

# Conservation of Risk: Insights from Einstein at ETH Zurich

**Morteza Bagheri**












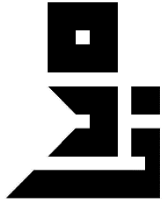
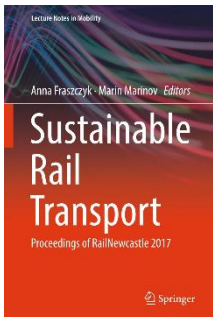
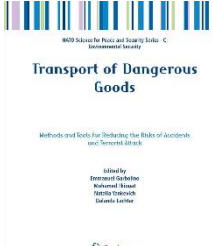
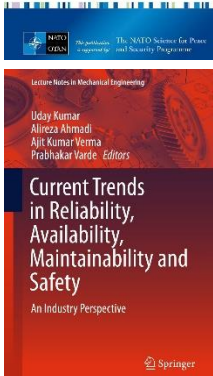




**Associate Professor**

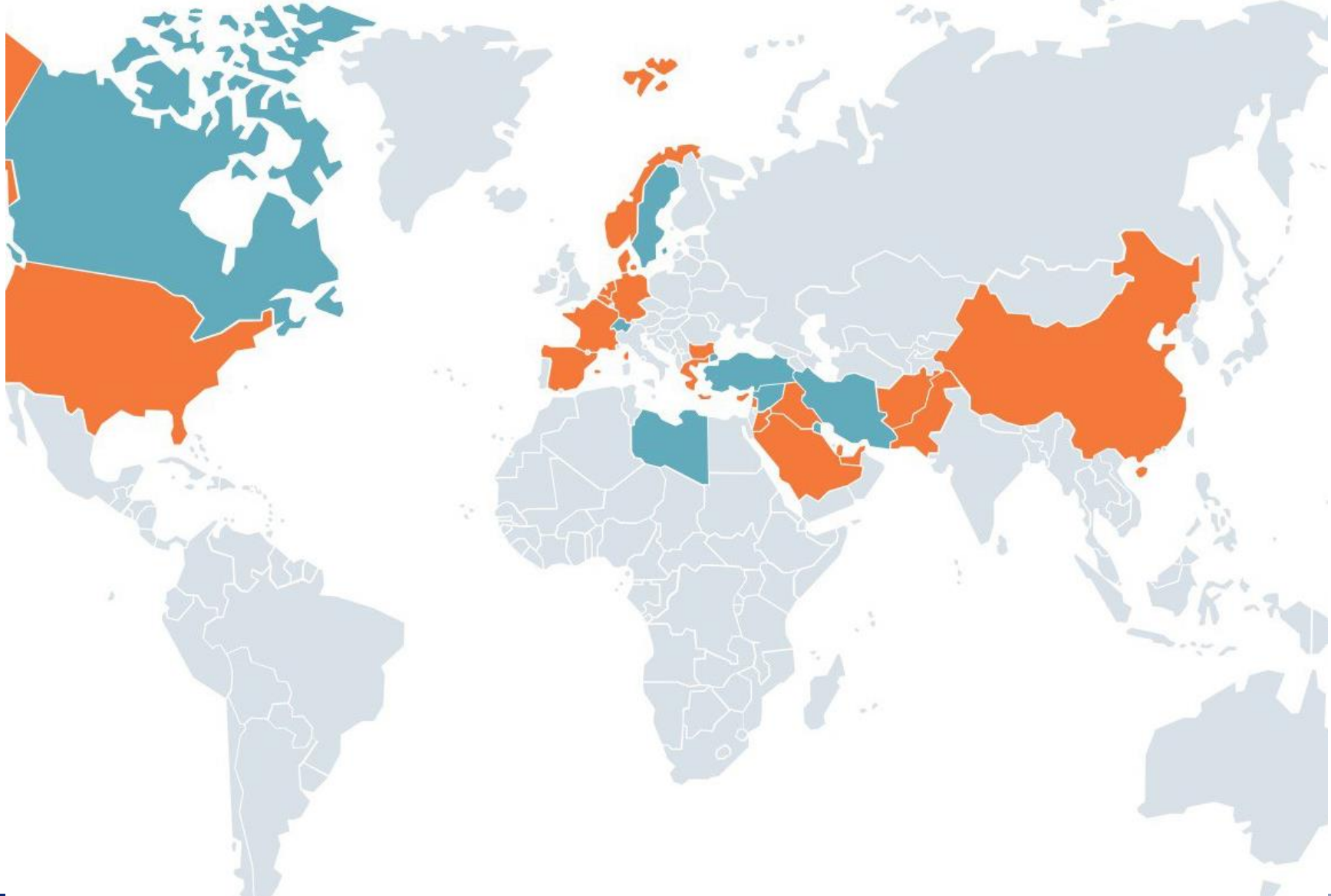
**Jointly Appointed in School of Railway Engineering &  
School of Industrial Engineering**

[morteza.bagheri@iust.ac.ir](mailto:morteza.bagheri@iust.ac.ir)

Wednesday, August 13, 2024 at 12:15

# My Background & Experience

Science	Industry	Innovations	Publications	Govt
    	   <p>سازمان ریلواری و تحقیقات جاده‌ای</p>	   	  	 <p>وزارت راه و شهرسازی جمهوری اسلامی ایران Ministry of Roads &amp; Urban Development Islamic Republic of Iran</p>  <p>سازمان منطقه آزاد کیش Kish Free Zone Organization</p>  <p>سازمان منطقه آزاد تجاری کراس ARAS FREE ZONE</p>  <p>منطقه آزاد چابهار Chabahar Free Zone</p>



- One of the top three technology university
- IUST 85 years old
- 420,000 m<sup>2</sup>
- 15 Schools
- 12 Research Institute
- 13 Research Center
- 9 Center of Excellence



- 415 faculty members
- Around 12000 Students
  - 5525 Undergraduate
  - 5445 Master students
  - 987 PhD students



## Undergraduate Studies:

- Railway Transportation Eng.
- Railway Rolling Stock Eng.
- Railway Track & Structures Eng



## Graduate Studies:

- Electric Railways Eng.
- Railway Safety Eng.
- Control, Signaling Eng.
- Railway Track Eng.
- Rolling Stock Design Eng.
- Established in 1997
- Unique Rail School in Western Asia
- 27 Faculty Members
- 15 Research Lab
- Center of Excellence in Rail





The "Transportation Systems and Logistics (TSL)" laboratory was established with the aim to promote research and education. TSL concentrates on the application of engineering management, and IT systems in transport systems, and logistics.

### Maintenance Management

Transportation Systems and Logistics Lab. @ IUST

#### TSL Seminar Series

"How different are the students in Iran and abroad"


On November 17th at 10:30 AM by Mr. Lajevardi

Join this [Link](#)

#### + TSL Events

### NEWS





**TSL**  
آزمایشگاه سیستم‌های حمل و نقل و لجستیک

## Transportation Systems and Logistics Lab

Iran University of Science and Technology  
Transportation, Logistics, Supply Chain and Storage · Tehran · 586 followers · 11-50 employees

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### About

The "Transportation Systems and Logistics (TSL)" laboratory was established to advance research and education in the field. TSL's focus is on utilizing engineering, management, and IT systems to address transportation systems and logistics issues. The primary objective of TSL is to foster an innovati ... see more

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- Introduction
- Hazmat by Rail Examples
- Literature Review
- Conclusion



# Conservation Duel at ETH: Einstein's Energy vs. Bagheri's Risk!!!

- Einstein's Energy conservation:  
*energy cannot be created or destroyed, only transformed from one form to another. (Einstein)*



# Two main Questions?

Conservation of Risk???

1) Eliminate Risk? Residual Risk

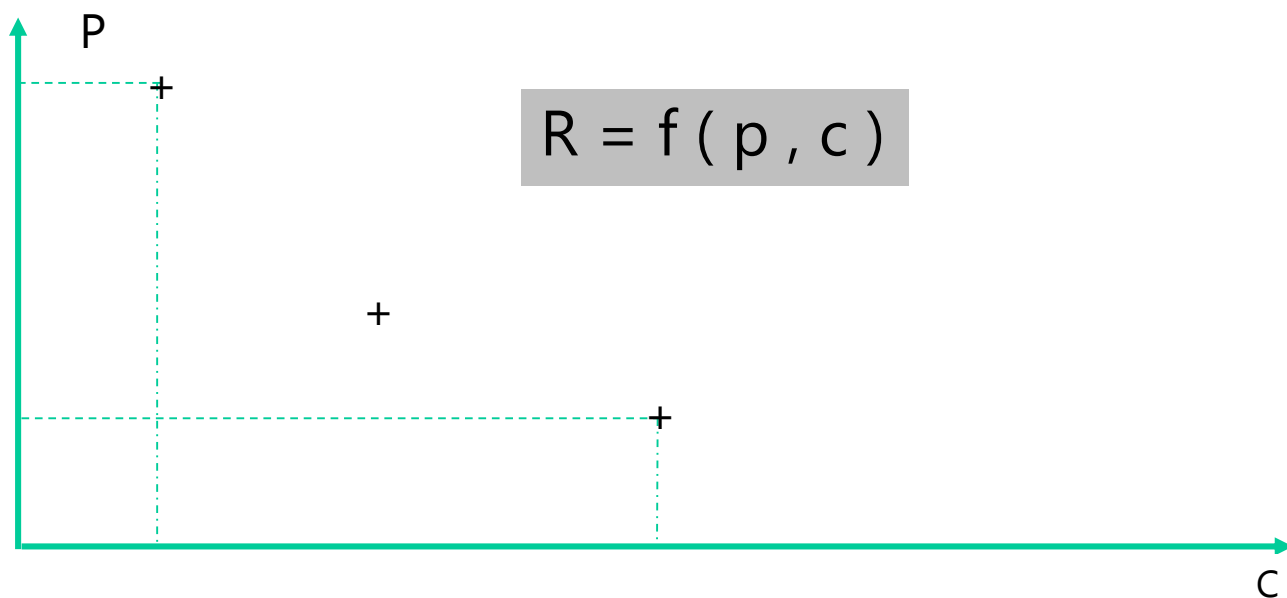
2) Mitigate Risk? Transfer Risk

- Even in academia, we often read the term “eliminating risk” in papers and books.
- Is it truly possible to eliminate risk?

- When we talk about mitigating risks, what exactly does it mean?
- Does it imply that some risks simply disappear, or are they transferred to other stakeholders?
- To have a comprehensive understanding, is it necessary to consider this transfer and optimize the total risks?

- Risk is related to future events!
- Risk is the probability of a hazard resulting in an accident! (Mohammad Shahriari)

Risk is the function of probabilities and consequences



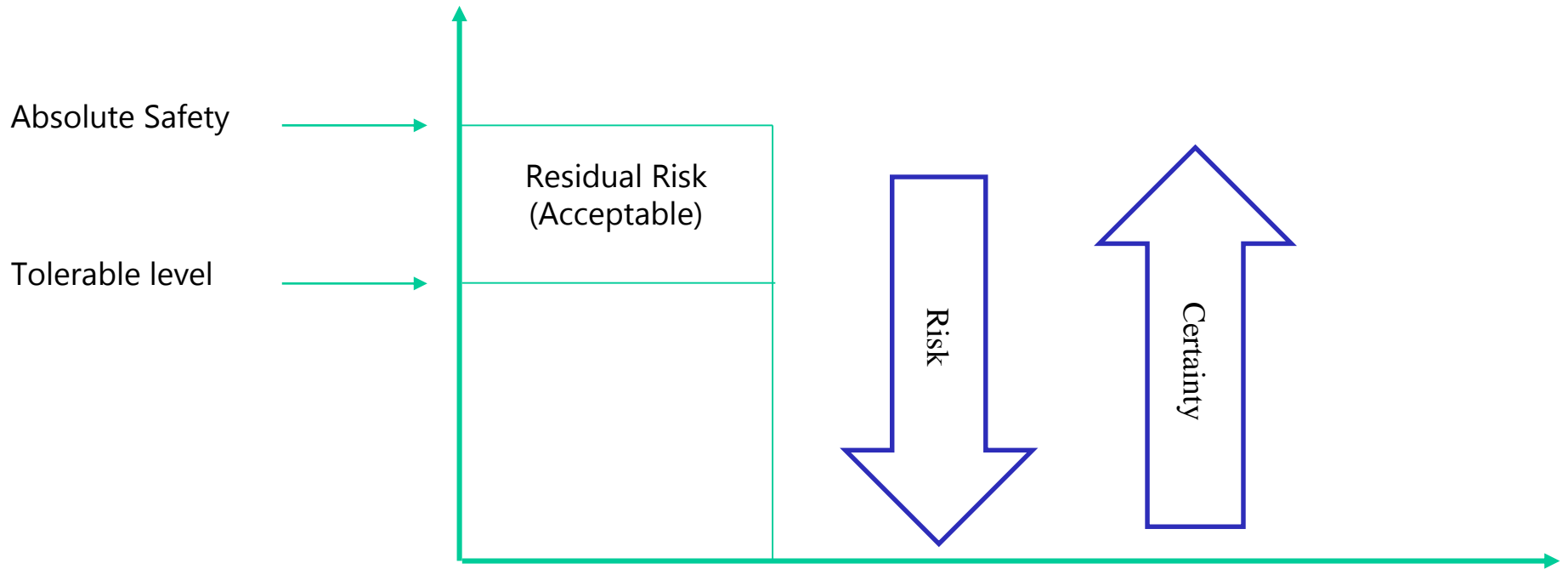


# Distinction between Risk and Uncertainty

- Risk equals uncertainty about the consequence of an activity seen in relation to the severity of the consequence! (Treje Aven)

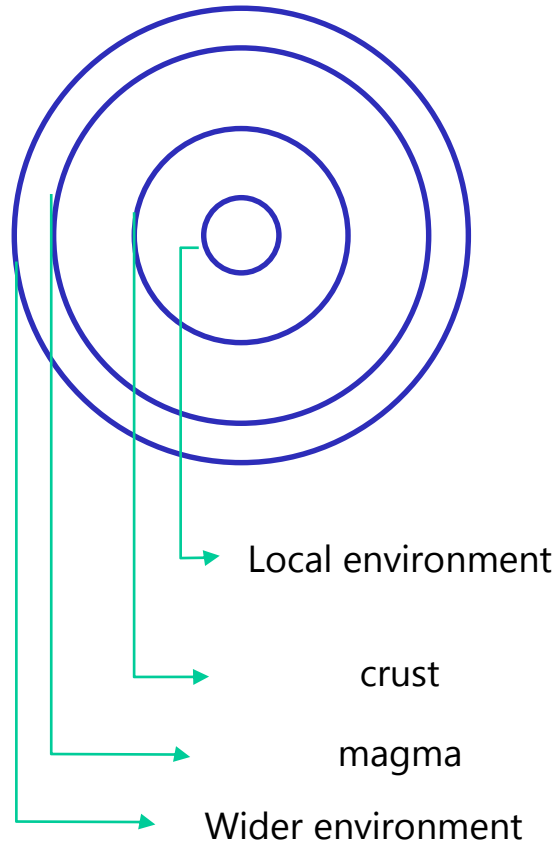


**Knowledge interpreted in terms of probability**

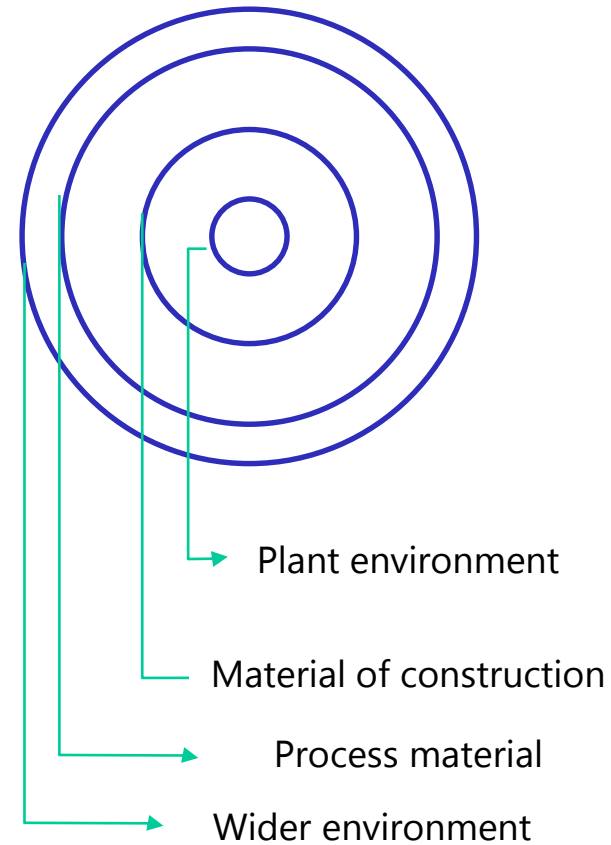


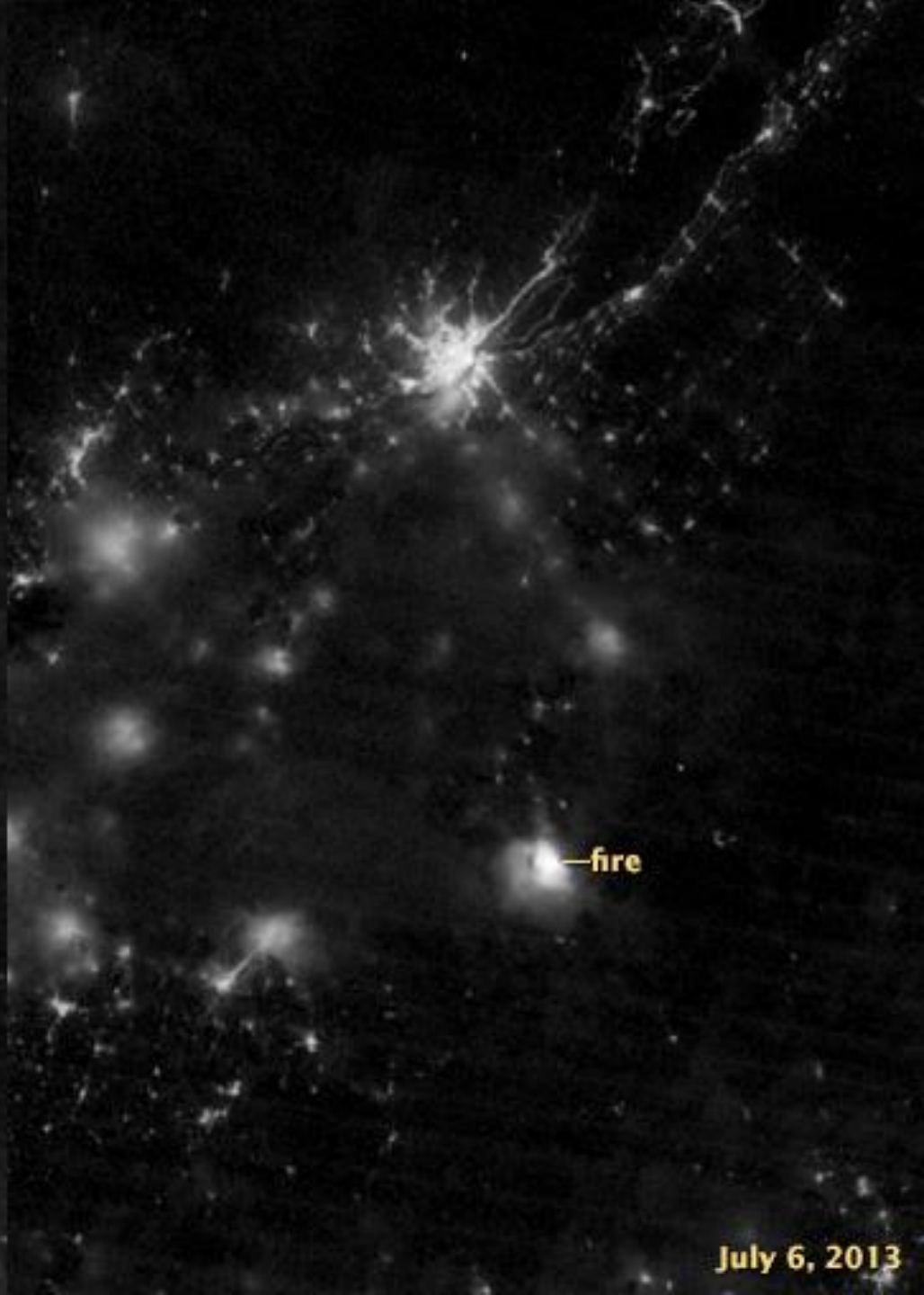
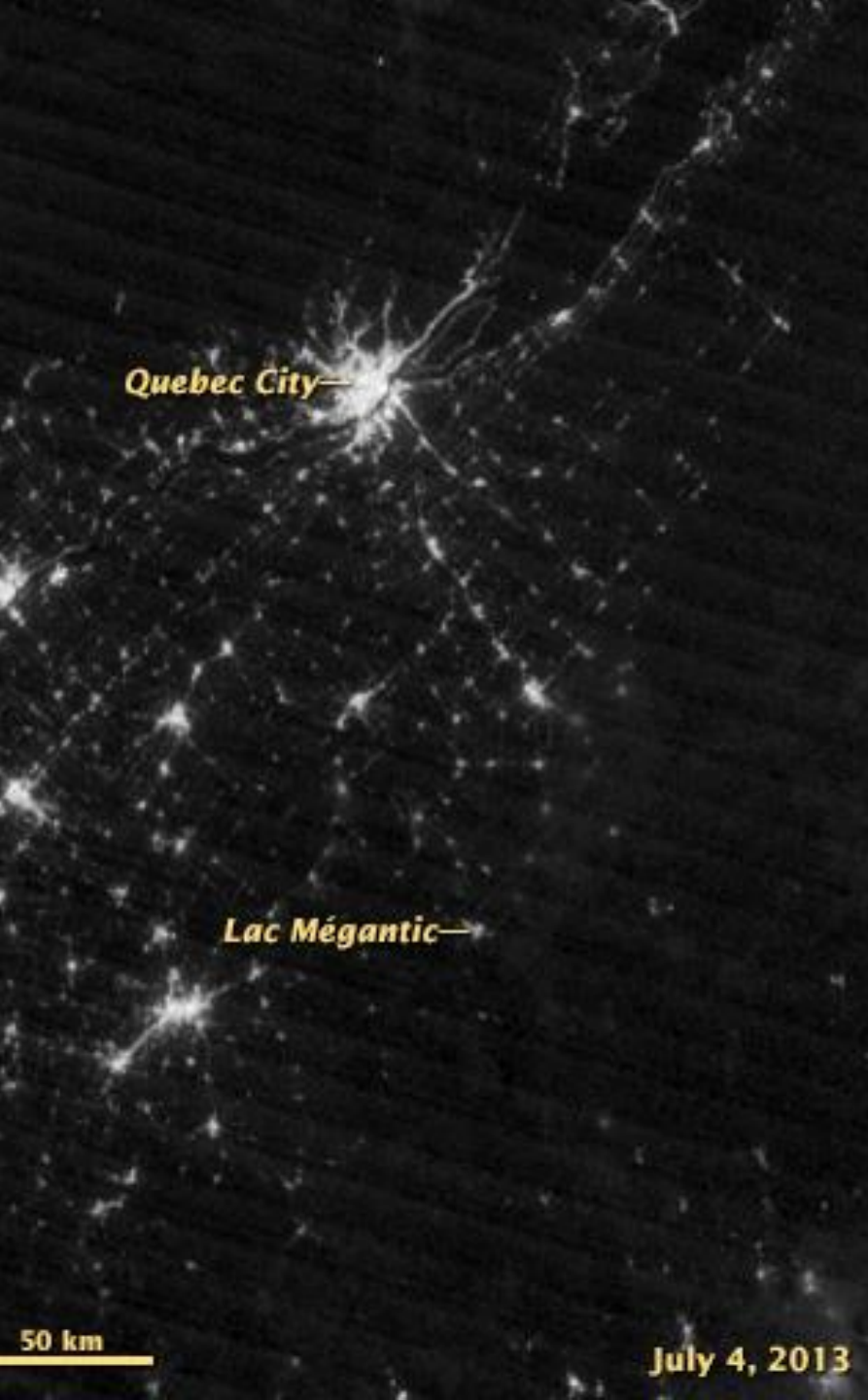
# Analogy bet. Earth & a Plant

## The Earth



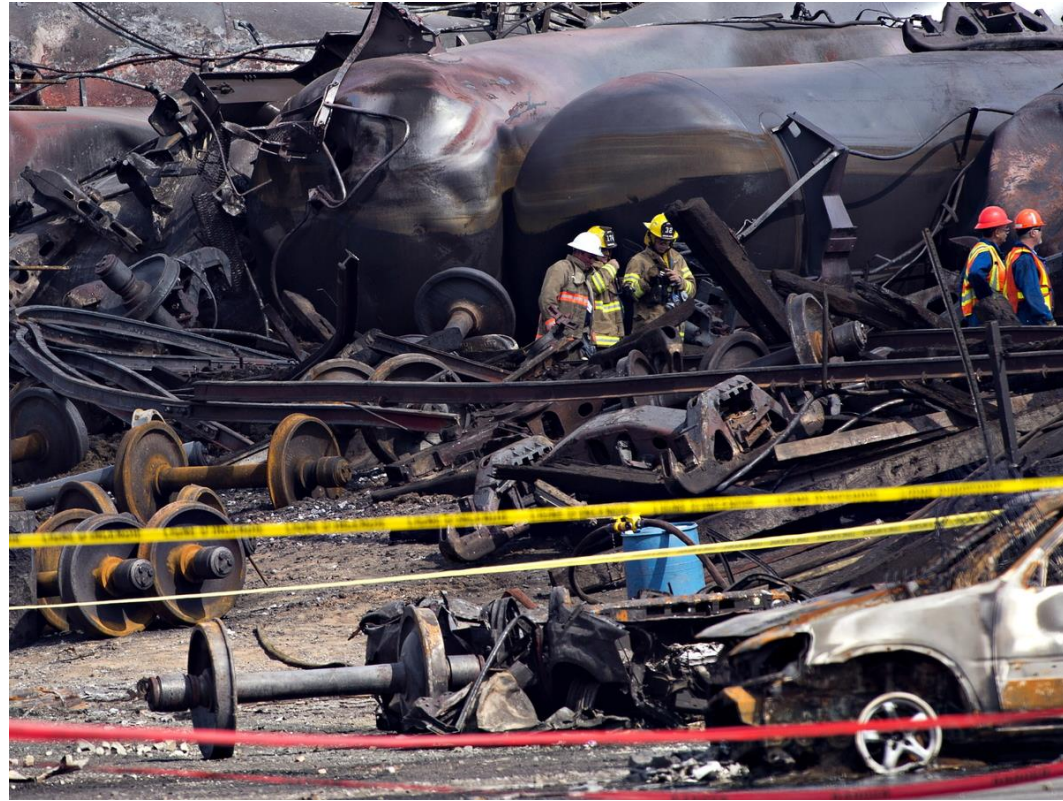
## A process plant





# Catastrophic Derailment in Canada

- 74 cars of crude oil derailed and exploded
- 42 people confirmed dead with 5 more missing
- Temp. up to 3,000 C
- Demanding \$7.6 m in cleanup costs



Montreal, Maine and Atlantic Railway in Lac-Mégantic (July 2013)



# Catastrophic Accident in Iran

- 289 killed (150 government officials, 24 Fire men)- 450 injured
- Five villages were seriously damaged
- Big crater with 25-30 meter depth and 80-150 meter width.
- Earthquake of 3.6 points in the Richter scale.



Stationary Hazmat Runaway in Neishabour (February 2004)

# Rail Accidents By Type

## Highway-Railway Crossing



## Derailment

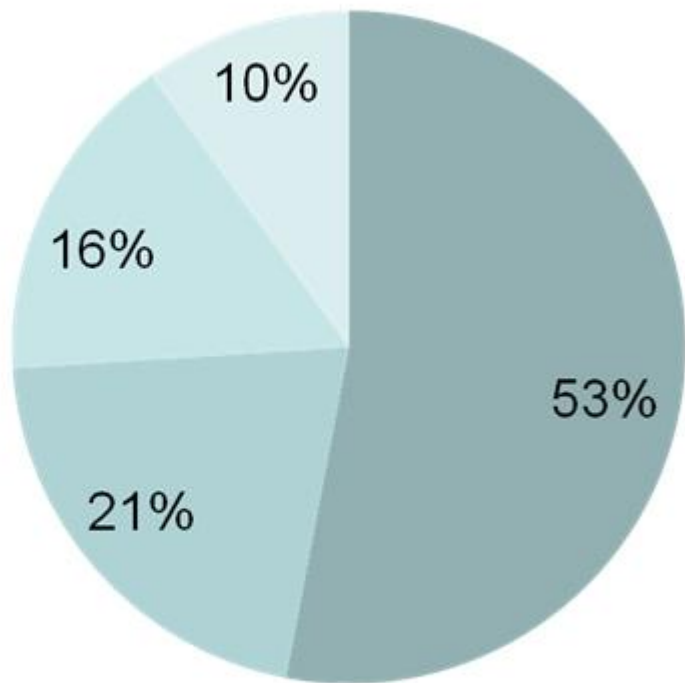


## Collision

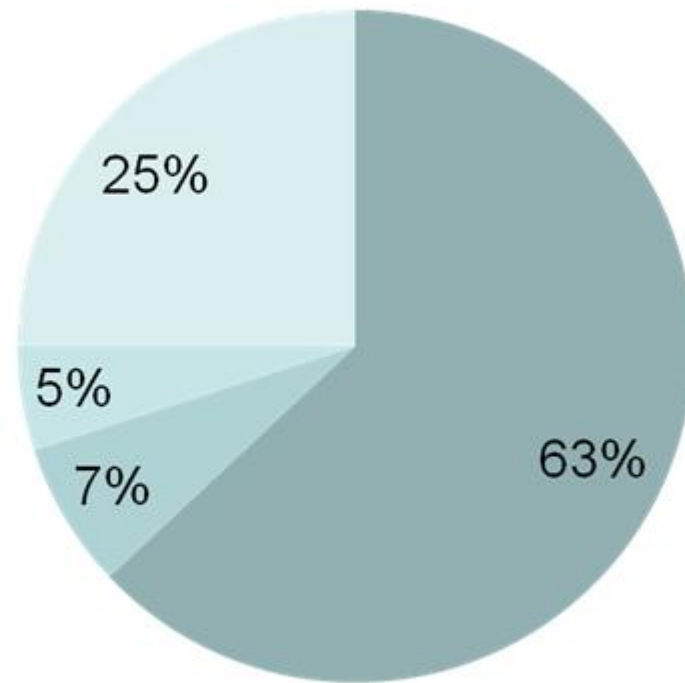


# Rail Accidents By Type

■ Derailments ■ H-R Crossing ■ Collisions ■ Other



Source: Canadian TSB



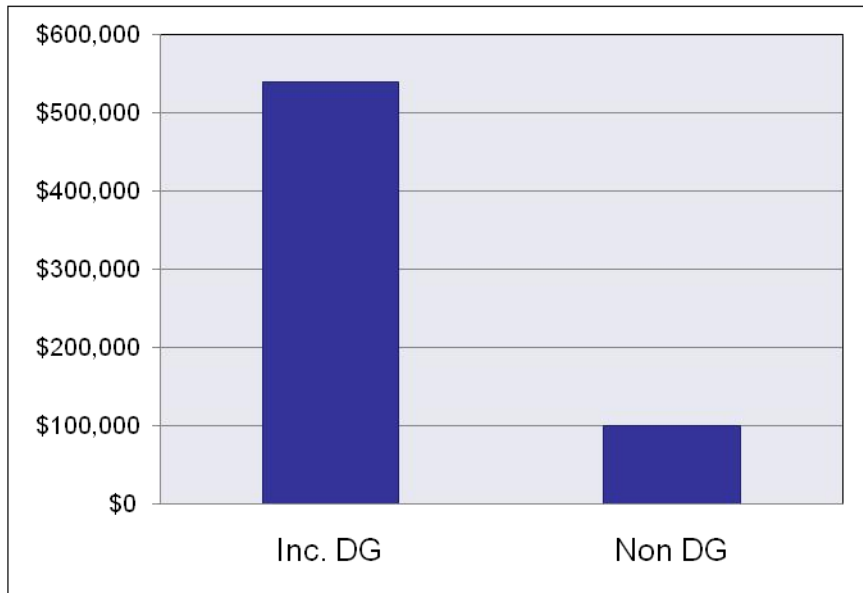
Source: US FRA

# Train Derailments





# Hazmat Rail Cars Derailment



Average damage (US \$)  
per derailment  
(Source: FRA )



Major threats: personal injuries &  
long term environmental damages

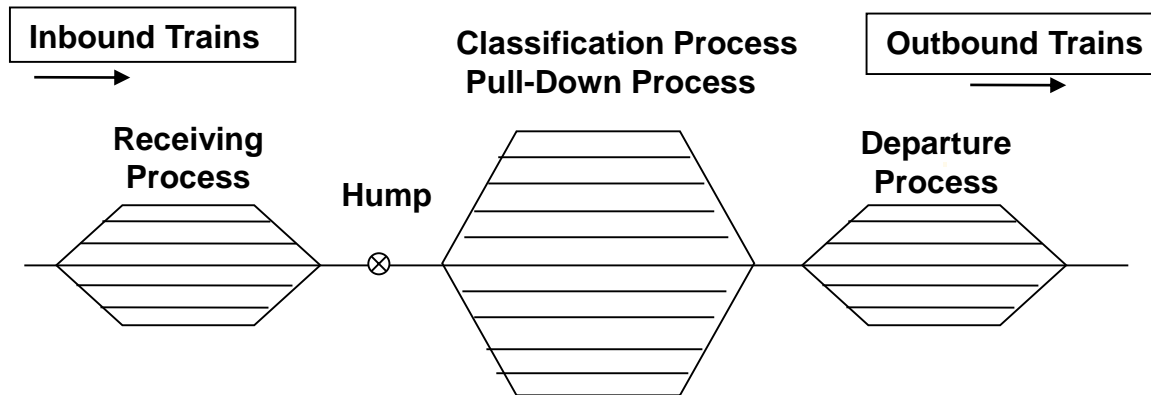
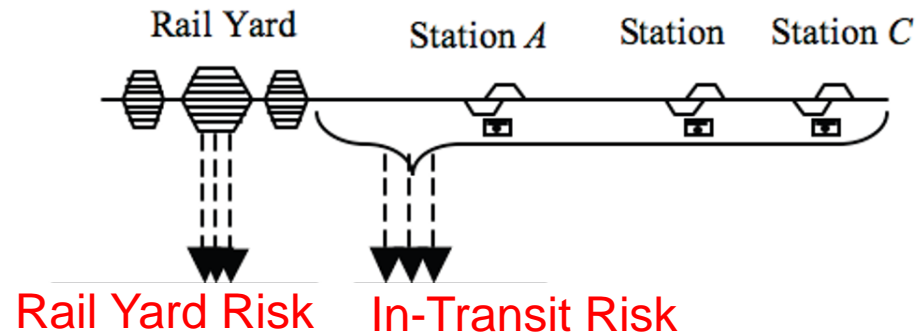


1. Prevention of train accident through improving track infrastructure & rolling stock (Verma et al., 2010)



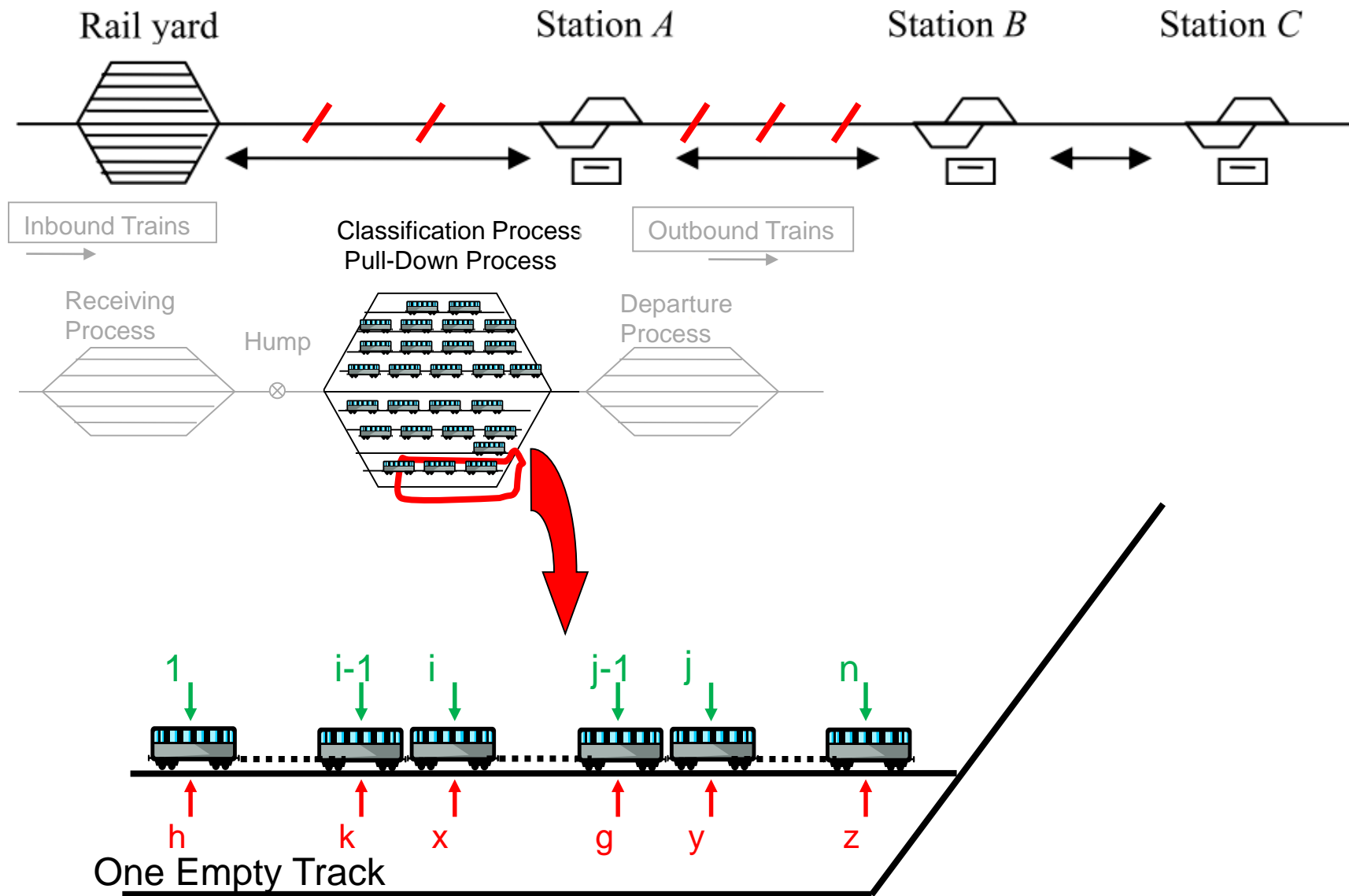
June 8, 2022 Train Collision excavator beside the track 14 fatalities & 86 injuries

## 2. Prevention of hazmat involvement car in a accident



(Fang & Reed, 1979; Thompson et al., 1989; Nayak & Palmer, 1980; English, et al., 1991; Saccomanno & El-Hage, 1992; HMTAA 1994; FRA, 2005; Bagheri et al., 2010a, 2010b)

# Hazmat Involvement (cont.)



# Hazmat Involvement(cont.)

- Risk Assessment Framework for the Rail Transport of Hazardous Materials: Formulation and Solution, Rahbar, M., and Bagheri, M., Transportation Research Record Journal
- Objective function
  - ✓ *Minimizing the HAZMAT derailment risk*
- Constraints
  - ✓ *Guarantee that each car would be located in one position of its block*
  - ✓ *Guarantee that each position of a block would be occupied by one car which belongs to this block*

# Hazmat Involvement(cont.)

$$\text{Min}\left(\sum_{i=1}^n R_i\right)$$

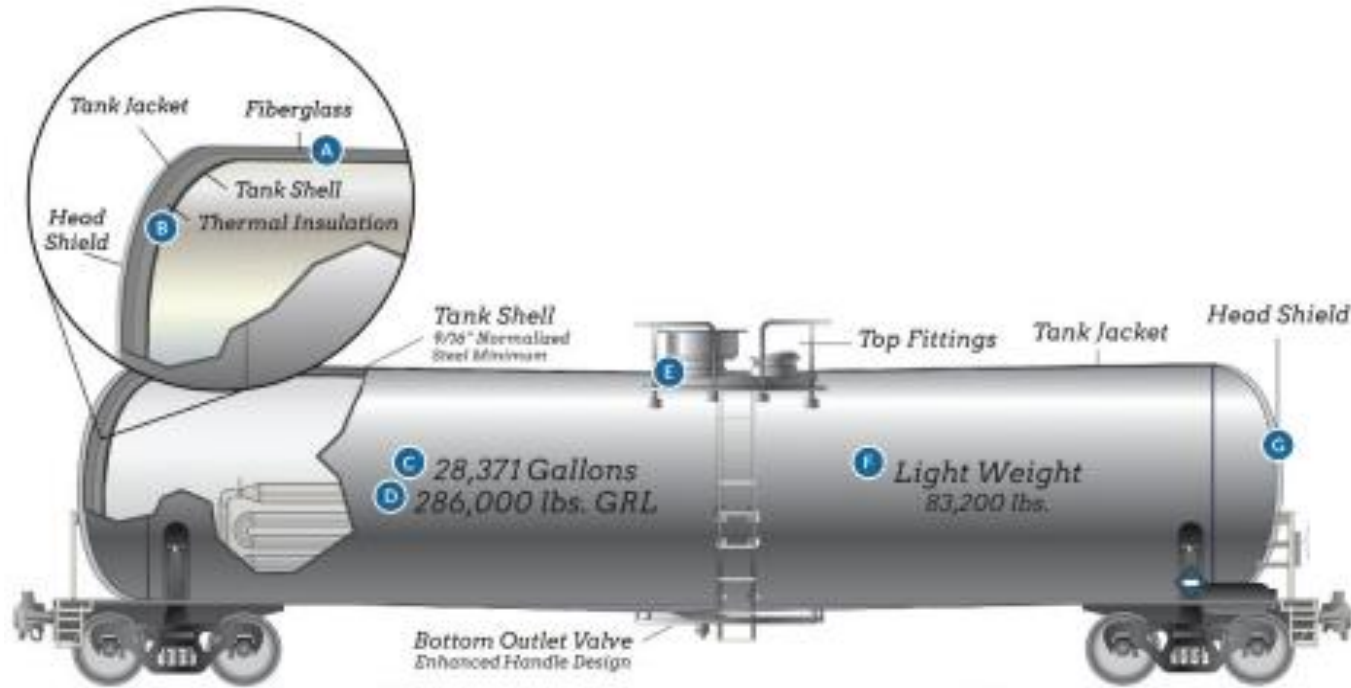
$$R_i = P_i \times C_i$$

$$P_i = P(TD) \times P(i | TD)$$

$$P(i | TD) = \sum_{j=1}^i [P_j^{POD} \times \sum_{k=i-j+1}^{n-j+1} P(k | j)]$$



### 3. Prevention of release for damaged Hazmat cars (Reducing rate of hazmat releases)

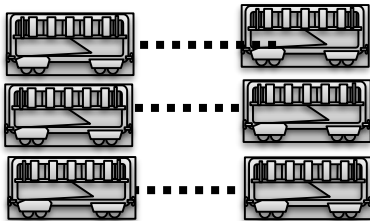


This is an artist's conceptual rendering and does not represent an actual engineering rendering of a "future" car

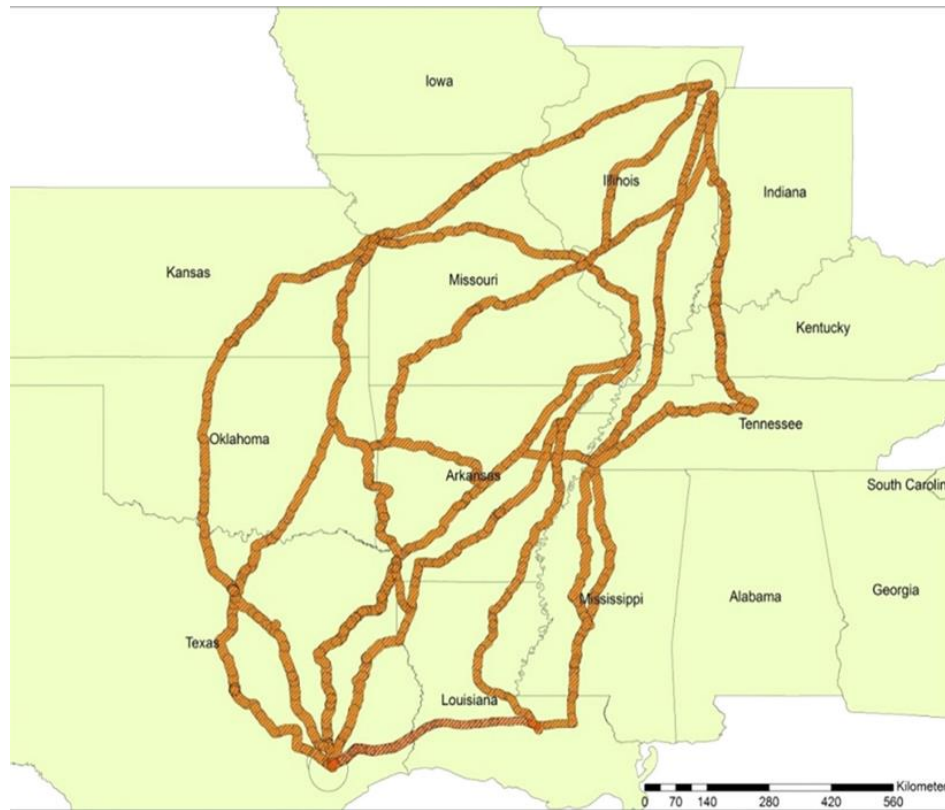
(Raj and Pritchard, 2000, Balkan et al., 2000, Sait and Balkan, 2005, Balkan et al., 2007, Balkan, 2003, ERAC 2007).

- Enhanced Tank Car Design Improves the Safety of Transporting Crude Oil and Alcohol by Rail

Christopher P. L. Barkan, Xiang Liu, M. Rapik Saat, TR News 298, June–July–August 2015



## 4. Rerouting the Hazmat shipment (Reducing severity of hazmat releases)



(Glickman, 1983; Abkowitz et al., 1989; Olekszyk, 1993; Glickman and Erkut 1996; Verma and Verter, 2007)

- Complex dynamics of transferring risk within the rail sector. Drawing on real-world examples from the rail industry, today lecture investigates how risk, particularly in hazmat transportation, can be managed and redistributed effectively!
- The risks associated with transporting hazardous materials by rail, showing how these risks are shifted to various parties like agencies and communities.

- Bagheri Conservation of Risk!!!

*In any system or process, the total risk remains constant, unless altered by an external force or intervention. Risk cannot be entirely eliminated; it can only be transformed or transferred within the system. When mitigating risks, the reduction in one area often results in the displacement of that risk to another, or its conversion into a different form of risk. To maintain a balanced system, it is essential to account for all risk transfers and transformations, ensuring that the total risk is optimized rather than merely redistributed.*

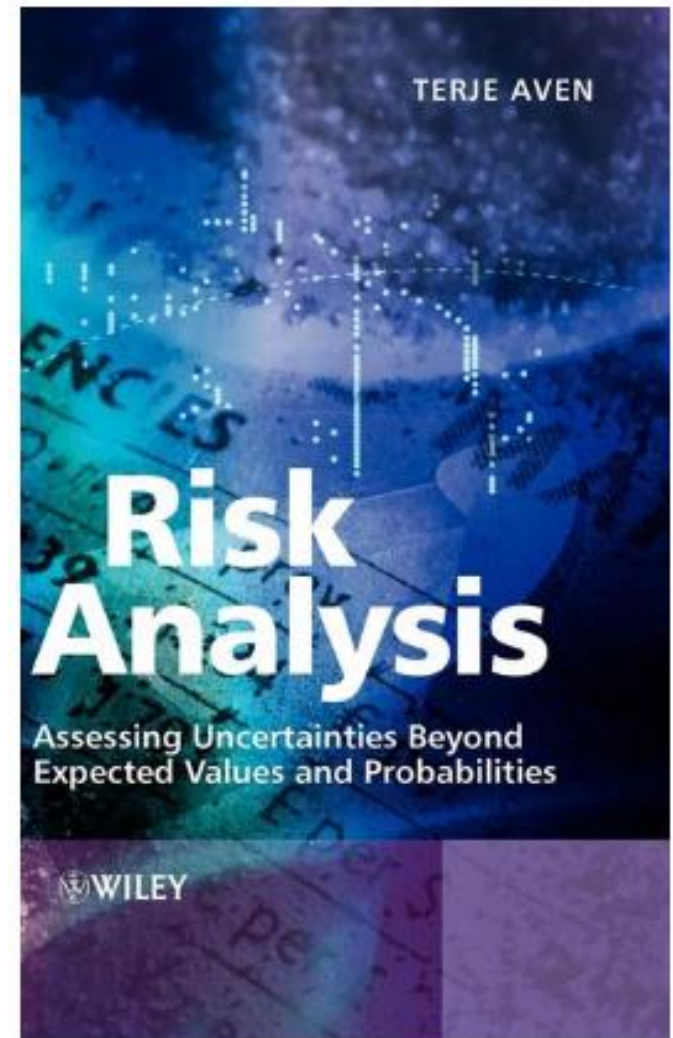
- **Risk Analysis**

Assessing Uncertainties Beyond Expected Values and Probabilities

**By Terje Aven**

University of Stavanger, Norway

**Wiley, 2015**





- Prof F. Corman, head of IVT(my host)

## ETH4D



## ETH RISK CENTER

**IVT** *Institut für Verkehrsplanung und Transportsysteme*  
*Institute for Transport Planning and Systems*

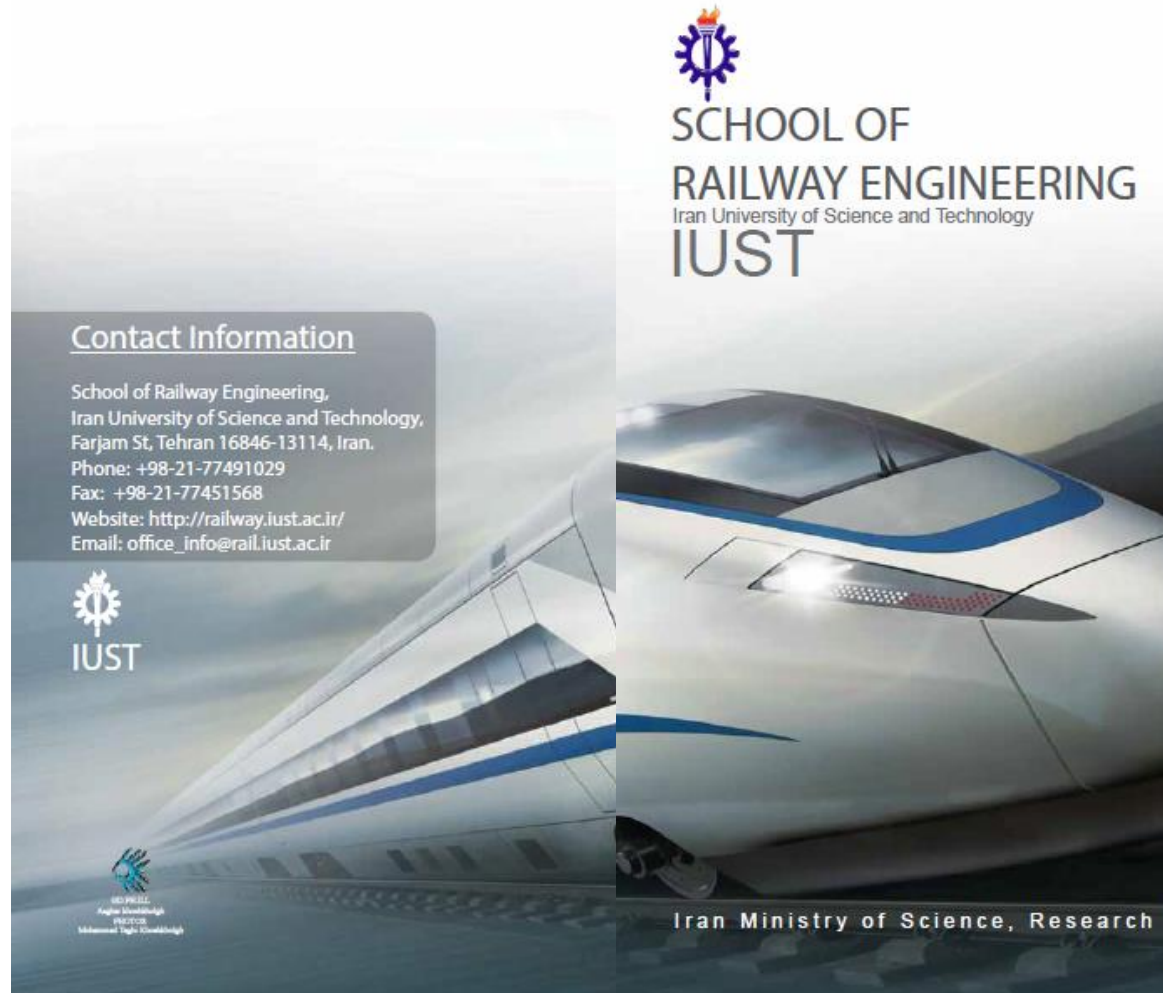
# Acknowledgment(cont.)

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**Thank You!**


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