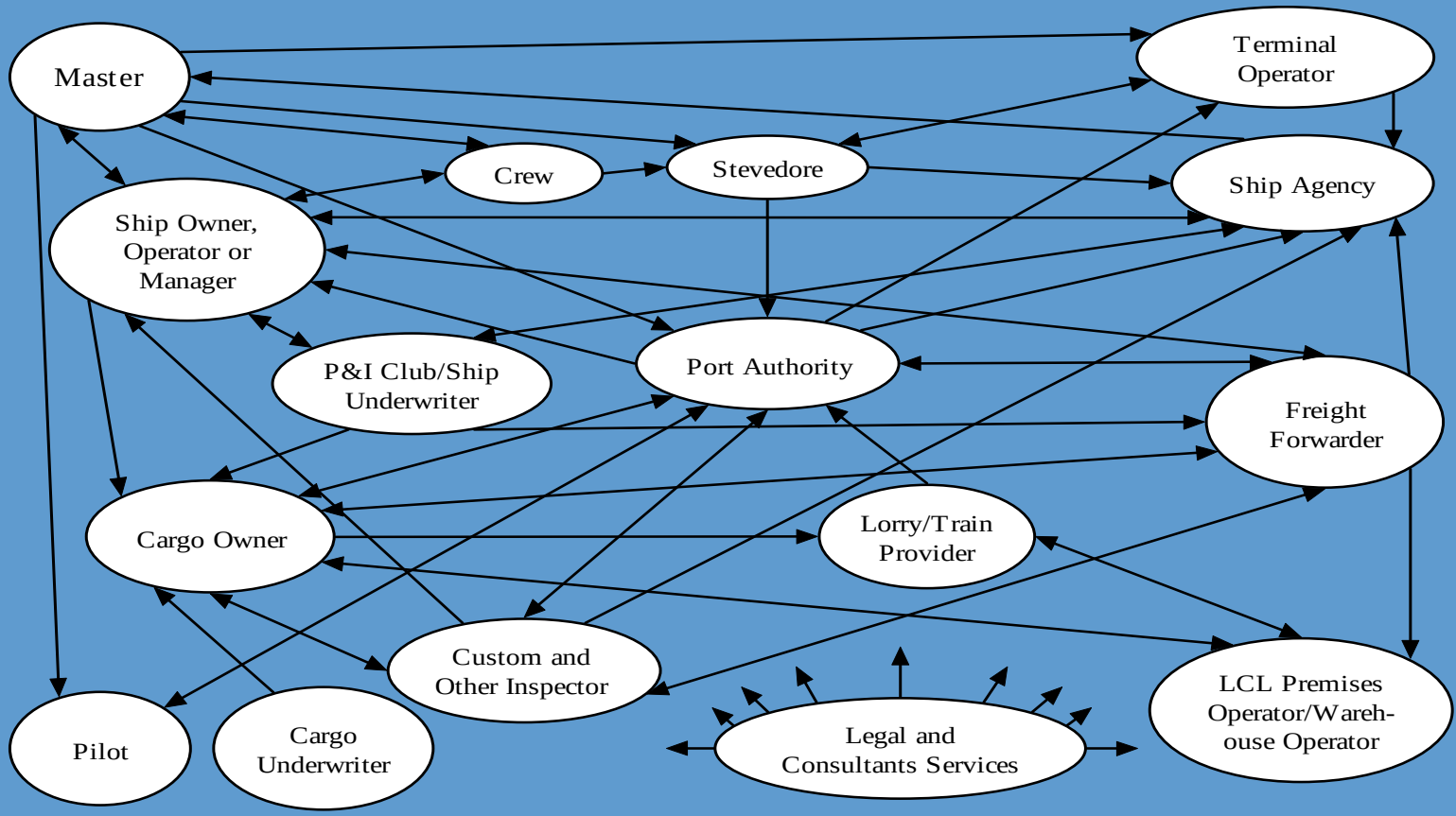
Stakeholder influence map



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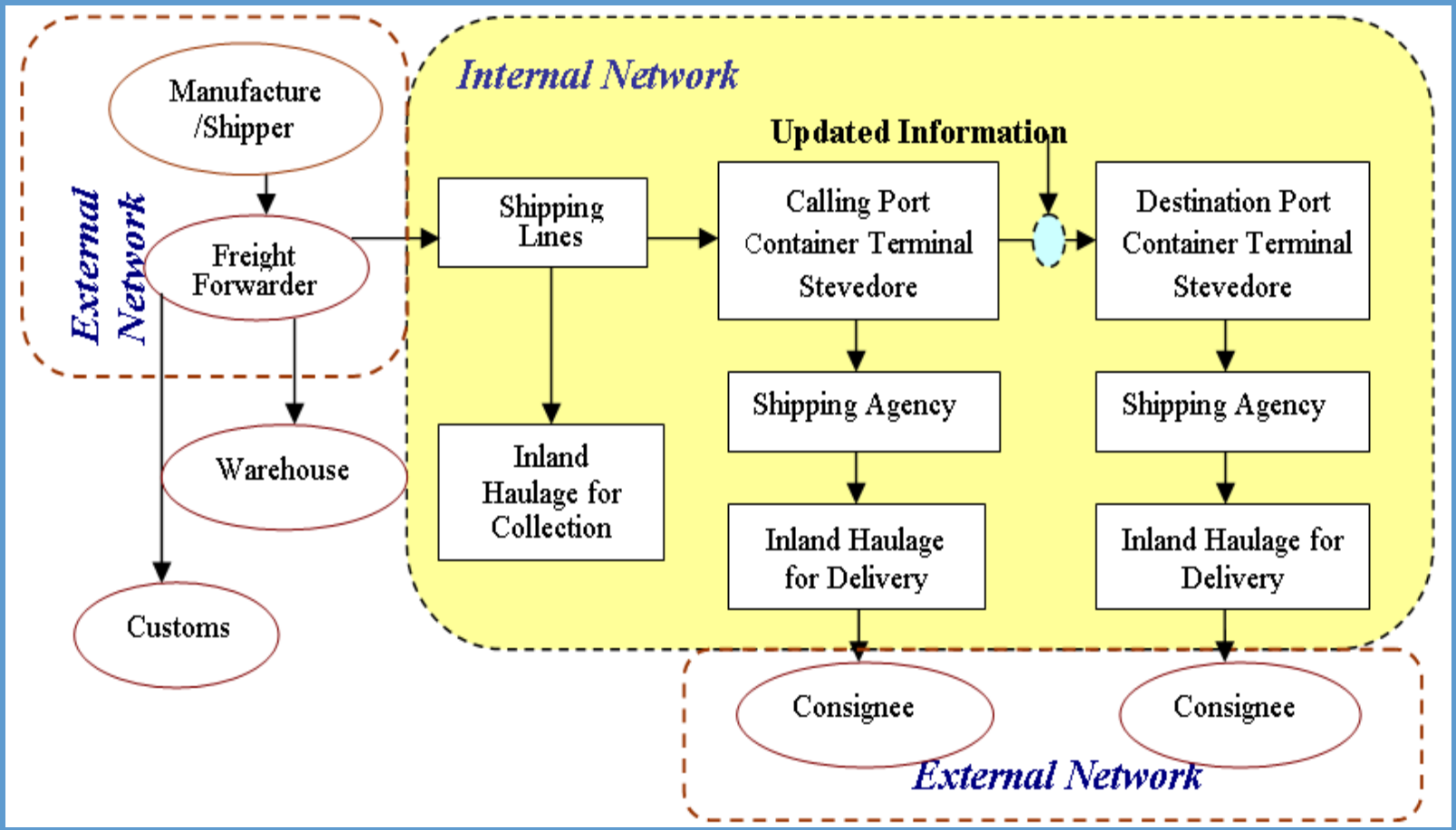
Operational process – Information flow



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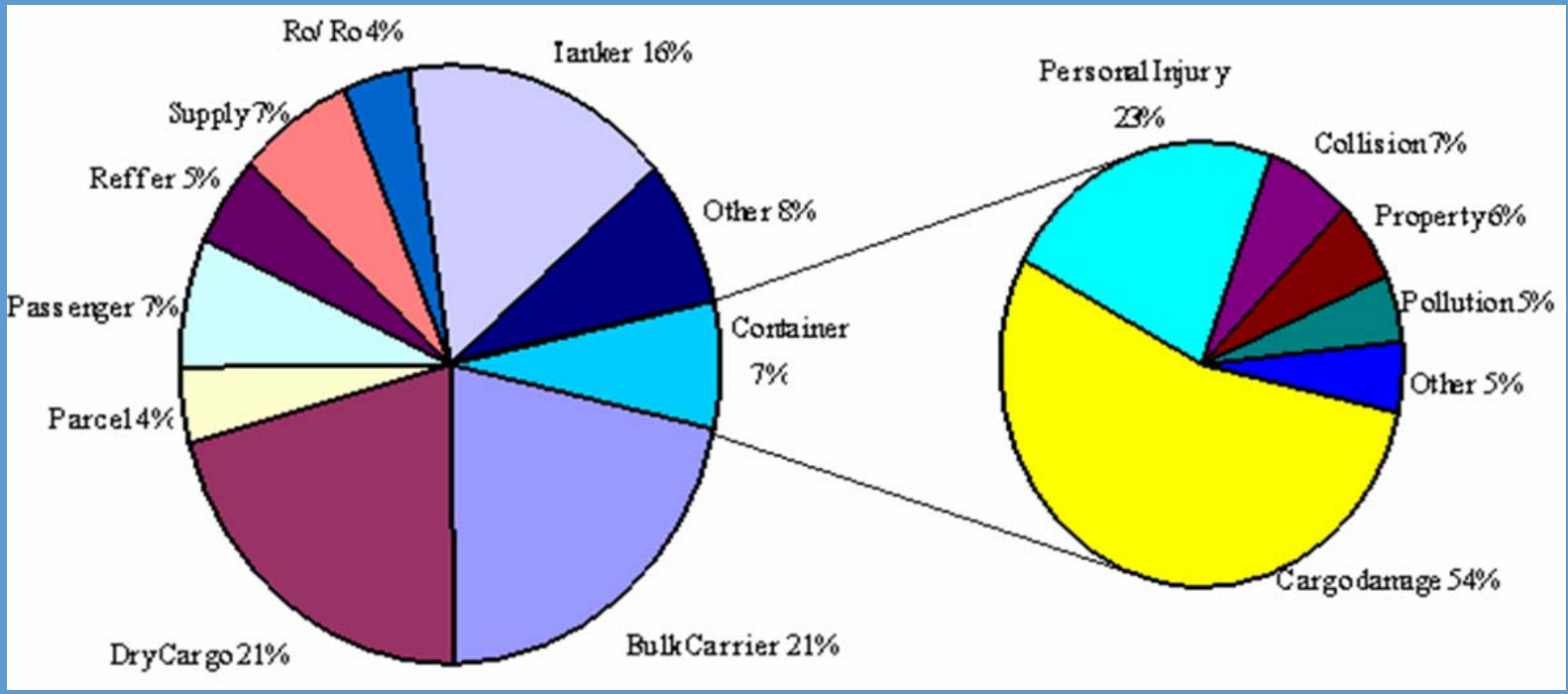
Historical failure data analysis

Containership



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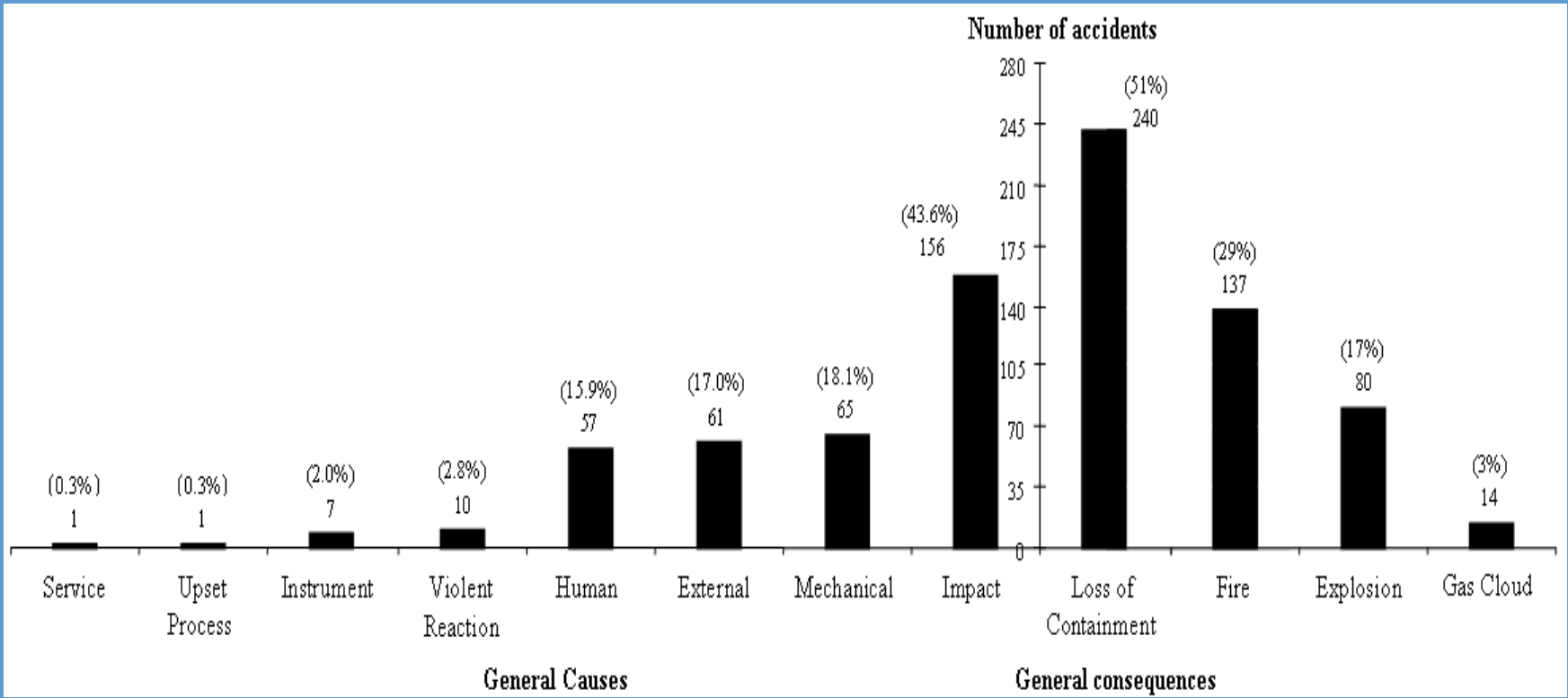
Historical failure data analysis

Port



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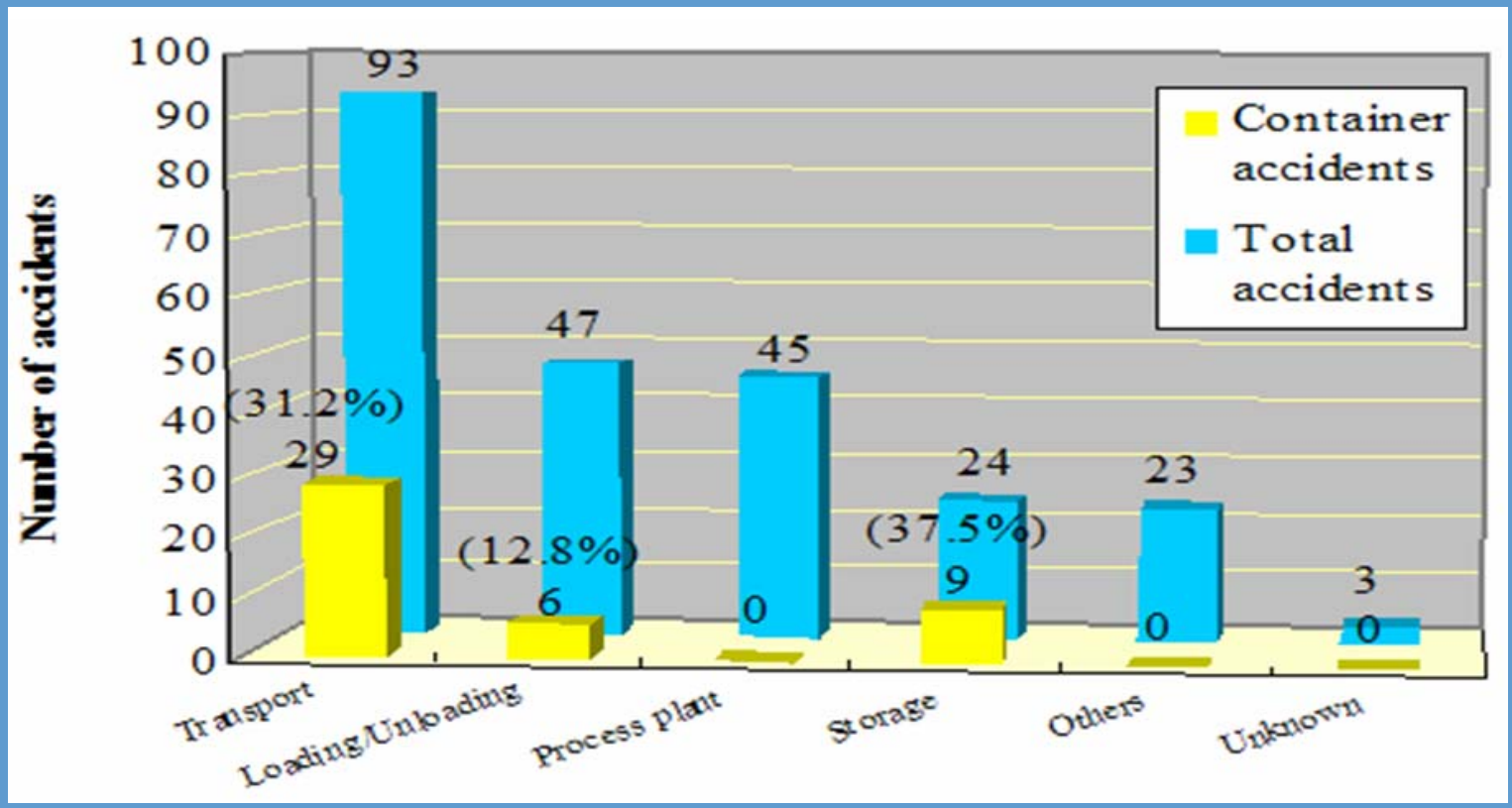
Historical failure data analysis

Container accidents in ports



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Historical failure data analysis

Risk scenarios in supply chains

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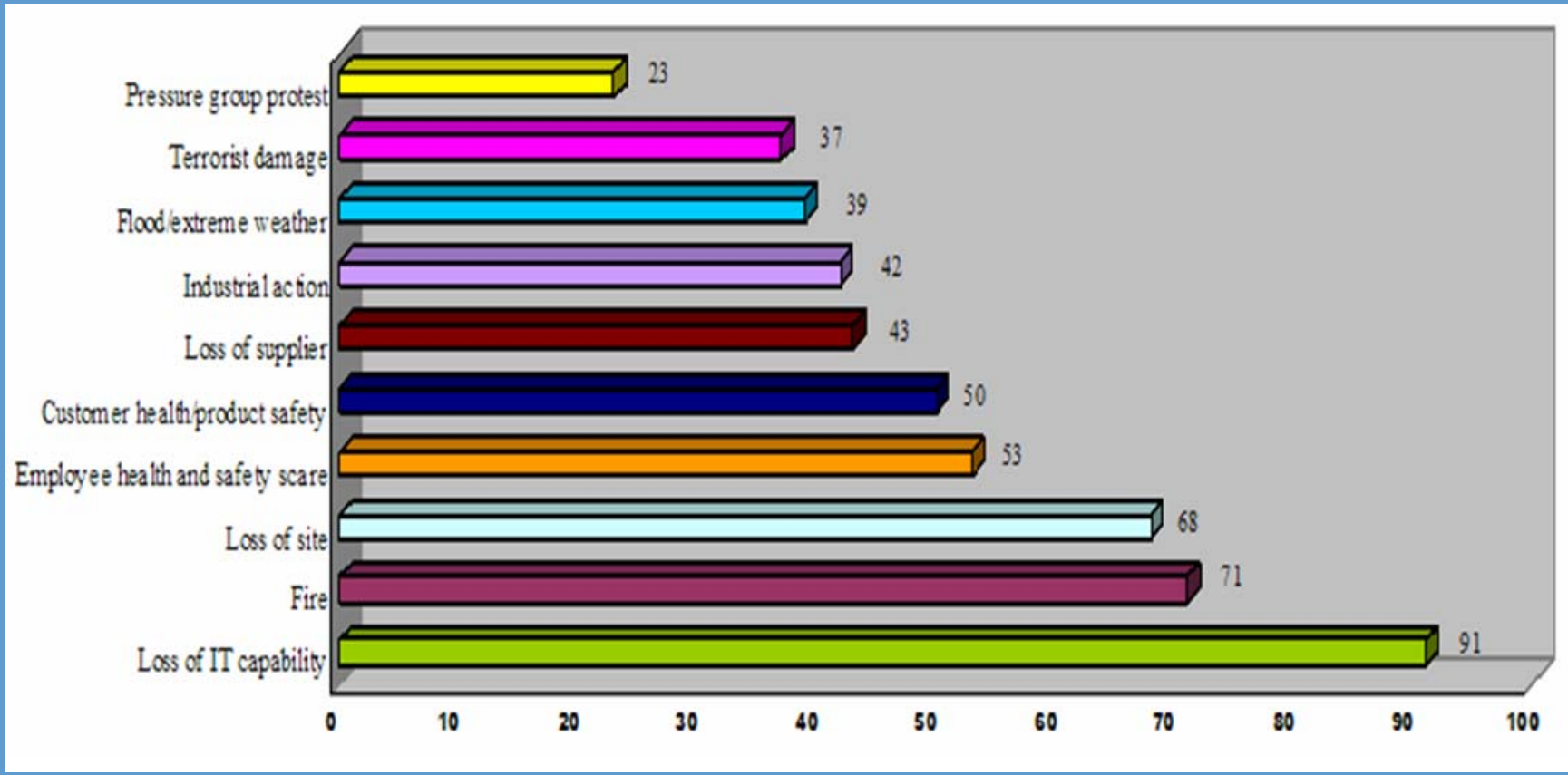

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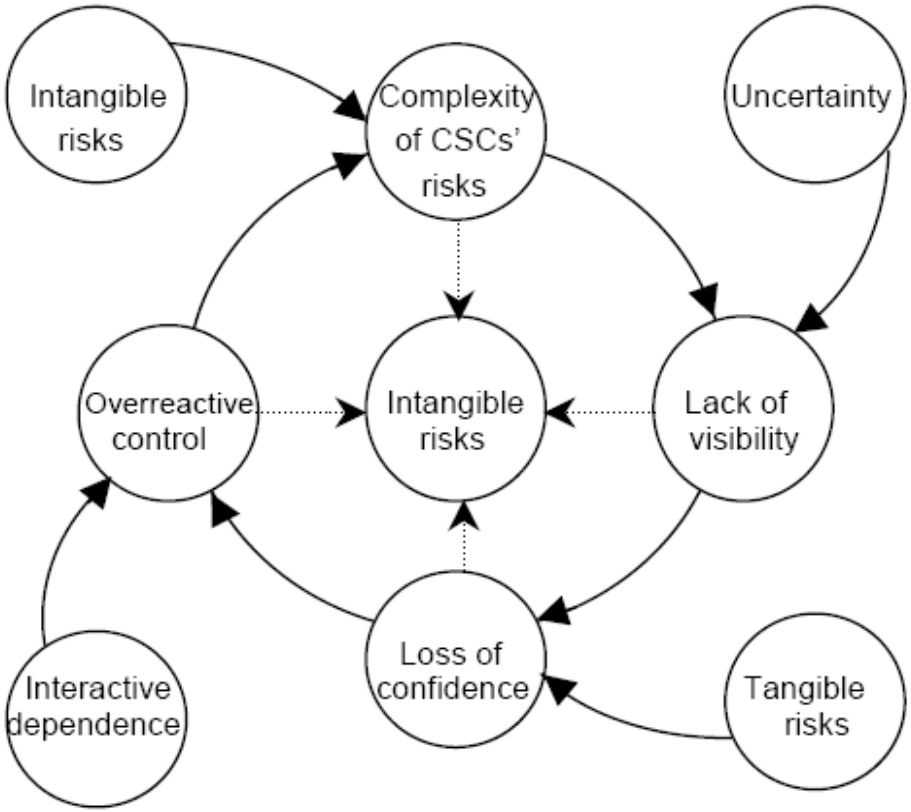
Risk characteristic of CSCs (problem analysis)

Risk scenarios in supply chains



The risk spiral of CSCs

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Advanced risk and security models

Identify risk parameters

- Nature of the risks in security
  Hazards and threats

- Hazard based risk parameters
  - *Likelihood (L)*
  - *Consequence (C)*
  - *Probability of Consequence (E)*

- Threat based risk parameters
  - *Will (W)*
  - *Damage capability (D)*
  - *Recovery difficulty (R)*
  - *Probability of damage (P)*

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Advanced risk and security models

i) Fuzzy rule based Bayesian reasoning for assessing hazards

Presentation of traditional rule base

$R = \langle X, A, D, F, \omega \rangle$

Rk: IF *A1k* and *A2k* and … and *AMk*, THEN *Dk*

where *Aik* ($\in$*Ai, i=1,…M*) is the fuzzy value of *ith* antecedent attribute *Xi* used in the *kth* rule and *Dk* ($\in$*D*) is the single consequence in the *kth* rule.

Rule 1: IF *Very low* and *Negligible* and *Highly unlikely*, THEN *Good.*
Rule 2: IF *Very low* and *Negligible* and *Unlikely*, THEN *Good.*
…

Presentation of rule base with belief structure

$R = \langle X, A, D, F, \omega, \alpha \rangle$

Rk: IF $A1k$ and $A2k$ and … and AMk, THEN $\{(\alpha 1k, D1), (\alpha 2k, D2), \ldots, (\alpha Nk, DN)\}$ ($\sum_{i=1}^{N} \alpha_i^k = 1$), with a rule weight θk and attribute weights $\omega 1k, \omega 2k, \ldots, \omega Mk$, $k \in \{1, \ldots, L\}$

Rule 1: IF *Very low* and *Negligible* and *Highly unlikely*, THEN 1 *Good.*
Rule 2: IF *Very low* and *Negligible* and *Unlikely*, THEN 0.8 *Good, 0.2 Average.*

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Rule 2: IF *very low (L1)* and *negligible (C1)* and *unlikely (E2)*, THEN {(*0.8*, *good (S1)*), (*0.2*, *average (S2)*), (*0*, *fair (S3)*), (*0*, *poor (S4)*)}

Given *L1* and *C1* and *E2*, the probability of *Sh* (*h* = 1, …, 4) is (0.8, 0.2, 0, 0) or *p*(*Sh*|*L1*, *C1*, *E3*) = (0.8, 0.2, 0, 0)

Risk inference using BN marginal probability calculation

$$p(Sh) = \sum_{i=1}^{7} \sum_{j=1}^{5} \sum_{k=1}^{7} p(Sh \mid Li, Cj, Ek)\, p(Li)\, p(Cj)\, p(Ek) \quad (h = 1, \ldots, 4)$$

Hazards-based risks can then be ranked in an order of importance.

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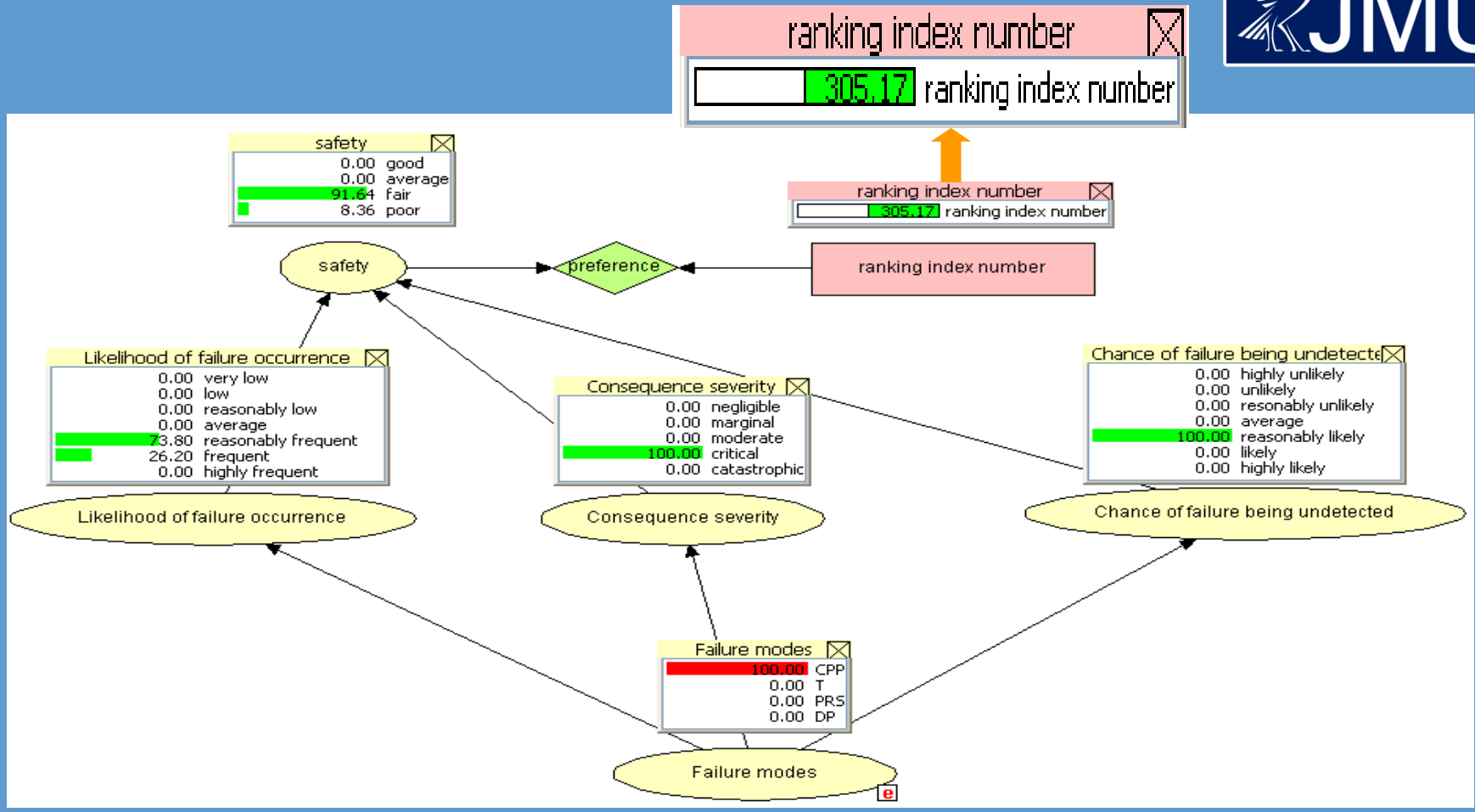
Visual aid in hazard based risk assessment



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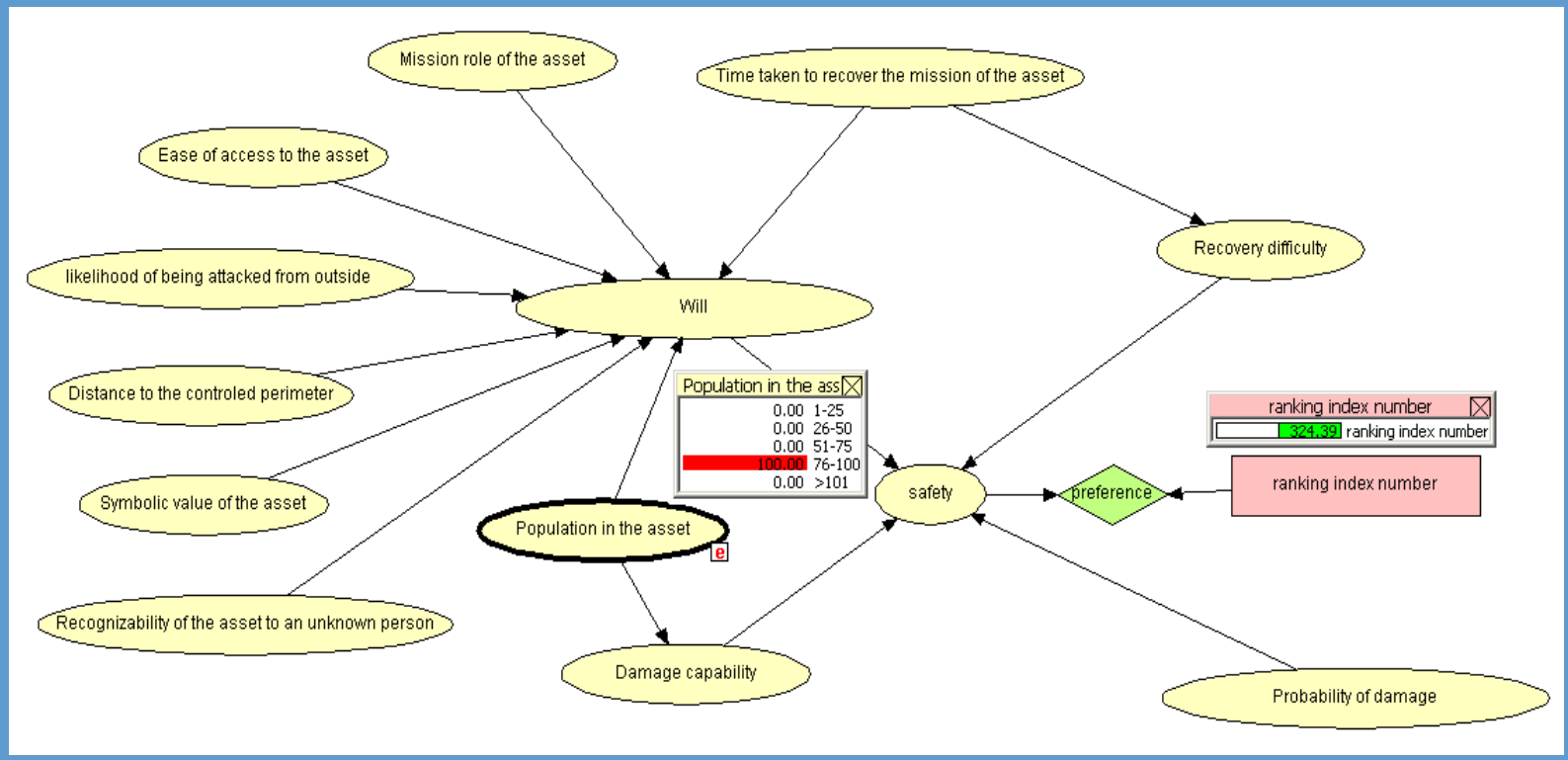
ii) Threats-based Bayesian reasoning

A proposal of port security assessment



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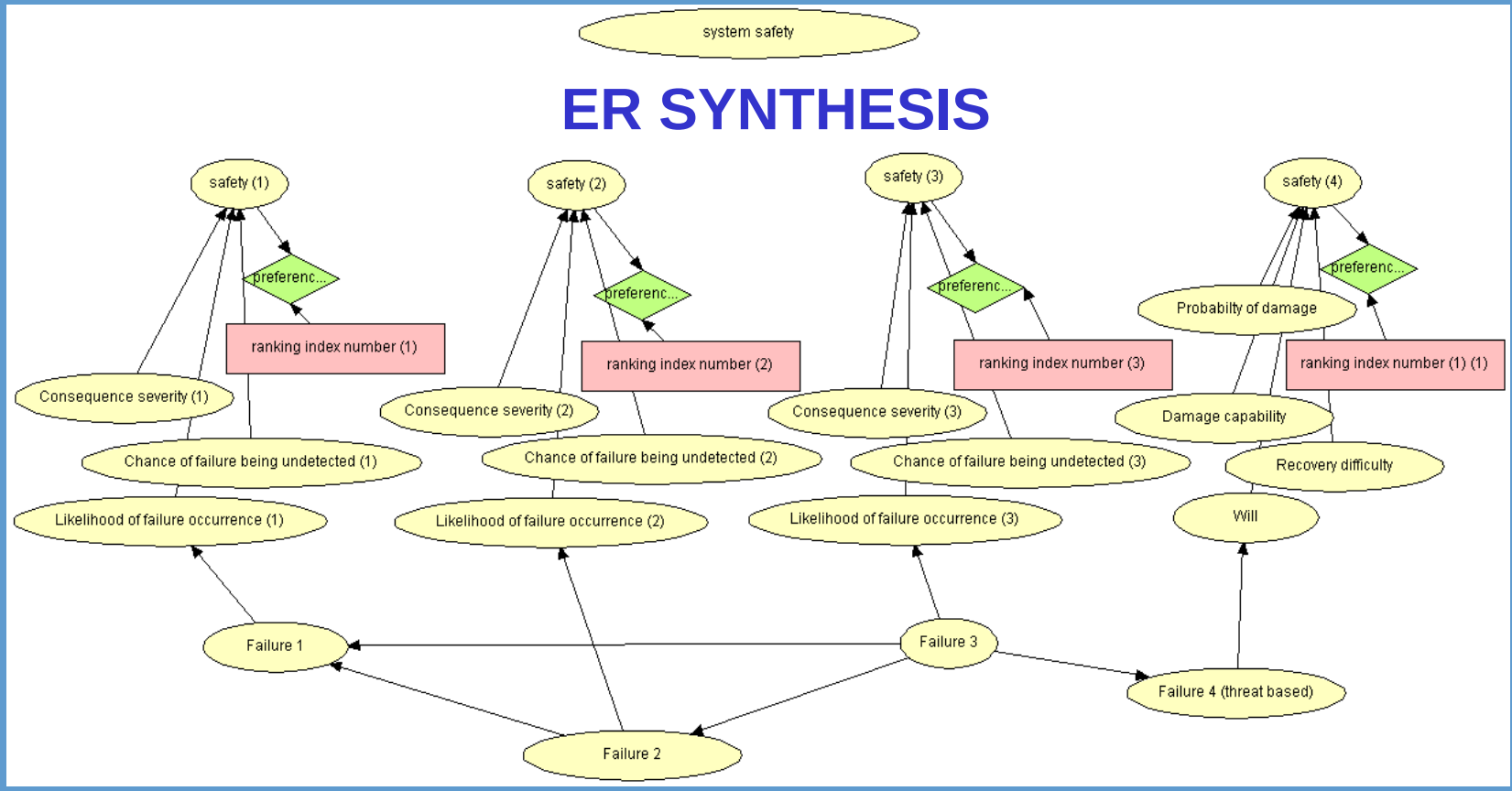
iii) A method of modelling failure dependence using both Bayesian and evidential reasoning (ER) – both hazards and threats



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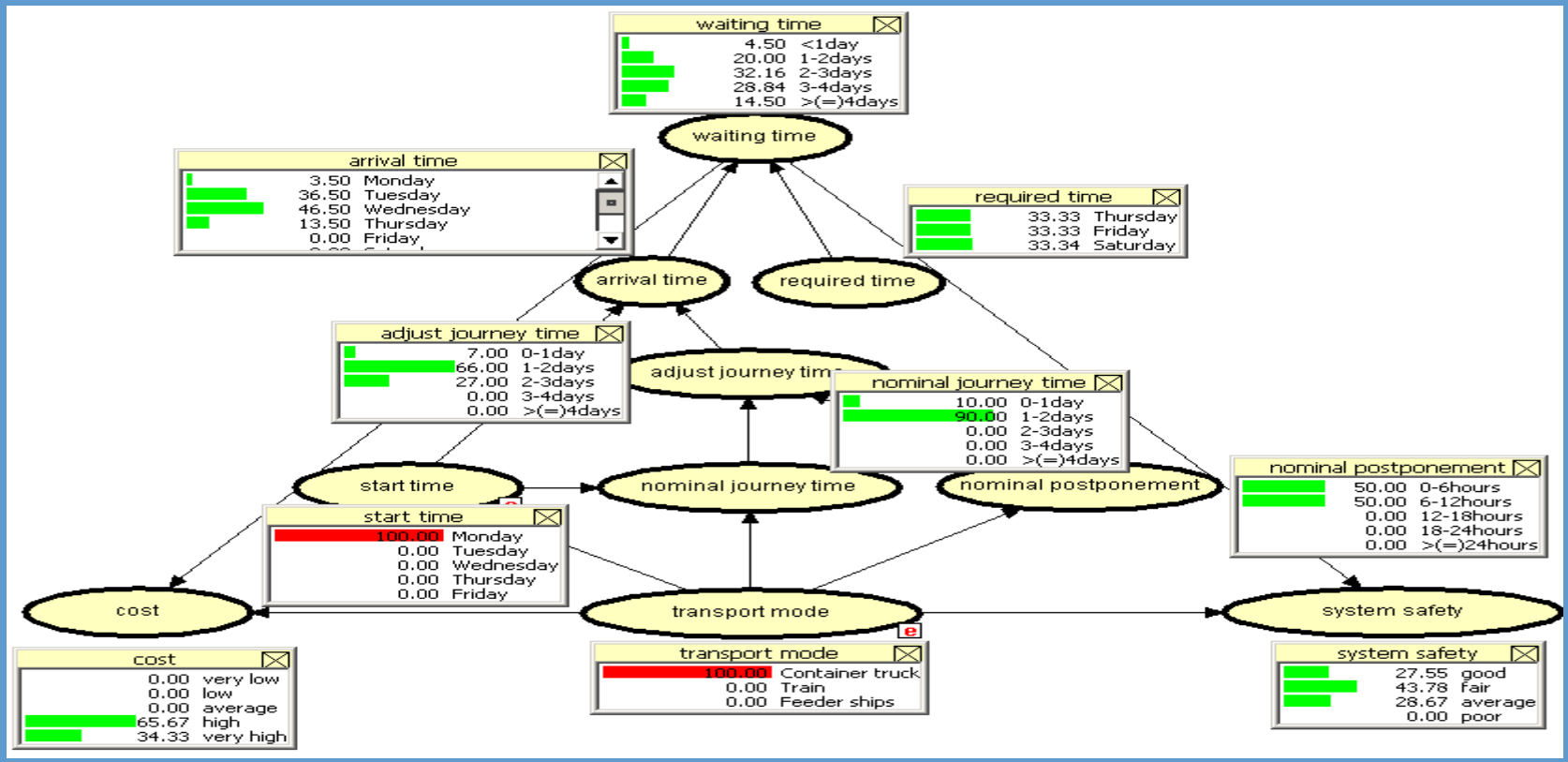
iv) Multiple dynamic attribute decision making

Determination of transport mode and start time



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Future work

- **Some preliminary study in this area has been conducted, evidenced by two PhD completions ("Risk assessment and decision making of container supply chains" in 2007 and "The development of safety and security assessment techniques and their application to port operations" in 2007).**

- **A UK research council grant of £248k has been secured from 2008 to 2011 with an aim of "Enabling Security and Risk-based Operation of Container Line Supply Chains (CLSCs) under High Uncertainties".**

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Conclusion

- The nature of the risks associated with CSCs has experienced a change from traditional hazard-based to modern vulnerability-focused (threat involved).
- It will be beneficial to use uncertainty treatment methods to develop novel and advance risk and security assessment models to facilitate the improvement of reliability performance of CSCs.
- The presentation only provides a preliminary study to serve a basis for such development.

Thank you.