US Fleet
Number of Registered Vehicles

- Passenger Cars
- Light Trucks

Registered Vehicles (in Millions)

US Passenger Car Fleet
Average Miles Per Vehicle Per Year

Passenger Cars
Light Trucks
US Passenger Vehicle Gasoline Consumption

- Passenger Car
- Light Truck

Gallons of Gasoline

Ten Billions


Massachusetts Institute of Technology
Cambridge, Massachusetts
US Automobile Fleet - Average Fuel Economy

![Graph showing average miles per gallon for passenger cars and light trucks from 1930 to 2000. The graph indicates a general trend of increasing fuel economy over time, with a noticeable increase in the late 1970s and early 1980s.](image-url)
US Vehicle Injuries and Fatalities

- Roughly 0.6% of Vehicle Crashes Involve Fatalities
- Roughly 33% of Vehicle Crashes Involve Injuries
- Roughly 66% of Vehicle Crashes Involve Property Damage Only

- Total Crashes Since 1988 Range between 6 and 6.8 million/year
Injuries and Fatalities Normalized By VMTs

- Although the absolute numbers show uneven trends, normalized values show downward trends, although less so for Injuries

- Per 100,000 population:
  - Deaths: 26 -> 16
  - Injuries: 1400 -> 1300

- Per 100,000 Drivers
  - Deaths: 51 -> 23
  - Injuries: 2000 -> 1950

- Per 100,000 Vehicles
  - Deaths: 53 -> 21
  - Injuries: 1930 -> 1740
## Vehicle Safety Technologies: Estimated Lives Saved (NHTSA)

<table>
<thead>
<tr>
<th></th>
<th>Seat Belts</th>
<th>Airbags</th>
<th>Child Restraints</th>
</tr>
</thead>
<tbody>
<tr>
<td>1982-88</td>
<td>20313</td>
<td>7</td>
<td>1086</td>
</tr>
<tr>
<td>1989</td>
<td>6333</td>
<td>8</td>
<td>238</td>
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<tr>
<td>1990</td>
<td>6592</td>
<td>37</td>
<td>222</td>
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<td>1991</td>
<td>7011</td>
<td>68</td>
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<td>1992</td>
<td>7390</td>
<td>100</td>
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<td>1993</td>
<td>8347</td>
<td>169</td>
<td>286</td>
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<td>1994</td>
<td>9206</td>
<td>276</td>
<td>308</td>
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<tr>
<td>1995</td>
<td>9790</td>
<td>470</td>
<td>279</td>
</tr>
<tr>
<td>1996</td>
<td>10414</td>
<td>686</td>
<td>365</td>
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</tbody>
</table>

- Various Technologies Developed and Imposed
- Interesting To Contract Scale Of Effect
CAFE

- Introduced To Compel Automakers To Reduce Gasoline Consumption

- Corporate Average Fuel Economy:
  
  \[ \text{Corporate Average Fuel Economy} = \frac{\sum \text{Ni}}{\sum \left\{ \frac{\text{Ni}}{\text{Fuel Economy of i-type vehicles}} \right\}} \]

- Interesting Consequences:

  If Car A Gets 20 mpg and Car B Gets 40 mpg and the CAFE Target is 30 mpg, How Many Cars Of Type B Must Be Sold For Every Car A That Is Sold?
Cost of Gasoline
Cost of Gasoline

Massachusetts Institute of Technology
Cambridge, Massachusetts
"First Principles" Mass/MPG Calculation

Mile Per Gallon

MPG = 8627.4 (Mass)

Vehicle Mass (pounds)
Rule of Thumb - 10-5 Rule

- A 10% Reduction In Mass...
- Yields A 5% Increase In Fuel Economy
- So, If A Baseline 3111 lb Vehicle Gets 21.6 mpg...

\[
\text{MPG} = 895.24 \text{ (mass)}
\]

-0.463

Miles Per Gallon

Vehicle Mass (pounds)
Some Scaling Modifications:

\[
\text{Mass} = 2.015 \text{ FE}^2 - 194.85 \text{ FE} + 6375.54
\]
# Current Vehicle Emission Standards (g/mi)

<table>
<thead>
<tr>
<th></th>
<th>NMHC</th>
<th>CO</th>
<th>NOx</th>
<th>NMHC</th>
<th>CO</th>
<th>NOx</th>
<th>NMOG</th>
<th>CO</th>
<th>NOx</th>
<th>% of new vehicle sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>LDV’s</td>
<td>0.25</td>
<td>3.4</td>
<td>0.4</td>
<td>0.125</td>
<td>1.7</td>
<td>0.2</td>
<td>0.09</td>
<td>4.2</td>
<td>0.3</td>
<td>60%</td>
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<tr>
<td>LDT1</td>
<td>0.25</td>
<td>3.4</td>
<td>0.4</td>
<td>0.125</td>
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<td>0.09</td>
<td>4.2</td>
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<td>6%</td>
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<tr>
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<td>4.4</td>
<td>0.7</td>
<td></td>
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<td>5.5</td>
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<td>25%</td>
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<tr>
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<td>0.32</td>
<td>4.4</td>
<td>0.7</td>
<td></td>
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<td>0.23</td>
<td>6.4</td>
<td>0.6</td>
<td>2%</td>
</tr>
<tr>
<td>LDT4</td>
<td>0.39</td>
<td>5</td>
<td>1.1</td>
<td></td>
<td></td>
<td></td>
<td>0.28</td>
<td>7.3</td>
<td>0.9</td>
<td>7%</td>
</tr>
</tbody>
</table>

- **EPA Tier 1 (50K)**
- **EPA Tier 2 (100K)**
- **LEV Standards (100k/200k)**

- **LDV:** All passenger cars
- **LDT1:** Gross Vehicle Weight Rating (GVWR) 0-6000 lb Loaded Vehicle Weight (LVW) 0-3750 lb
- **LDT2:** GVWR 0-6000 lb LVW 3751-5750 lb
- **LDT3:** GVWR 6001-8500 lb Adjusted Loaded Vehicle Weight (ALVW) 0-5750 lb
- **LDT4:** GVWR 6001-8500 lb ALVW 5751-8500 lb