Relationships Between Fatality Risk, Mass, and Footprint

February 25, 2011

Objective

- **Estimate the effect on societal fatality rates of mass reduction without changing footprint**
  - **"Societal" fatality rate: includes occupants of other vehicles and pedestrians**
  - **Footprint = track width x wheelbase**

How to change mass without changing footprint

- **In the abstract**
  - ♦ **Add or remove sandbags in the trunk**
- **In actual practice to date – also tends to change the vehicle in other ways**
  - ♦ **Luxury features & powerful engines**
  - ♦ **Protective structure & padding**
- **Mostly in the future**
  - ♦ **Substitute lighter & stronger materials**

Mass in collisions of 2 light vehicles (momentum)

- **Mass reduction harms me and helps the other vehicle**
- **Relative mass of the 2 vehicles:**
  - **If mine is lighter, mass reduction harms me more than it helps you**
  - **If mine is heavier, mass reduction helps you more than it harms me**
- **Proportionate reductions in <u>both</u> vehicles: should have little net effect**

Effects of mass on handling & stability

- **Reduced stability if added mass raises the center of gravity**
- **Enhanced stability if it lowers cg**
- **Slower response to steering**
  - ♦ **Harmful if wise maneuver**
  - ♦ **Beneficial if inappropriate maneuver**

Benefits of increased mass

- **Knock down medium-sized trees or poles**
- **In collisions with**
  - ♦ **Medium-size trucks**
  - ♦ **Unoccupied parked cars**
  - ♦ **Deformable or movable objects**

Benefits of increased size (footprint)

- **Stability**
- **More crush space surrounding the occupants**

Historical trend (since at least 1976)

- **Heavier (and larger?) vehicles are better driven**
  - ♦ **As evidenced by lower culpability in 2-vehicle crashes**
- **Is mass a cause, an effect, or neither?**

2010 NHTSA Report

- **Pages 464-542 of FRIA, March 2010**
- **Statistical analysis of fatality rates of MY 1991-1999 cars (2- & 4-door) and LTVs in CY 1995-2000**
  - **By curb weight and footprint**
  - **Societal fatality rate per billion VMT**
    - **Registration years from Polk**
    - **VMT per year from NASS (by vehicle type only)**

2010 NHTSA Report

- **Induced-exposure crashes from 8 States**
  - Each crash assigned national weight-factors in registration years and VMT
  - Apportions the VMT by driver age & gender, rural/urban, etc.
- **Logistic regressions for 6 crash types:**
  - Rollovers
  - Collisions with fixed object, ped-bike-motorcycle, heavy truck, car, LTV

Independent variables

- Curb weight (2-piece linear)
- Footprint
- Driver age & gender
- Rural/urban, day/night, speed limit
- Frontal air bag, ABS, AWD
- Vehicle age, calendar year

Fatality increase per 100-pound reduction (holding footprint constant)

Cars < 2,950 lbs	2.21 %
Cars ≥ 2,950 lbs	.90 %
LTVs < 3,870 lbs	.17 %
LTVs ≥ 3,870 lbs	- 1.90 %

Discussion

- **Mass reduction harmful overall in light cars, beneficial in heavy LTVs**
  - **Especially in collisions of 2 light vehicles**
  - **Consistent with momentum considerations**
- **Footprint beneficial in all crashes, but especially rollover and fixed-object**

Discussion

- **Mass reduction beneficial or non-significant in rollover and fixed-object crashes**
  - **Consistent with handling/stability considerations (lowers cg)**
  - **Caveats about accuracy due to collinearity of mass and footprint**

Discussion

- **Slight tendency (3 of 4 vehicle groups, but only one significant): mass reduction harmful overall**
  - **Consistent with the historical trend that heavier vehicles are better driven**

2010 Conclusion

- **If mass reduction in MY 2012-2016 emphasizes the heavier LTVs and maintains footprint**
  - ♦ **Fatalities will not increase significantly**
  - ♦ **May decrease**

Status/Next Steps

- **2010 report peer-reviewed by:**
  - **Charles Farmer, IIHS**
  - **Paul Green, UMTRI**
  - **Anders Lie, Swedish Transport Administration**
- **New study of MY 2000-2007 vehicles in CY 2002-2008 crashes underway**
  - **(2010 report was MY 1991-1999 in CY 1995-2000)**

Developments, 2000-2007

- **Great increase in crossover utility vehicles (CUV)**
  - ♦ **LTVs with car-like structure and use patterns**
  - ♦ **Lower rollover risk than past SUVs**
- **Curb weights increased for all types of vehicles**

Developments, 2000-2007

- **Major safety improvements**
  - ♦ Frontal air bags in all new vehicles
  - ♦ ESC will greatly reduce rollovers and fixed-object crashes
  - ♦ Increased belt use
  - ♦ Curtains and side air bags
- **Poor safety performers phased out**
  - ♦ New vehicles designed to IIHS offset test

Issues for new analysis

- **CUVs**
  - ♦ **Make separate vehicle category?**
  - ♦ **Combine with cars? Keep with LTVs?**
- **Tools to address collinearity of curb weight and footprint**
- **Can analyses consider the mass of the "other" vehicle in 2-vehicle crashes?**

Issues for new analysis

- **More detailed VMT data**
  - ♦ Odometer readings by make and model
- **New control variables**
  - ♦ ESC
  - ♦ Side and curtain air bags
  - ♦ IIHS test results
- **Future effect of ESC on the number and distribution of fatalities**

Limitations of historical, statistical analyses

- **Cross-sectional analysis**
  - ♦ Compares fatality rates of light & heavy vehicles as they are
  - ♦ Does not zero in on a specific mass reduction – before versus after
- **Cannot control for all driver factors**
  - ♦ E.g., if more risky drivers select lighter and smaller vehicles

Limitations of historical, statistical analyses

- **Historical analysis lags behind the latest vehicle developments**
  - ♦ **Intentional mass reduction by materials substitution not yet widespread in 2007, let alone 1999**
  - ♦ **Vehicles became lighter or heavier mostly for other reasons**
    - o **E.g., to provide features that consumers desired**