



U.S. Department
of Transportation
**Pipeline and
Hazardous Materials
Safety Administration**



Quantifying Factors & Trends in Casualties due to Hazardous Materials Transportation

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Society for Risk Analysis - Annual Meeting

Charleston, SC

December 6, 2011

Who Is PHMSA?

- Agency of U.S. Department of Transportation
- Created in 2005, a merger of the Office of Pipeline Safety (OPS) and Office of Hazardous Materials Safety (OHMS)

OHMS coordinates oversight of **hazmat** transportation in the U.S. and aboard U.S.-based carriers

- Regulation
- Public information and training
- Granting variations (“special permits”) from regulation
- Technical review of new products (both hazmats and their packaging)
- Field inspections
- ...and data evaluation and analysis



Hazardous Materials



- Explosive (fireworks) or under pressure (compressed gases)
- Poisonous (ammonia, chlorine) or biohazardous (infectious agents)
- Asphyxiant (carbon dioxide)
- Corrosive (hydrochloric acid, sulfuric acid)
- Flammable (gasoline, hydrogen, lithium), and
- Radioactive materials

- Federal Motor Carrier Safety Administration (FMCSA)
- Federal Railroad Administration (FRA)
- Federal Aviation Administration (FAA)
- United States Coast Guard (USCG, within DHS)

Hazmat Safety vs. All Transportation

- In 2009 there were:
 - 33,000 deaths on highways
 - 500 deaths in air transportation
 - 400 deaths in rail transportation
 - 150 deaths in commercial water transportation

&

- **12 deaths** due to hazmat transport across all modes

What is our goal?

- PHMSA faces the enviable “challenge” of a strong track record
- We want to know how to direct our attention and resources to prevent future events
- Can we **characterize underlying risk** in a useful way?
 - ...and how? Depends on our data capabilities

New Risk Management Framework

- Reorientation toward a systematic approach to identifying and mitigating or controlling hazards
 - Questions include the normative (How can we define unacceptable risk?) and positive (Can we model risk potential in such a heterogeneous, multimodal field?), as well as what we can do to correct for our data gaps

How to Approach Risk Management?

- First step - reviewing history to see:
 - Where there have been consistent problems
 - Where there are trends (increasing or decreasing) & correlations, and
 - Where there is no incident history
 - If we have no data on historical consequences in HMT, the question of how to use it is moot
 - E.g., no documented casualties from radioactive materials in transportation



 U.S. Department of Transportation Research and Special Programs Administration	Hazardous Materials Incident Report	Form Approval OMB No. 2137-0039
<p>According to the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number. The valid OMB control number for this information collection is 2137-0039. The filing out of this information is mandatory and will take 96 minutes to complete.</p>		
<p>INSTRUCTIONS: Submit this report to the Information Systems Manager, U.S. Department of Transportation, Research and Special Programs Administration, Office of Hazardous Materials Safety, DHM-63, Washington, D.C. 20590-0001. If space provided for any item is inadequate, use a separate sheet of paper, identifying the entry number being completed. Copies of this form and instructions can be obtained from the Office of Hazardous Materials Website at http://hazmat.dot.gov. If you have any questions, you can contact the Hazardous Materials Information Center at 1-800-HMR-4922 (1-800-467-4922) or online at http://hazmat.dot.gov.</p>		
PART I - REPORT TYPE		
<p>1. This is to report: <input type="checkbox"/> A) A hazardous material incident <input type="checkbox"/> B) An undeclared shipment with no release</p> <p style="margin-left: 100px;"> <input type="checkbox"/> C) A specification cargo tank 1,000 gallons or greater containing any hazardous materials that (1) received structural damage to the lading retention system or damage that requires repair to a system intended to protect the lading retention system and (2) did not have a release. </p>		
<p>2. Indicate whether this is: <input type="checkbox"/> An initial report <input type="checkbox"/> A supplemental (follow-up) report <input type="checkbox"/> Additional Pages</p>		
PART II - GENERAL INCIDENT INFORMATION		
<p>3. Date of Incident: _____ 4. Time of Incident (use 24-hour time): _____</p>		
<p>5. Enter National Response Center Report Number (if applicable): _____</p>		
<p>6. If you submitted a report to another Federal DOT agency, enter the agency and report number: _____</p>		
<p>7. Location of Incident: City: _____ County: _____ State: _____ ZIP Code (if known): _____</p> <p style="margin-left: 20px;">Street Address/Mile Marker/Yardname/Airport/Body of Water/River Mile _____</p>		
<p>8. Mode of Transportation <input type="checkbox"/> Air <input type="checkbox"/> Highway <input type="checkbox"/> Rail <input type="checkbox"/> Water</p>		
<p>9. Transportation Phase <input type="checkbox"/> In Transit <input type="checkbox"/> Loading <input type="checkbox"/> Unloading <input type="checkbox"/> In Transit Storage</p>		
<p>10. Carrier/Reporter Name _____</p> <p style="margin-left: 20px;">Street _____</p> <p style="margin-left: 20px;">City _____ State _____ ZIP Code _____</p> <p style="margin-left: 20px;">Federal DOT ID Number _____ Hazmat Registration Number _____</p>		
<p>11. Shipper/Offeror Name _____</p> <p style="margin-left: 20px;">Street _____</p> <p style="margin-left: 20px;">City _____ State _____ ZIP Code _____</p> <p style="margin-left: 20px;">Waybill/Shipping Paper _____ Hazmat Registration Number _____</p>		
<p>12. Origin (if different from shipper address) Street _____</p> <p style="margin-left: 20px;">City _____ State _____ ZIP Code _____</p>		
<p>13. Destination Street _____</p> <p style="margin-left: 20px;">City _____ State _____ ZIP Code _____</p>		
<p>14. Proper Shipping Name of Hazardous Material: _____</p>		
<p>15. Technical/Trade Name: _____</p>		
<p>16. Hazardous Class/Division: _____</p>		
<p>17. Identification Number: _____ <small>(E.g. UN2764, NA 2020)</small></p>		
<p>18. Packing Group: _____ <small>(if applicable)</small></p>		
<p>19. Quantity Released: _____ <small>(Include Measurement Units)</small></p>		
<p>20. Was the material shipped as a hazardous waste? <input type="checkbox"/> Yes <input type="checkbox"/> No If yes, provide the EPA Manifest Number: _____</p>		
<p>21. Is this a Toxic by Inhalation (TIH) material? <input type="checkbox"/> Yes <input type="checkbox"/> No If yes, provide the Hazard Zone: _____</p>		
<p>22. Was the material shipped under an Exemption, Approval, or Competent Authority Certificate? <input type="checkbox"/> Yes <input type="checkbox"/> No</p> <p style="margin-left: 20px;">If yes, provide the Exemption, Approval, or CA number: _____</p>		
<p>23. Was this an undeclared hazardous materials shipment? <input type="checkbox"/> Yes <input type="checkbox"/> No</p>		
<p>Form DOT F 5800.1 (01-2004) Page 1 Reproduction of this form is permitted</p>		





Reporting Casualties in HMT



- PHMSA is the only real aggregator of hazmat incident data; We collect information via Form 5800.1 on all hazmat releases in transportation
- Our data are only as good as are reported by carriers; we face multiple challenges in recordkeeping, not least that **minor** incidents
 - Are highly underreported, and
 - Represent a massive data-processing effort out of proportion to the risk and consequences involved
- **Major** incidents involving deaths & injuries* due to hazmat transportation in the United States are better substantiated; for convenience, these will be referred to collectively as casualties

** in this case: major injuries, requiring admittance and stay in the hospital for at least one night and/or the loss of a minimum of three days from work*

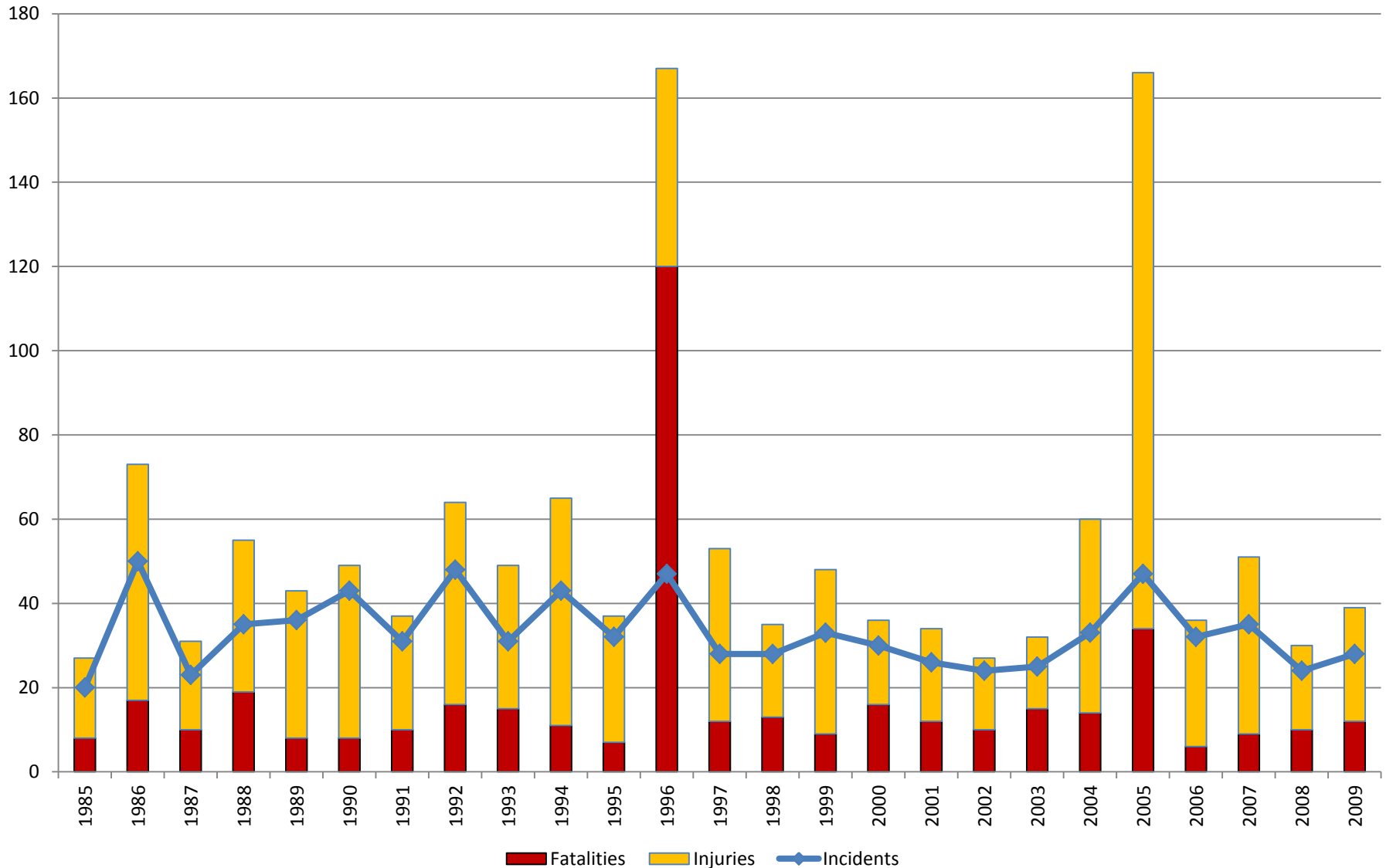
Historical Record: Casualty Overview

- Over **25 years** (1985-2009), we have documented
 - **421 fatalities** and
 - **921 injuries**

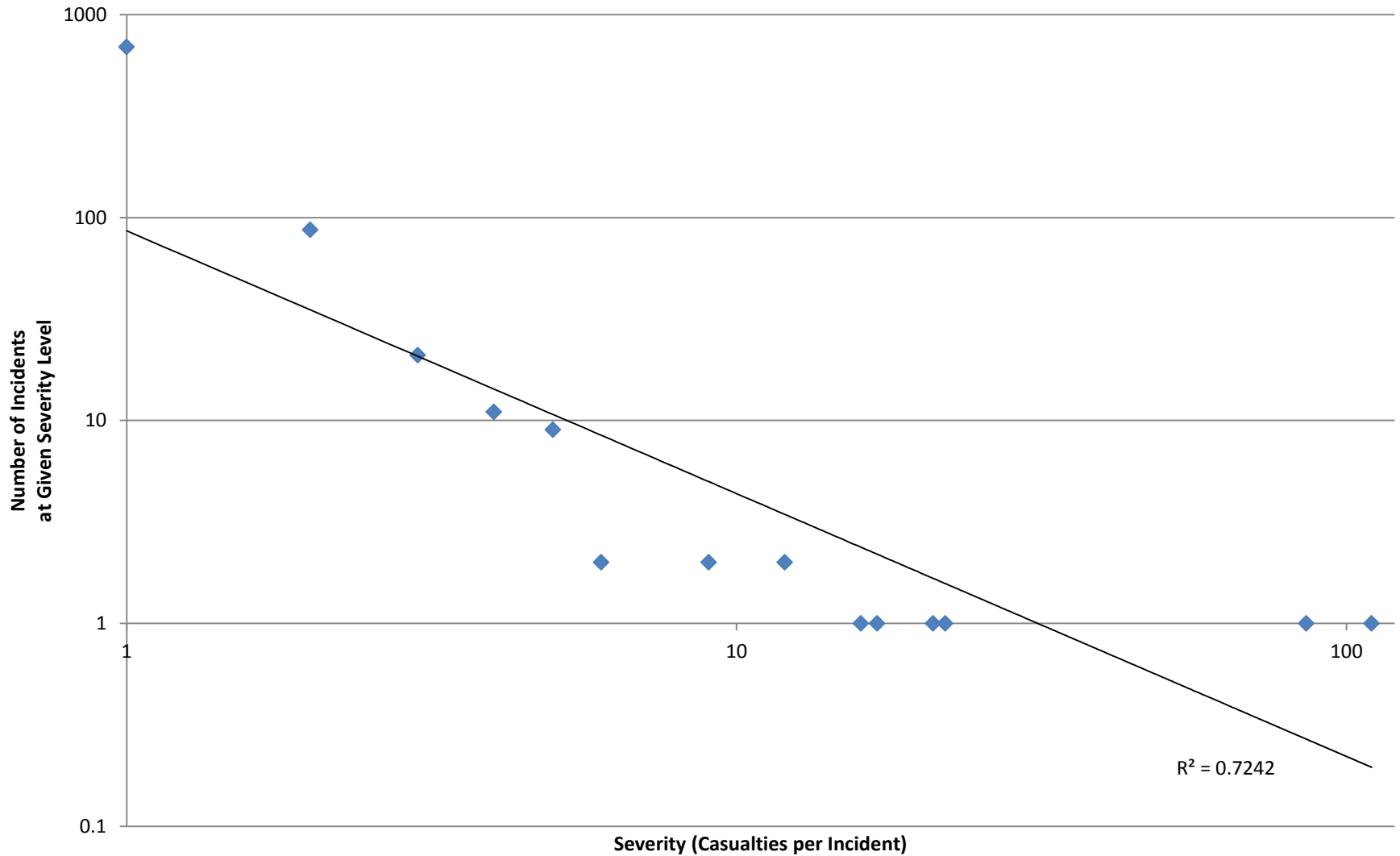
due to hazmat released in transportation, which collectively occurred in

- **830 incidents**
- These have not demonstrated a clear year-to-year pattern

Incidents with Casualties due to Hazmat, 1985-2009



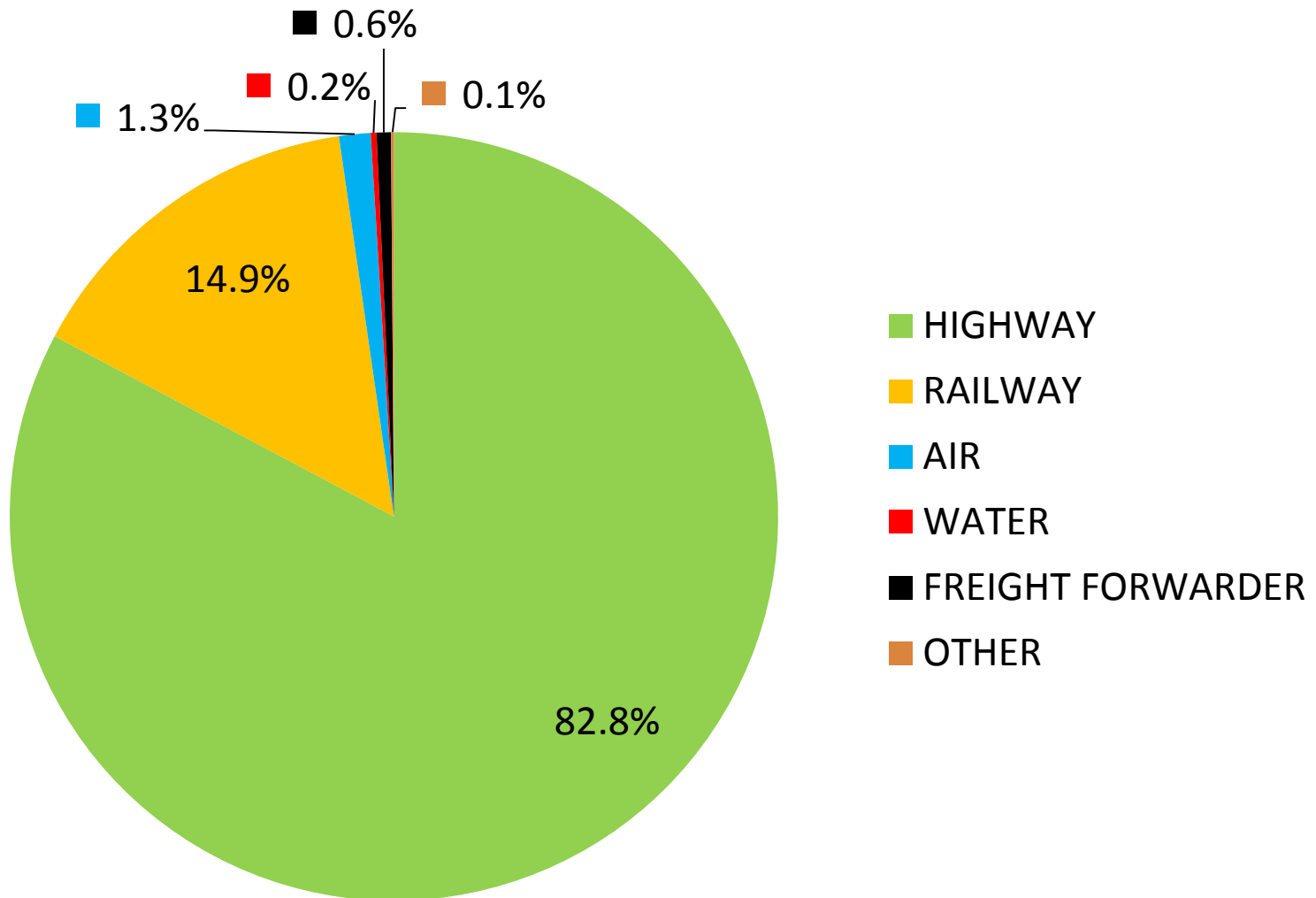
Logarithmic Scatterplot of Casualties per D&I Incident, 1985-2009



What can we say about these incidents?

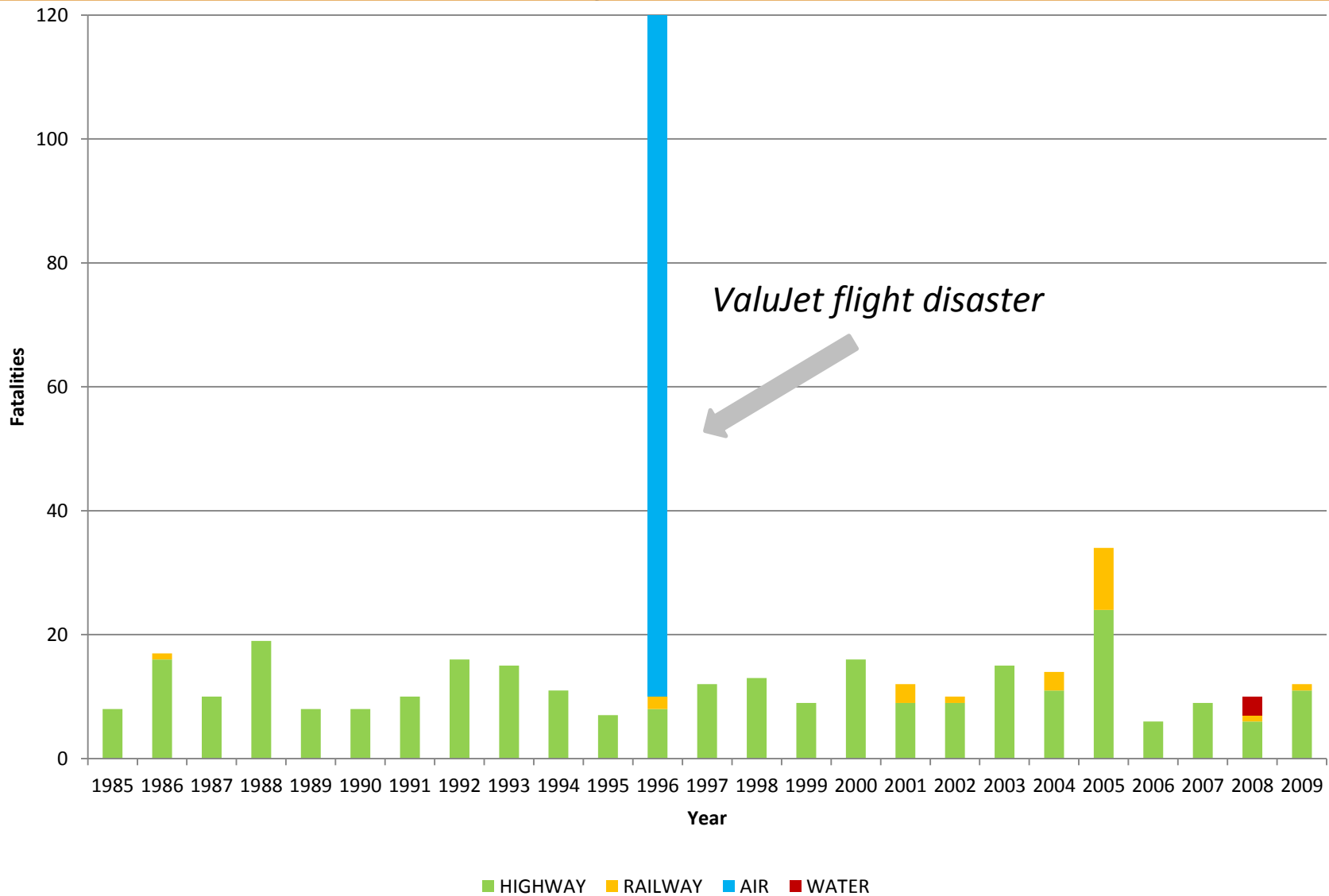
- Certain aspects of an incident are categorical and more easily recorded:
 - Mode (road, rail, air, water)
 - Phase (loading, in transit, storage, unloading)
 - Shipment size (bulk / non-bulk)
 - The occurrence of certain events
 - Fire, explosion, gas dispersion
 - Who is affected (hazmat workers, the general public, emergency responders)

Incidents by Mode, 1985-2009

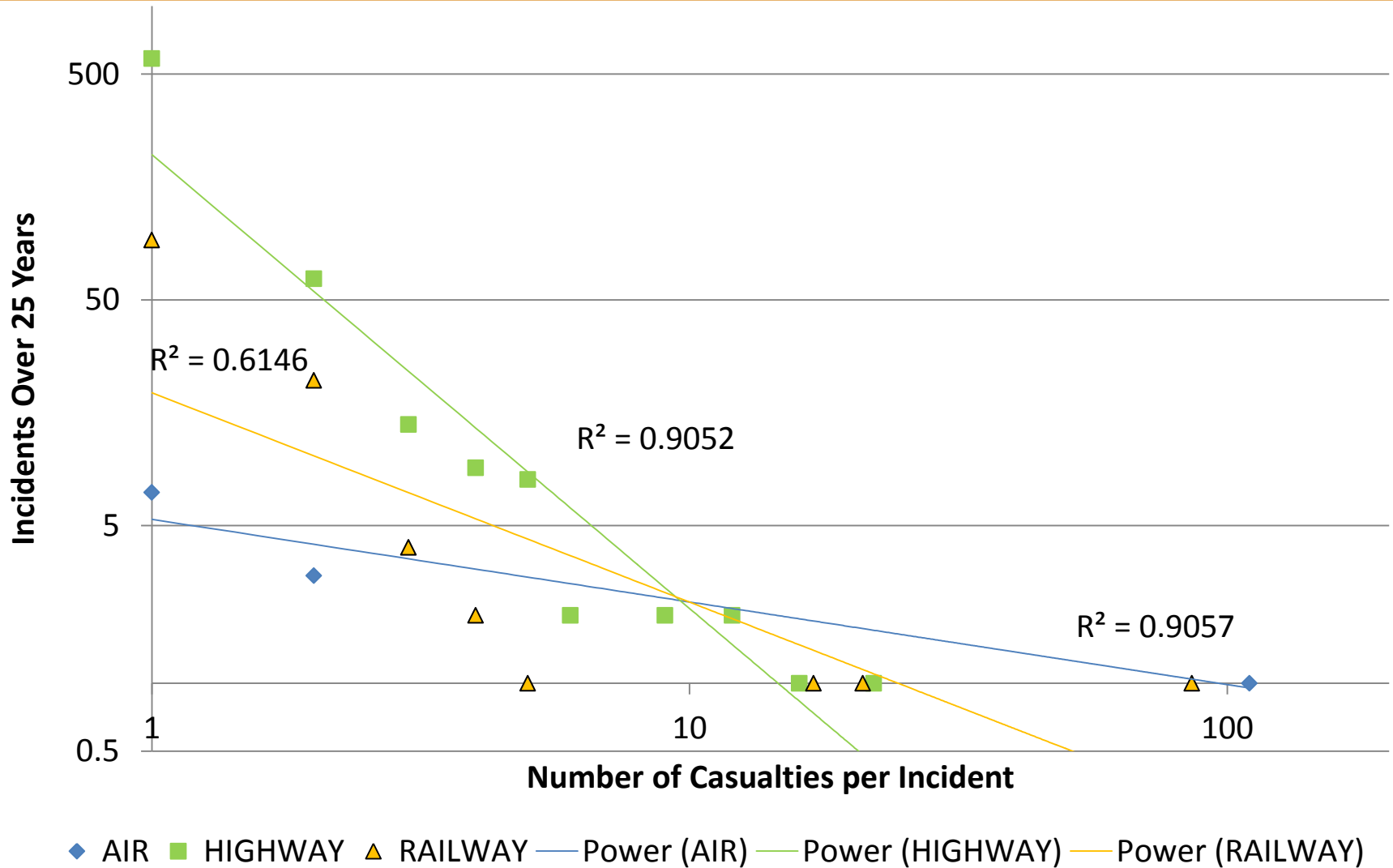




Fatalities by Mode, 1985-2009

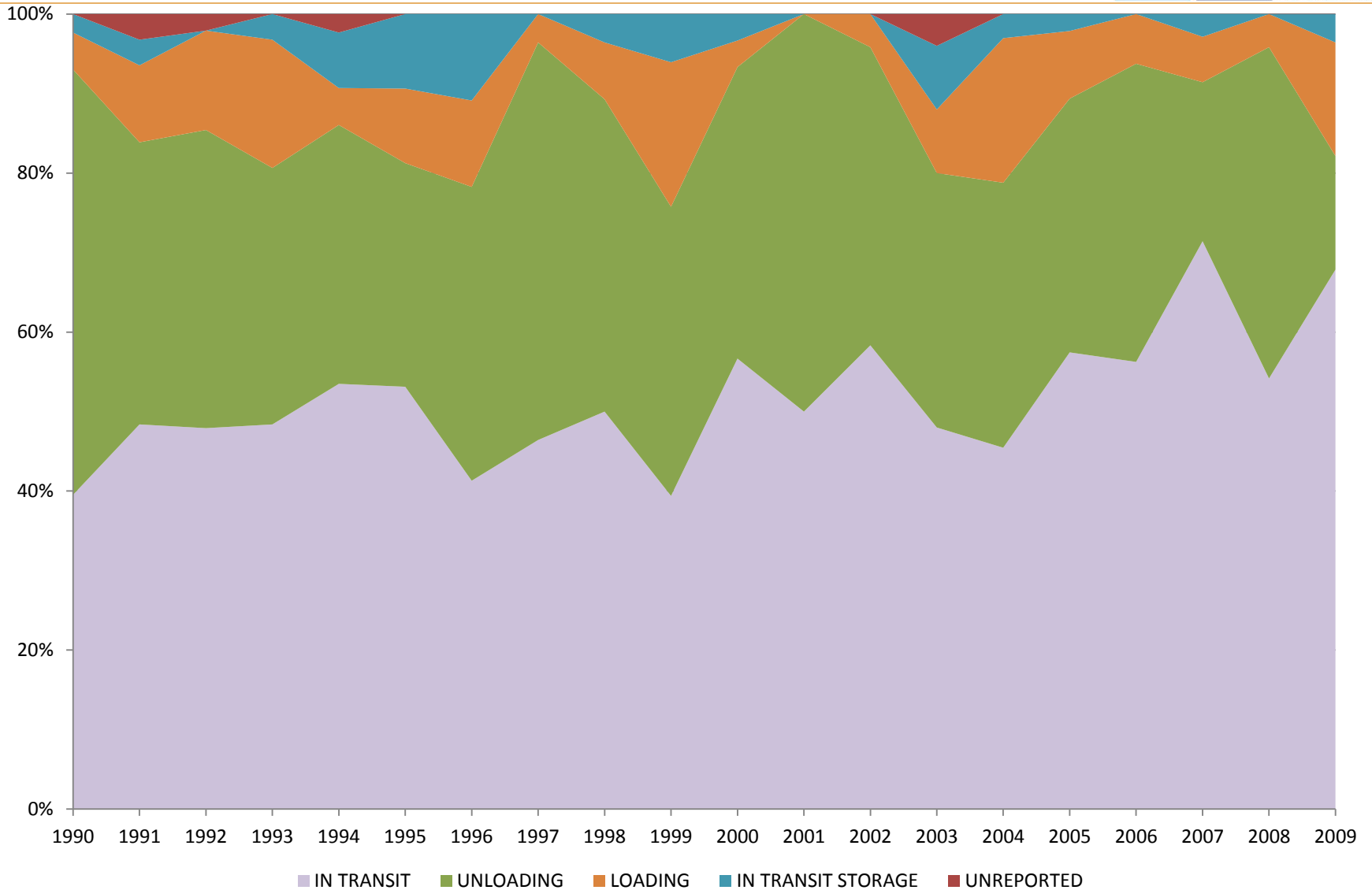


Frequency and Severity of D&I Incidents by Mode, 1985-2009





D&I Incidents by Transportation Phase, as Percent of Annual Total, 1990-2009



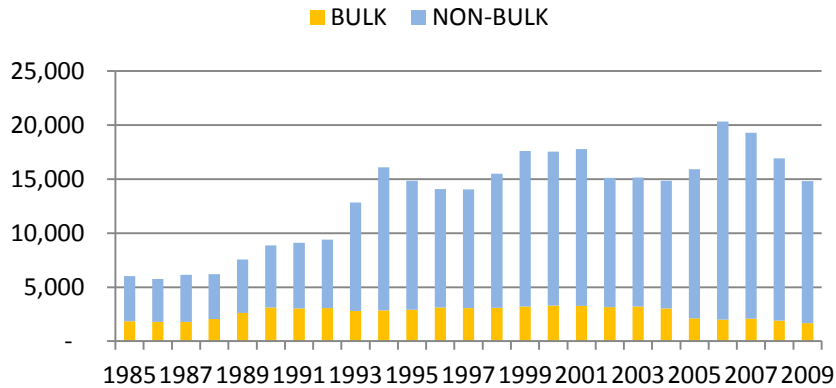
Number of Fatalities by Mode and Phase, 1990-2009

	IN TRANSIT	IN TRANSIT STORAGE	LOADING	UNLOADING	Grand Total
AIR	110				110
HIGHWAY	184	4	5	31	224
RAILWAY	17			4	21
WATER	3				3
Grand Total	314	4	5	35	358

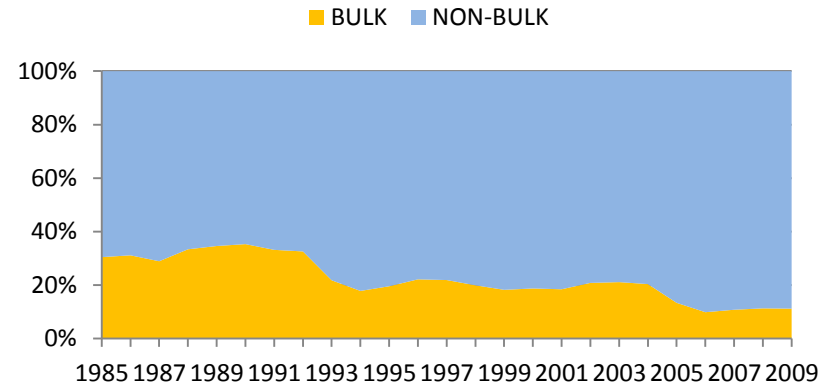
Number of Major Injuries by Mode and Phase (1990-2009)

	IN TRANSIT	IN TRANSIT STORAGE	LOADING	UNLOADING	Grand Total
AIR	5		3	5	13
HIGHWAY	178	25	52	245	500
RAILWAY	205	7	3	20	235
WATER	3				3
Grand Total	391	32	58	270	751

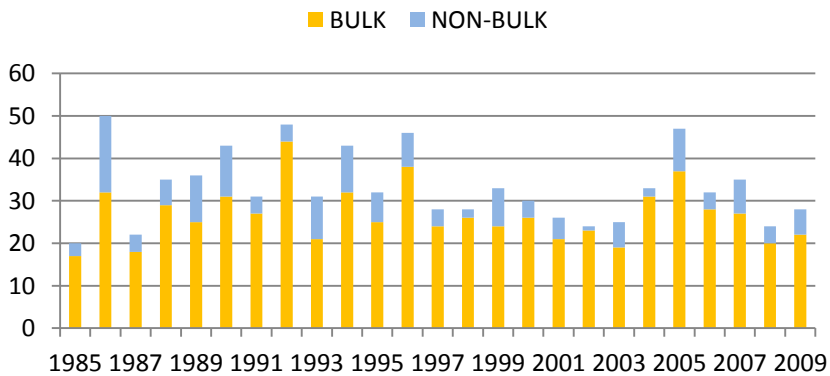
Number of All Reported Incidents by Packaging Size (Bulk vs. Non-Bulk), Raw Numbers, 1985-2009



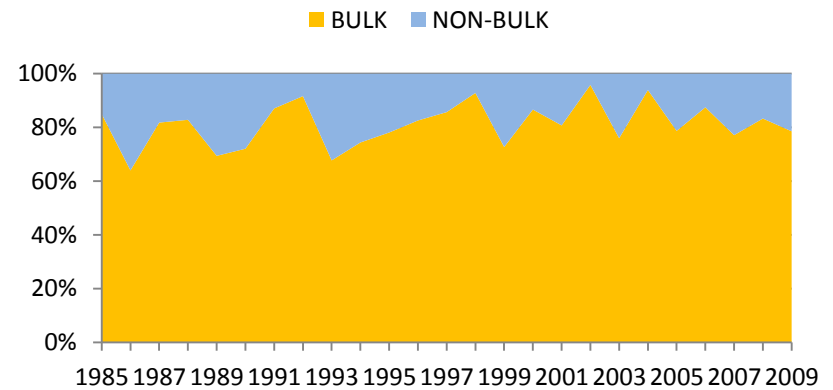
Annual Percent of All Reported Incidents by Packaging Size (Bulk vs. Non-Bulk), 1985-2009



Number of D&I Incidents by Packaging Size (Bulk vs. Non-Bulk), Raw Numbers, 1985-2009



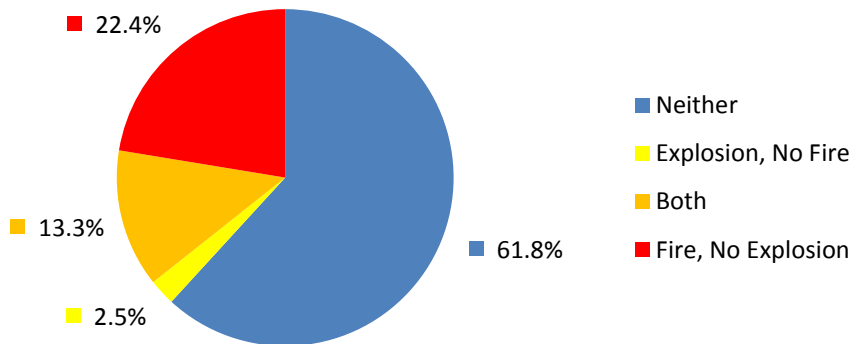
Annual Percent of D&I Incidents by Packaging Size (Bulk vs. Non-Bulk), 1985-2009



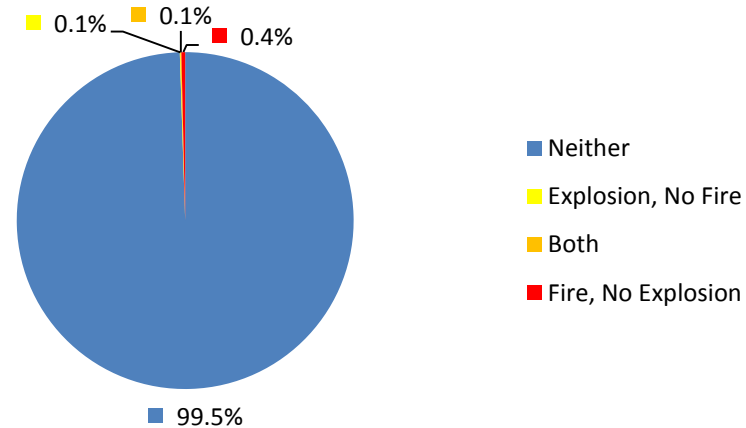
Number of D&I incidents with and without Fire And Explosion with Respect to All Reported Incidents, 1985-2009

Presence of Ignition Events	D&I Incidents	All Reported Incidents	D&I Incidents as % of All Reported Incidents
Neither	513	330,172	0.20%
Explosion, No Fire	21	232	9.10%
Both	110	270	40.70%
Fire, No Explosion	186	1,202	15.50%
Total	830	331,876	0.30%

D&I Incidents by Ignition Indicators, 1985-2009

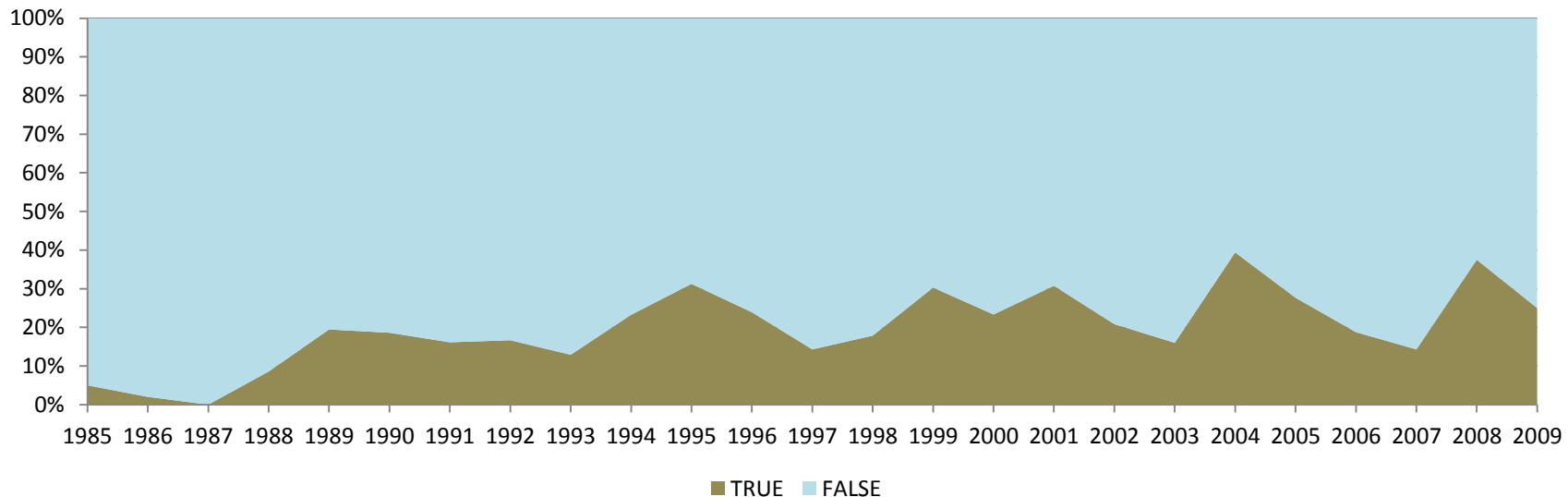


All Incidents by Ignition Indicators, 1985-2009





Gas Dispersion Incidents as Proportion of All Annual D&I Incidents, 1985-2009



Highway D&I Incidents

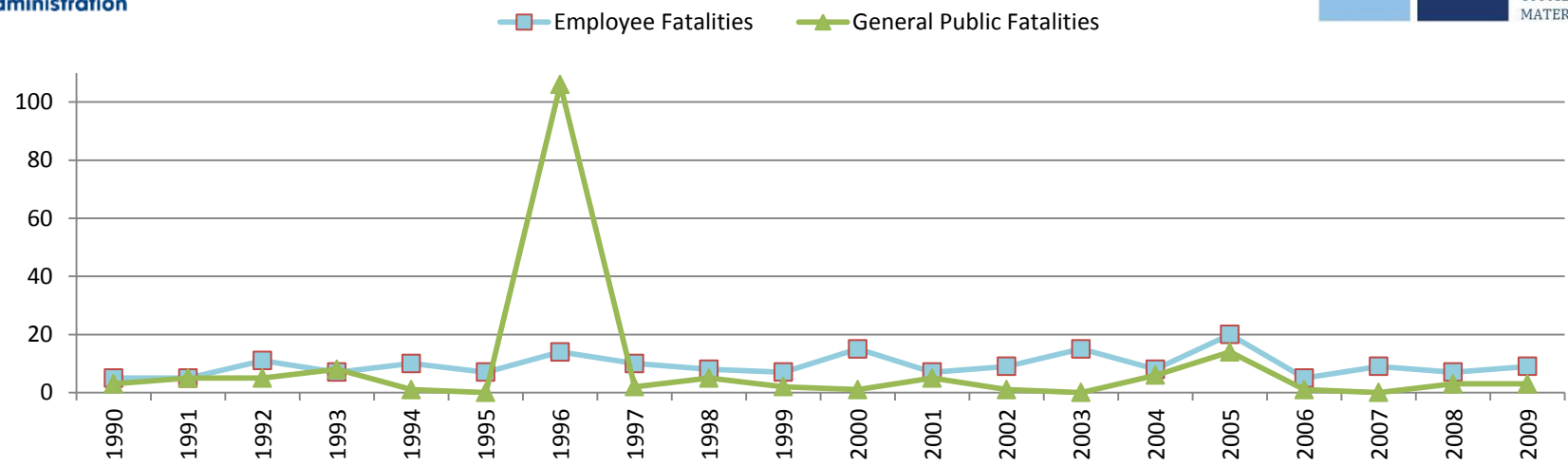
Highway	Gas Dispersion	
	FALSE	TRUE
Incidents	83.6%	16.4%
Fatalities	89.5%	10.5%
Injuries	83.1%	16.9%

Railway D&I Incidents

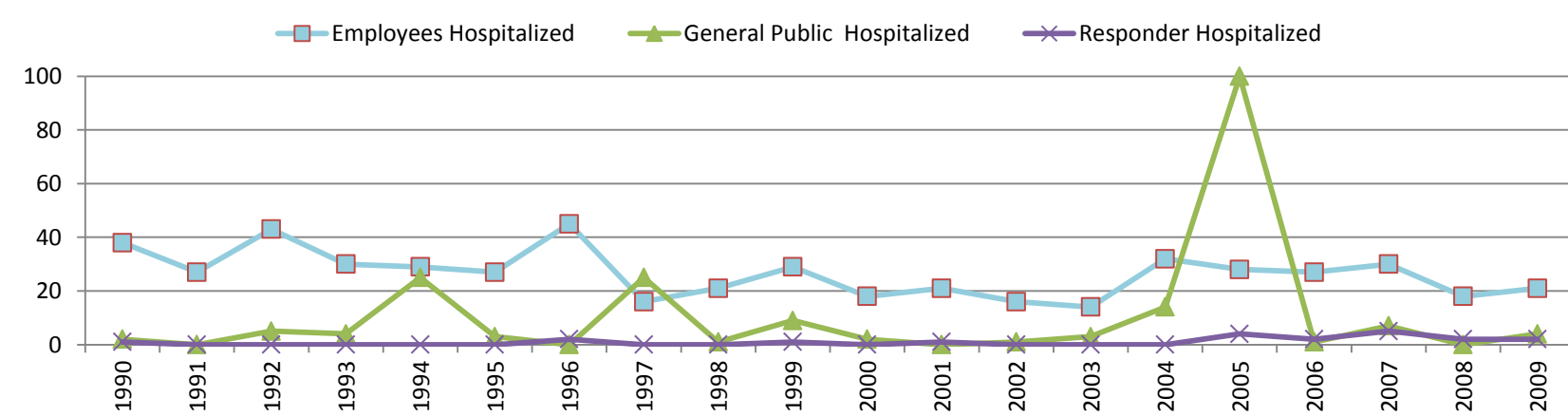
Railway	Gas Dispersion	
	FALSE	TRUE
Incidents	62.7%	37.3%
Fatalities	22.7%	77.3%
Injuries	44.2%	55.8%



Hazmat Fatalities by Victim Type and Year, 1990-2009



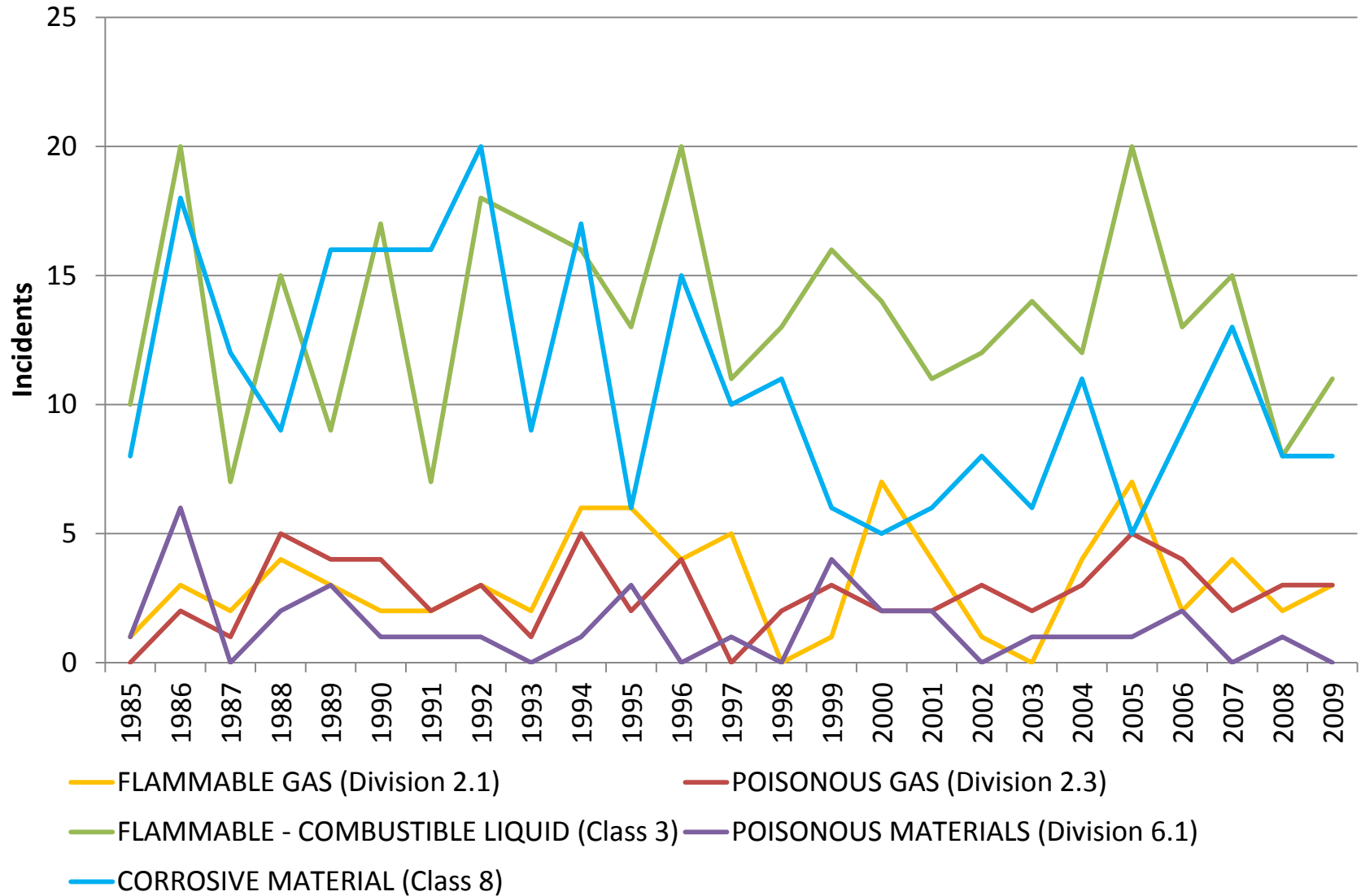
Hazmat Hospitalizations by Victim Type and Year, 1990-2009



Some aspects present added challenges:

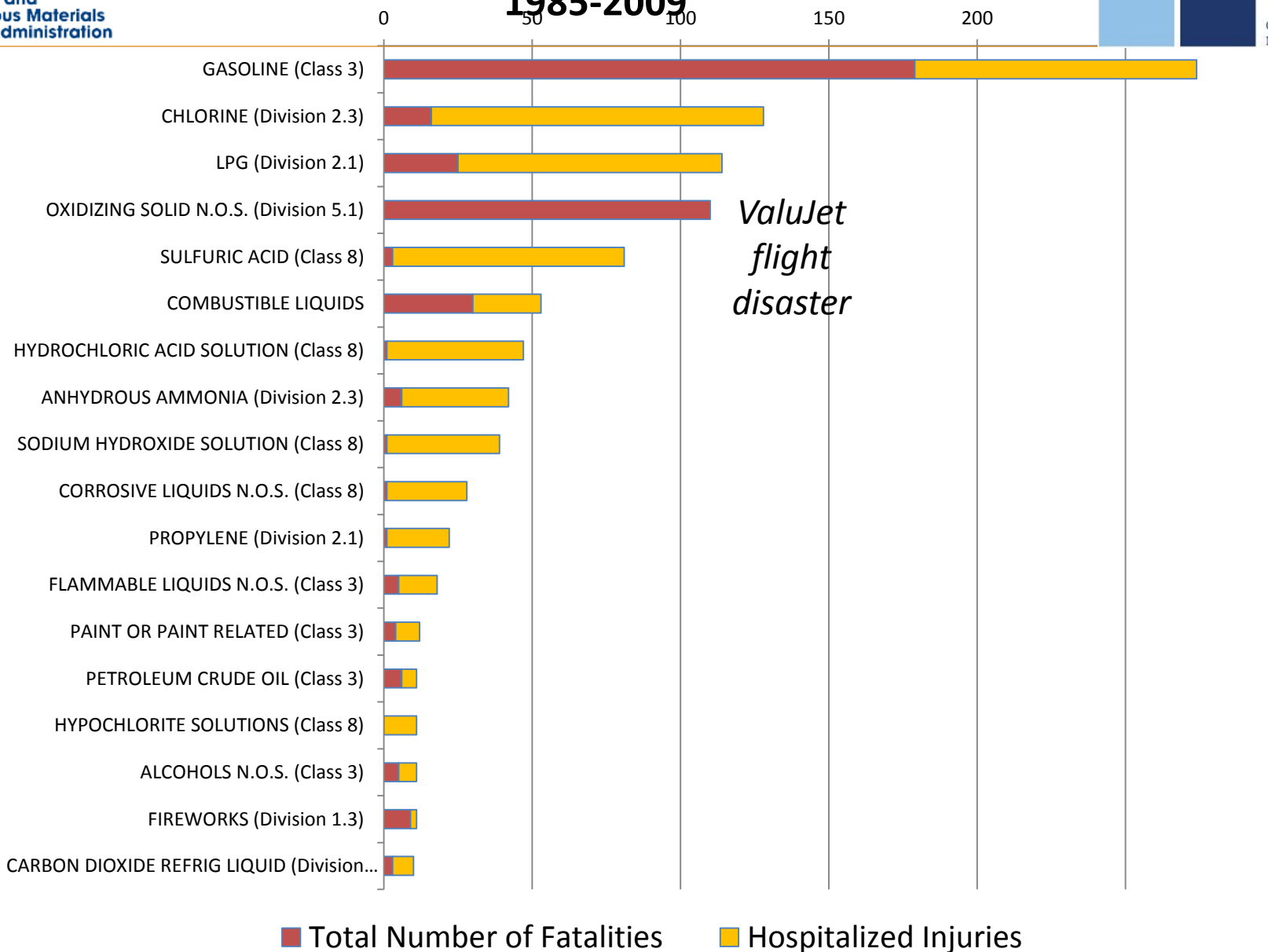
- Commodity (multiple items may be present)
- Packaging (not recorded consistently)
- Cause of failure
 - the reporting system has undergone multiple revisions over the years and
 - the options presented for reporting allow for great subjectivity

Top 5 Commodity Classes Involved in Casualty Incidents, 1985-2009



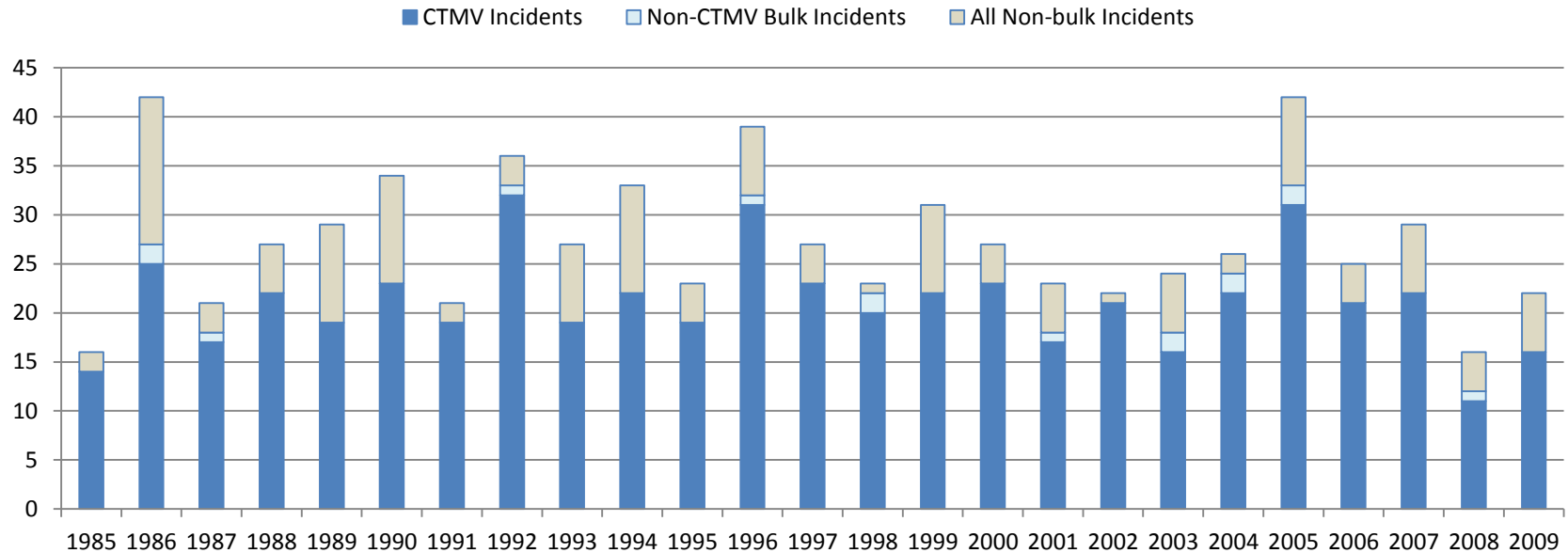


Commodities with 10 or More Associated Casualties, 1985-2009

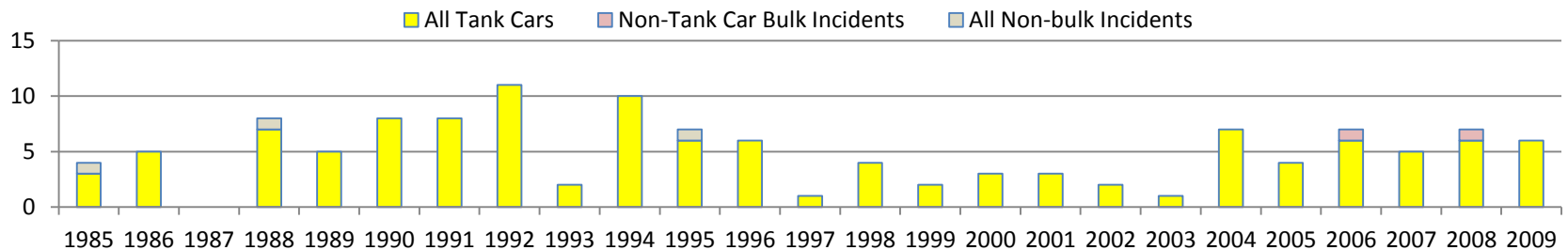




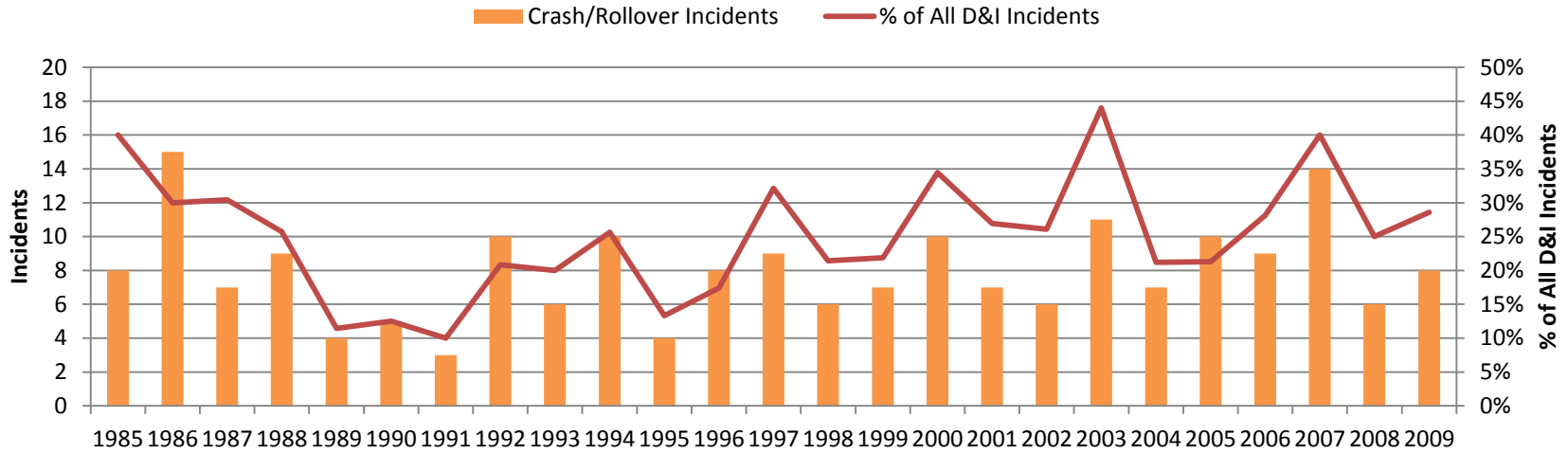
Highway D&I Incidents by Number Involving CTMVs, Other Bulk, and Non-bulk Packaging, 1985-2009



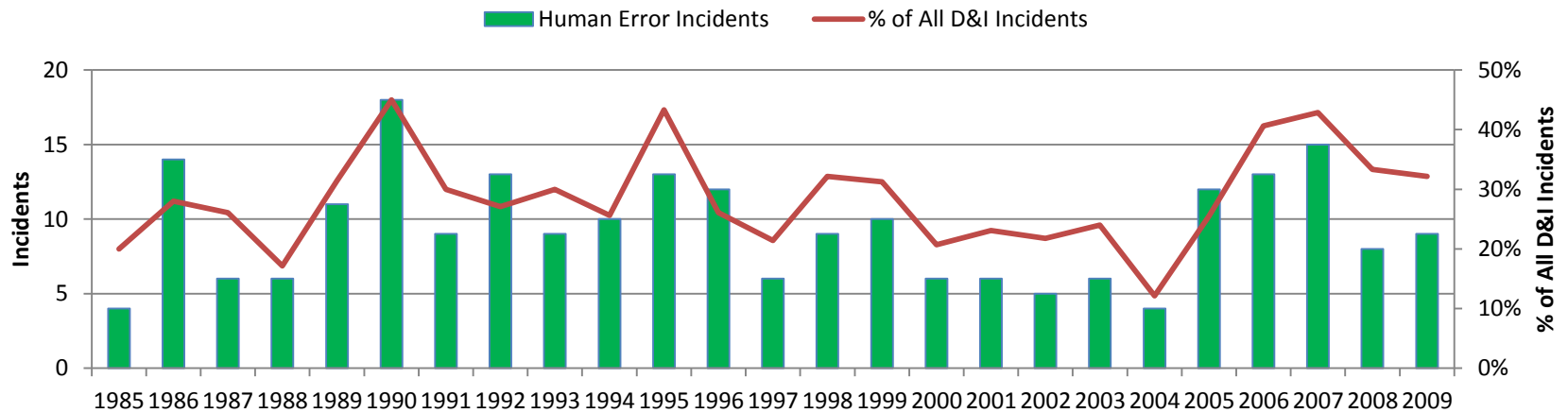
Railway D&I Incidents by Number Involving Tank Cars, Other Bulk, and Non-bulk Packaging, 1985-2009



Crash and Rollover Incidents and Their Proportion of All D&I Incidents, 1985-2009



Human Error Related Incidents and Their Proportion of All D&I Incidents, 1985-2009



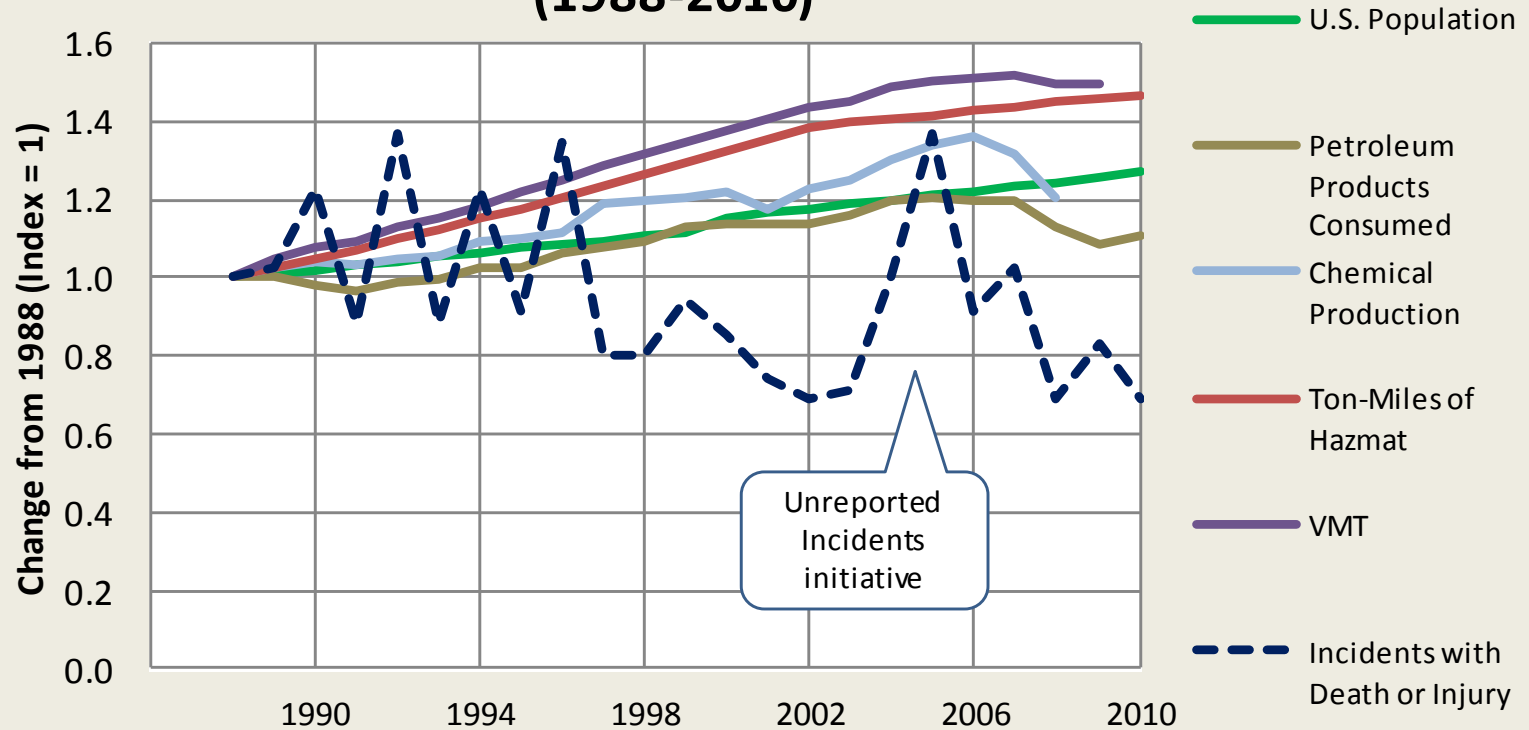


What About Normalization?



- All numbers up to this point have been gross figures
- Does it make sense to approach them in terms of exposure (**by volume or distance moved**), economic activity, population affected, or number of safety personnel?

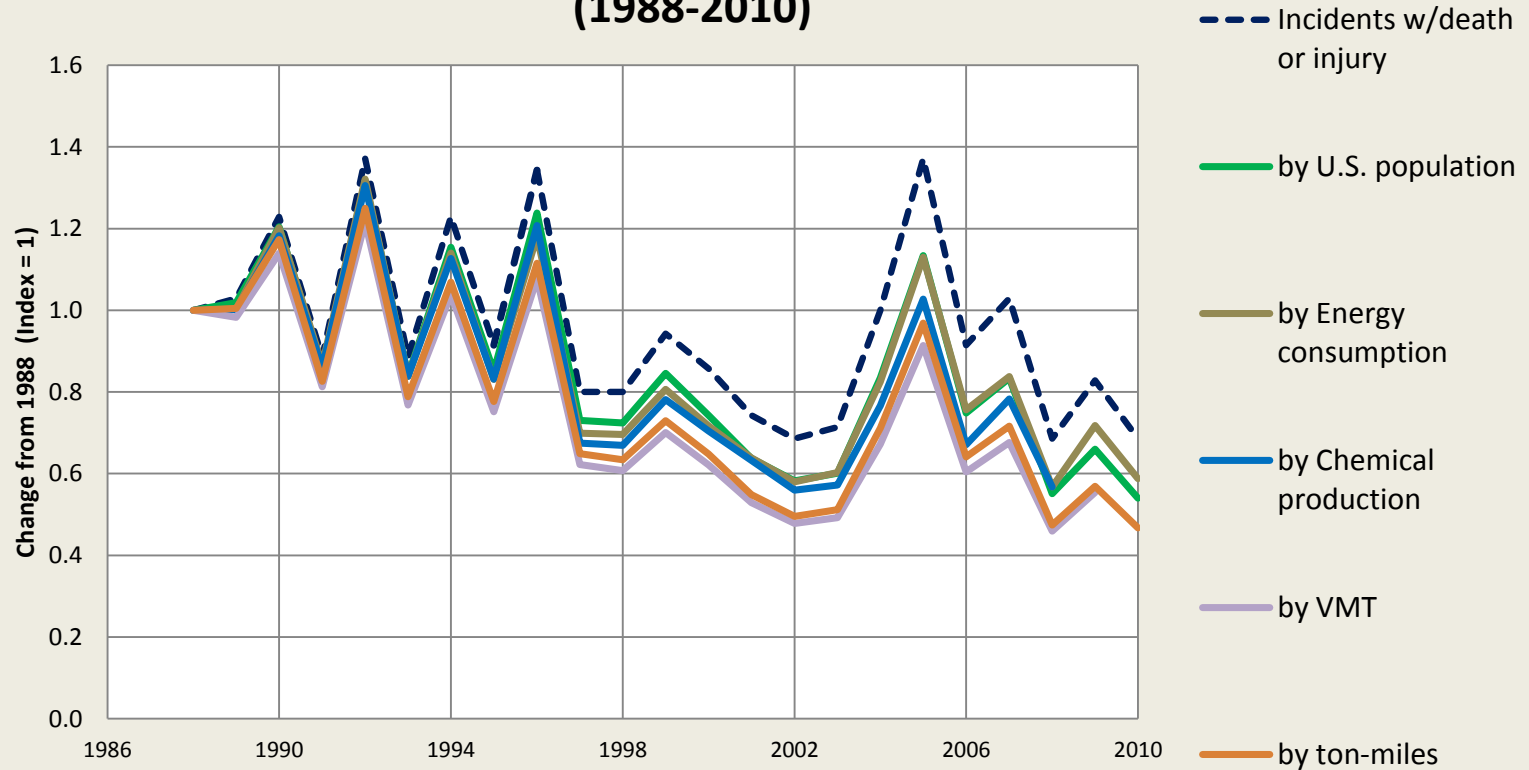
Hazmat Safety: Context Measures (1988-2010)



Data Sources: Census Bureau, Energy Information Administration, Bureau of Economic Analysis, Bureau of Transportation Statistics, PHMSA Incident Data - as of Sep. 13, 2010

Courtesy of Rick Kowalewski, PHMSA

Hazmat Safety: Normalizing Metrics (1988-2010)



Data Sources: Census Bureau, Energy Information Administration, PHMSA Annual Report Data, BTS ton-mile estimates, PHMSA Incident Data - as of Sep. 13, 2010

Courtesy of Rick Kowalewski, PHMSA



Challenges in Determining Trends



- Is using a “recency bias” reasonable?
 - Whatever happened last year is probably more relevant than what happened 20 years ago—but we want to escape the trap of reactionary thinking
- Can’t rely on past incidents alone to tell future. Seeking info from:
 - PHMSA offices (special permits, approvals, field inspections, technical staff)
 - Outside experts



Further Considerations



- The **Red Queen** and the **Whack-a-Mole**: Our regulatory regime is evolving—usually in response to past events—but *new technologies* and *latent risks* make it difficult to guess where to turn next; we can't know what will lead to the next ValuJet
- Even if we could account for a certain likelihood and magnitude of LPHC / black swans (as well as an estimate of the more predictably regular events), our area of responsibility is broad and our office is small—how can we use info to actually affect risk?

Next Step: Building RM Framework

- Finding best practices for developing a model
- Avoiding pitfalls of relying on bad or irrelevant data
- Making normative decisions (e.g., Can we weigh certain events more heavily?)
- Identifying collaboration opportunities
 - Currently developing an RFI

Questions? Comments?

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<http://www.phmsa.dot.gov/hazmat/risk>

