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Risk Analysis for Truck Transportation of High Consequence Cargo

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Workshop on Risk Assessment and Safety Decision Making under Uncertainty

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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}/yr – commonly assumed**
- **Called Design Basis Accidents (DBA)**

Resulting forces → accident environments

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**

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Building the Technical Case for “Credible”

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

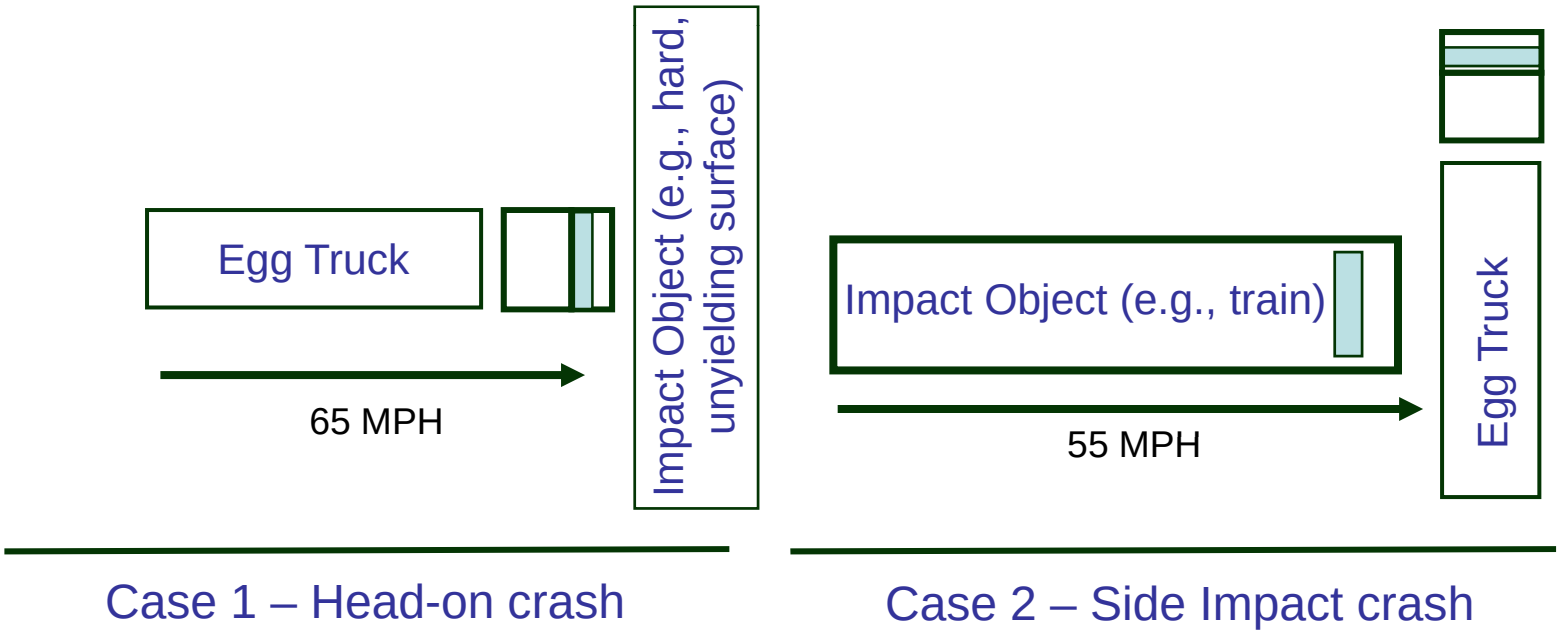
⇒ **Bin accidents into cardinal impact directions**

⇒ **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



Case 1 – Head-on crash

Case 2 – Side Impact crash

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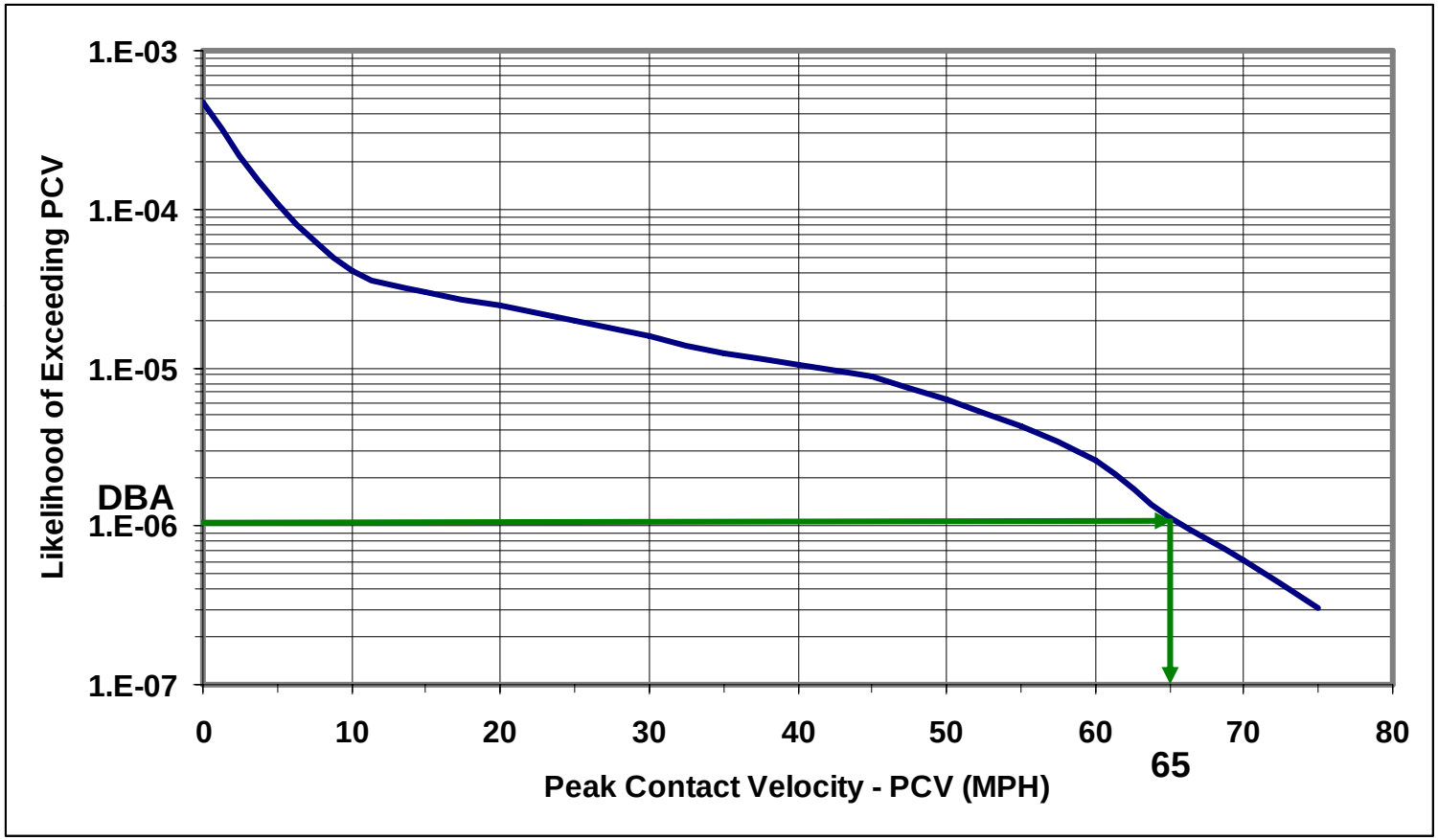
Results: 10^{-6}/yr Design Basis Accidents



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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**

- **...**