Risk Analysis for Truck Transportation of High Consequence Cargo

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Comparing fixed facilities to transportation

The “chicken ranch” controls everything they can to drive down risk
  – Control environment, work processes, work pace, and workers

The “egg haulers” drive the State and US highways with high kinetic energy and less-controllable risks
  – Other drivers (beginners, impaired, distracted, etc.)
  – Other vehicles (tankers, hazmat, super-heavies)
  – Road environments (bridges/tunnels/abutments/construction)
  – Degraded weather

Lots of uncertainty in the type of transportation accidents to plan for
Begin with the End in Mind
Keep cargo safe during credible worst-case accidents

What is credible?
- Depends on the person
- Often use a low likelihood of occurrence
  - $10^{-6}/\text{yr}$ – commonly assumed
  - Called Design Basis Accidents (DBA)

What is safe?
- Demonstrated safe environments through testing and analysis

How to “keep cargo safe”
- Controls mitigate accidents environments to demonstrated safe cargo environments
  - Tractor and trailer, cargo restraints, operations
What kinds of insults are a concern?
- Mechanical – crash breaks eggs
- Thermal – fire cooks eggs
- Electrical – energy “fries” eggs
- Combined environments – cause broken, scrambled, fried eggs!
- …

Let’s focus on mechanical insults
- Pay attention to assumptions, extensions, limitations in the details
- Pay attention to narrowing of focus as we focus in on quantitative solutions
Dealing with the reality of limited data

“Egg haulers” have too few accidents & miles for meaningful statistics
⇒ Assume we’re no worse than the industry average and use national databases
⇒ Determine the accident-per-mile rate

No national accident databases exist for high-energy crashes, but trucks involved in fatal accidents (TIFA) are tracked
⇒ Assume TIFA accidents encompass high-energy accidents
⇒ Identify the most severe TIFA accidents for investigation

Details of severe accidents are buried in police accident reports
⇒ Analyze the ~1500 worst TIFA accidents to infer worst environments

Organize TIFA accidents into analyzable groups
⇒ Bin accidents into cardinal impact directions
⇒ Determine equivalent insult to egg truck
Unifying metric for analyzing crashes

**Peak Contact Velocity (PCV) in MPH** is the maximum change in velocity that would be experienced by the cargo due to an accident.
- Based on conservation of momentum
- Assumes plastic deformations

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**Case 1 – Head-on crash**

- **Egg Truck**
- **Impact Object (e.g., hard, unyielding surface)**
- **65 MPH**

**Case 2 – Side Impact crash**

- **Impact Object (e.g., train)**
- **55 MPH**
- **Egg Truck**
Results: $10^{-6}$/yr Design Basis Accidents

![Graph showing the likelihood of exceeding PCV against peak contact velocity (MPH).](image-url)
Testing to Find DBA Forces

- In 2002, we crashed an “egg truck” into a hard unyielding surface at 65 MPH to measure truck and cargo accelerations
- Results provided the environments to design restraints and controls
My Lessons Learned

“In theory, there is no difference between theory and practice; In practice, there is.” – Yogi Berra

- Real world is dirty, messy, incomplete, unknown
- We must make assumptions, use limited data & imperfect models

“It's not so much what you don't know that can hurt you, it's what you think you know that ain't so.” – Will Rogers

- Reasonable assumptions can lead to reasonable analyses
- Tenuous assumptions, data or analyzes may be worse than no analysis

“All happy families resemble one another, each unhappy family is unhappy in its own way.” – Leo Tolstoy

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