Trailer Dynamics and Trailer Crashes

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7 Years w/ U-Haul International
- Customer Focused Engineering
- Safe Trailering
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13 Years w/ Ford Motor Company
- 2004 Ford GT, 2005 Mustang GT 500
- 2005-2019 sedans
- 2015 Mustang Vehicle Dynamics, NVH

Automotive Enthusiast and Driver Training Instructor - NASA
Session Overview

- Trailer / Towing Terminology
- Loading and Tongue Weight
- What Causes Sway
- Sway Demonstration
- Parameters Affecting Sway
- Common Crashes
- Crash Investigation
Trailer Terminology

Common Terms

- Hitch
- Ball Mount
- Ball
- Coupler
- Tongue
- Cargo

- Driver
- Car
- Frame or Structural Members
- Hitch
- Ball Mount

- Trailer
- Body Frame Suspension
- Tongue

- Load

Symposium on Traffic Safety
Hitch & Coupler

- What is a Hitch, what is a Coupler?
  The Hitch, Coupler and Ball Mount are often confused

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>Hitch</td>
<td>An accessory component of the Tow Vehicle. It is a towing device mounted on the rear of the tow vehicle that provides the connecting point for the trailer.</td>
</tr>
<tr>
<td>Coupler</td>
<td>A component part of the Trailer. It is the connecting device mounted at the front of the trailer tongue that is connected directly to the hitch ball on the car during trailer hookup.</td>
</tr>
<tr>
<td>Ball Mount</td>
<td>An accessory component of the Tow Vehicle. It is a towing device mounted into the hitch it includes the hitch ball and the mall mount</td>
</tr>
</tbody>
</table>
Hitch

Hitch can be:
- Receiver Hitch or
- Bumper Hitch (integrated into bumper system)
Hitch Ball & Ball Mount

Hitch Ball and Ball Mount are part of the Hitch System – Tow Vehicle
Retaining Pin

The ball mount is held in place by a Pin
Coupler

The Coupler is the trailer part that connects to the Hitch ball

Traditional U-Haul Coupler

Drop-n-Tow® Coupler
Hitch System Ratings

Every component of the hitch system has a rating. Each rating *must* be higher than the total trailer weight.

- Hitch = 5000 pounds
- Ball mount = 5000 pounds
- Ball = 6000 pounds

Hitch System Rating  = **5000 pounds** (Limited by Hitch & Ball mount)
Weighing In

Gross Vehicle Weight (GVW) - Base Curb Weight plus Cargo plus Passengers. It is actual weight obtained from a scale.

Gross Vehicle Weight Rating (GVWR) – is the maximum allowable weight of the fully loaded vehicle (Passengers and Cargo). GVW must never exceed GVWR

Gross Combination Weight Rating (GCWR) – is the maximum allowable weight of the towing vehicle and the loaded trailer (Passengers and Cargo). GCW must never exceed GCWR
Weighing In

Where do I find the GCWR, GVWR, GAWR?

- GVWR and GAWRs are found on the left B-Pillar of the tow vehicle in the Safety Compliance Certification Label.

- GCWR is found in the Owner’s Manual or in the manufacturer’s Towing Guide.
Safety Chains & Retainer

• Purpose of Safety Chain or Cable is to *Maintain Connection* between the Tow Vehicle and Trailer, in the event the Coupler Comes off the Ball or the Ball comes off the Hitch (SAE J684)

• Safety Chains include a retainer on the “hook”, to prevent the chain from coming off during transit

• Strength of Chain to meet industry standard
Trailer Tongue

- The Trailer Tongue is a structural member, that extends forward from the front of the trailer body to the Coupler.
- The Tongue may include a surge brake component on braked trailers.
- Damaged Tongue is often result of crash:
  - Jackknife will bend Tongue sideways
  - Head-on collision will bend Tongue up
  - Broken-off Tongue is severe example.
Trailer Brake System

Purpose of Trailer Brakes
- To shorten stopping distance
- To meet industry standards
- To permit heavier trailers

NOT the purpose of Trailer Brakes
- Prevent or counteract sway
- Prevent trailer jackknife or “pushing”
Proper Loading

- What is a great rule for distributing weight in a trailer?

60/40

- Load 60% of the weight into the front half of the trailer and 40% in the rear of the trailer.

- LOAD HEAVIER IN FRONT.

See trailer manufacturer loading recommendations for specific trailer designs.
Trailer Loading

Trailers are designed to be loaded Heavier In Front

Weight

60% 40%
What Causes Sway?

Parameters that affect Sway

- Speed
- Driver Inputs – Steering & Braking
- Loading Condition

Weight too far behind the Hitch Ball reduces stability

(MOI = m*r²) – Baseball bat example
Loading Affects Sway - MGTD
Trailer Sway
Trailers Design Affects Sway

Parameters that improve Sway Stability

- Longer tongue length
- Axle further rearward
- Cg Forward – Cargo moved in further in front of trailer suspension
- Lower trailer yaw Moment Of Inertia (MOI)

Too much tongue weight can cause other issues, particularly when tow vehicle is loaded heavily

- Tow Vehicle rear GAWR exceeded
- Understeer lower than vehicle design criteria
Common Trailer Crashes

- Sway & Loss Of Control
- Sleeper / Inattention
- Jackknife & Tongue Bent Or Broken Off
- Coupler Off Ball
- Trailer Brakes Inoperative
- Axle Or Other Metal Fracture
Trailer Crash Investigation

What Data Do You Need?

- **Trailer Weight And Tongue Weights**
- VIN decal with GVWR
- Scene photos
- Trailer photos – Cargo, Tongue, Wheels, Suspension, Decals, etc.
- Tow vehicle data
- ACM data
Trailer Inspection - Weights
VIN Decal

• Identifies how much total weight the trailer can carry

• Identifies tire inflation and tire size & type
Trailer Jackknife
Coupler off Ball

Look For Elvis Lip
- Exists – Then coupler was attached at the time of the roll-over

No Elvis Lip – Look For:
- Loose latching system
- Ball Mount that came out of the Hitch
Trailer Brakes Inoperative

Electric Brakes – check for
- 7-Pin Connector at Tow Vehicle is connected
- Brake shoes engage when brakes energized

Surge Brakes – check for
- Fluid leaks at Master Cylinder, wheel cylinder connections
- Master Cylinder fluid level and fluid condition
- Surge Brake operation
Axle or Metal Fracture

- Where was the tire found?
- Does the tire have impact or lateral scrub marks?
Summary

Trailer Loading, Speed, Driver Inputs
- All Important To Sway

Crash Analysis Involves Many Elements
- The More Elements Identified The Better Understanding Of What Occurred

- In Trailer Accidents, Getting Trailer Weights Can Provide Tremendous Insight As To Cause Of Crash
Questions?