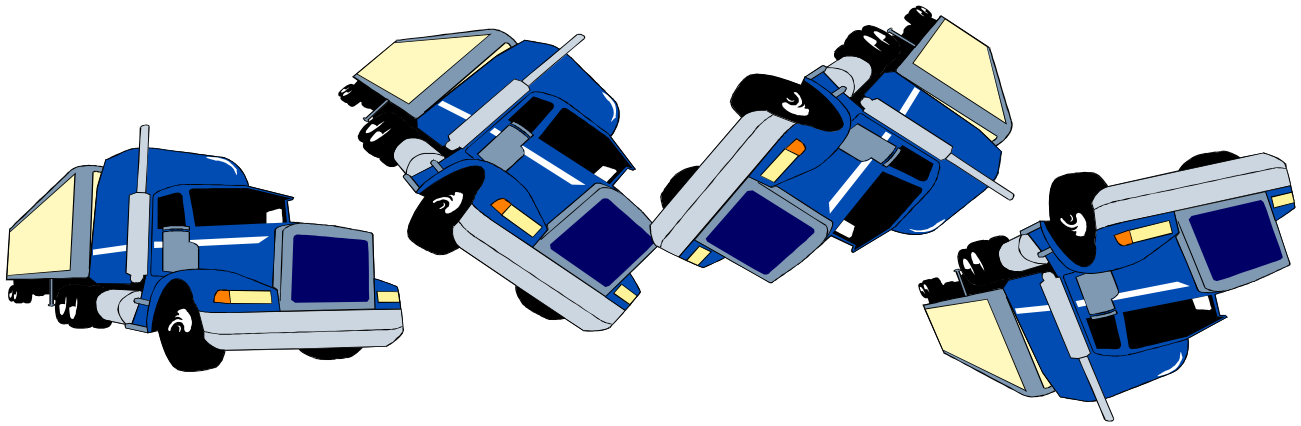
Training Package

AIGA TP 18/15

Vehicle Rollover Prevention



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Vehicle Rollover Prevention

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Introduction

- Statistics available for the road transport industry in the US (all industries, not just industrial gases) indicate that there are approximately **15,000** commercial vehicle roll-overs per year, **58%** of these result in driver fatalities, **95%** in hazardous material spills and average direct costs of **$120,000** per event.

- Major industrial gas companies experienced between 25 and 45 rollovers per year, with similar consequences and cost in the years of 2000's.

- The vehicle rollover accident rate has been improved in recent years for the Industrial Gas Companies. However, considering **the severe impact**, it is still very critical for the gas companies and transportation companies to ensure that they have processes and driver training program in place to reduce the risk of rollovers and other serious vehicle incidents, to avoid any impact on human life and health, material and environmental damages.

Purpose

- Explain the vehicle rollover basics
- Describe the factors that cause vehicle rollover accidents
- Introduce ways to prevent from vehicle rollover

Vehicle Rollover Basics

Vehicle Rollover Basics

Rollovers can be categorized into two major types

- **Tripped**
  - The vehicle leaves the roadway, the tyres sink in soft soil, or the vehicle hits an object such as a guardrail or curb
- **Loss of Control**
  - Usually consists of speed and/or steering errors
  - **Major factor in heavy vehicle rollovers!**

Vehicle Rollover Basics

Centre of Gravity (COG)

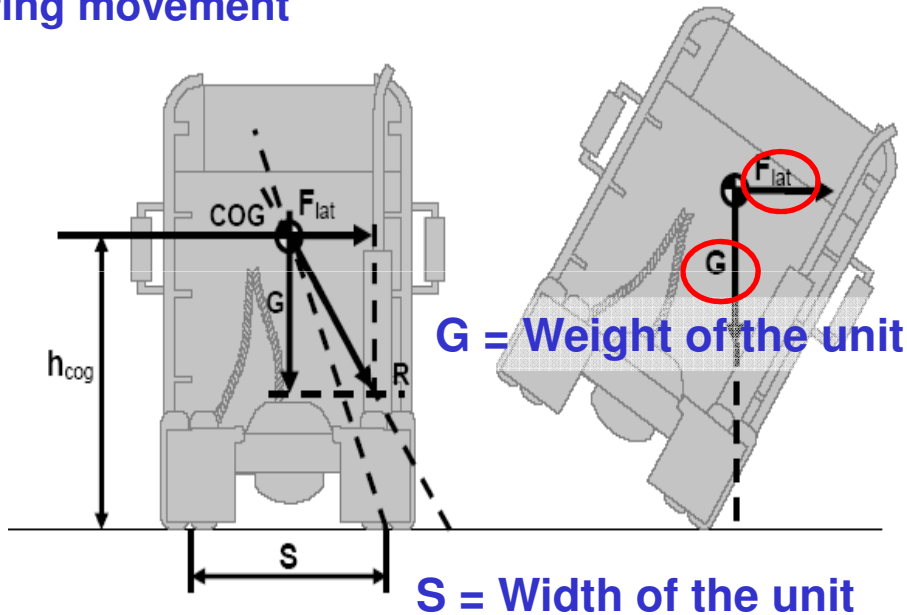
- COG is the average location of the weight of an object

Vehicle Rollover Basics

Forces acting on a vehicle

Lateral acceleration = Force that acts from the side of the tractor during movement

COG = Center of gravity = balancing point for the unit



G = Weight of the unit

S = Width of the unit

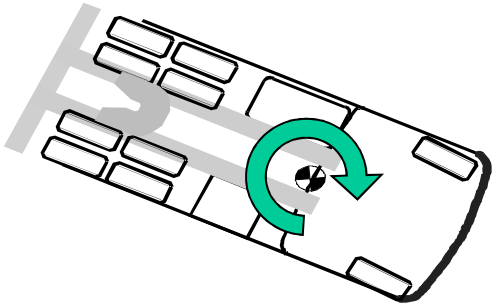
- Rollover occurs when torque caused by a lateral force is greater than the torque by G force, i.e. hcog * F lat > G * S/2

- The higher the COG, the easier it is to tip the unit

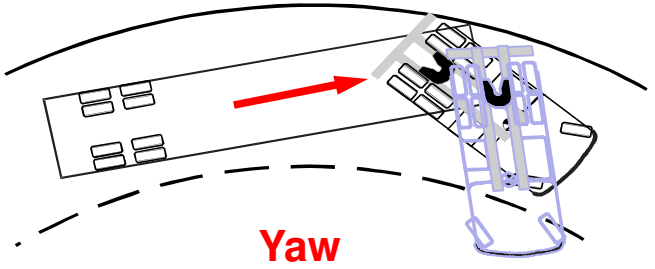
Vehicle Rollover Basics

YAW

- Horizontal spin / rotation
- Instability can lead to rollovers
- **Critical for tractor-trailer combinations**

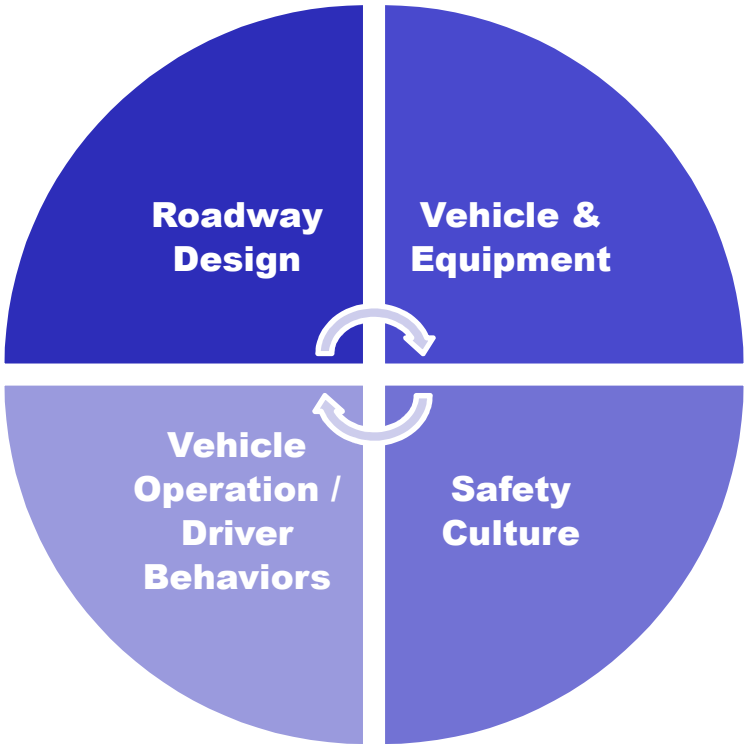


Over-Steering (Jackknife)



Factors that Cause Rollover

Factors that Cause Rollover



1 - Roadway Design

- Posted speed limits on ramps and curves for cars but **NOT** for trailers
- **Tight** curves or turns
- **Short** deceleration lanes before exits
- Drainage **ditches** close to the road
- **Steep** drop-offs near edge of road
- Curves with a **negative bank**
- Curves with **poor visibilities**

Alignment	No Roll	Roll 1st Event	Roll Later Event	Total Rollovers	Total Crashes	Percent Rollover Crashes	Percent of All Rollovers
Van							
Straight	7,996	117	607	724	8,720	8.3%	67.6%
Curve	1,308	142	202	344	1,652	20.8%	32.1%
Unknown	21	0	3	3	24	12.5%	0.3%
Total	9,325	259	812	1,071	10,396	10.3%	100.0%
Tank							
Straight	1,143	71	199	270	1,413	19.1%	56.0%
Curve	210	126	85	211	421	50.1%	43.8%
Unknown	2	0	1	1	3	33.3%	0.2%
Total	1,355	197	285	482	1,837	26.2%	100.0%

*

- **Higher possibility to have a rollover upon curve** than straight road when a vehicle accident is involved

* **Cargo Tank Roll Stability Study Final Report**

2 - Vehicle & Equipment

- Vehicle's Center of Gravity (COG)
- Stability of the Vehicle
- Stability of the Cargo
- Type of the Vehicle (rigid tanker, semi trailer, tube trailer, ISO container, cylinder truck)

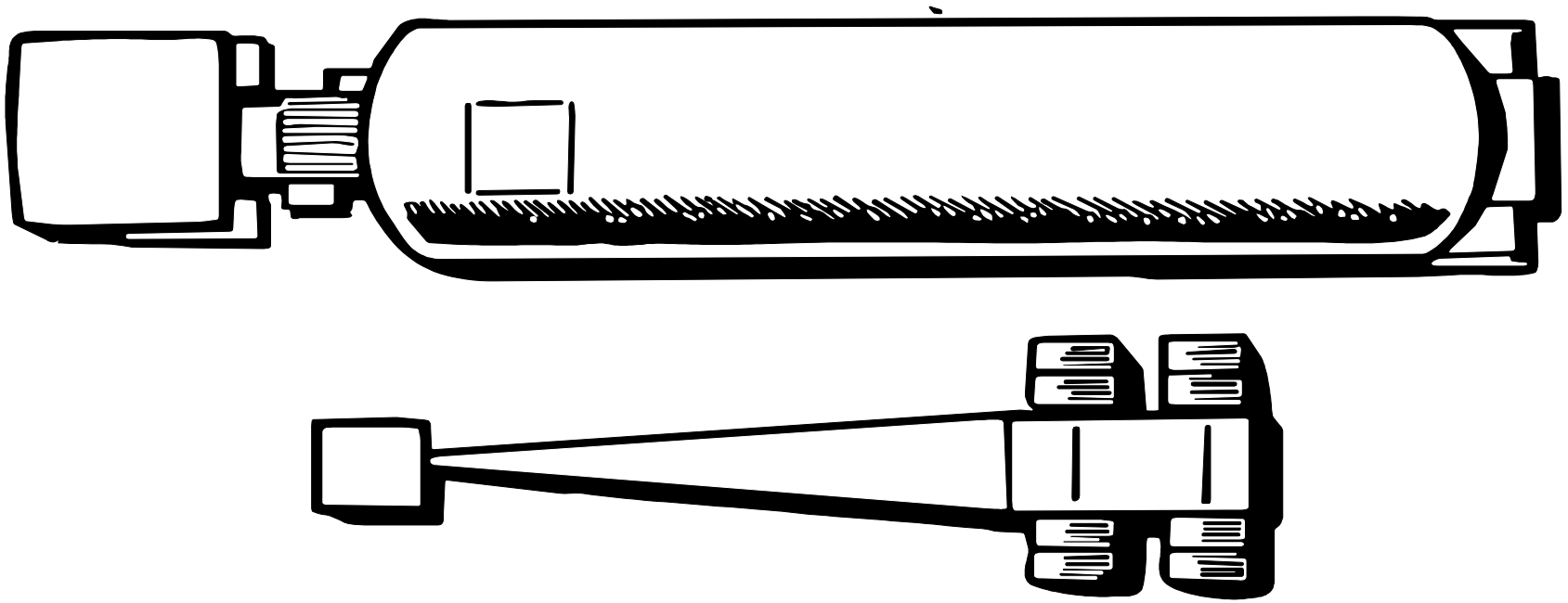
Centre of Gravity

- The higher the Center of Gravity, the easier to overturn the vehicle

- Trailer design to lower the Centre of Gravity **of both the vehicle and the load**, this improves vehicle stability

Stability of Vehicle

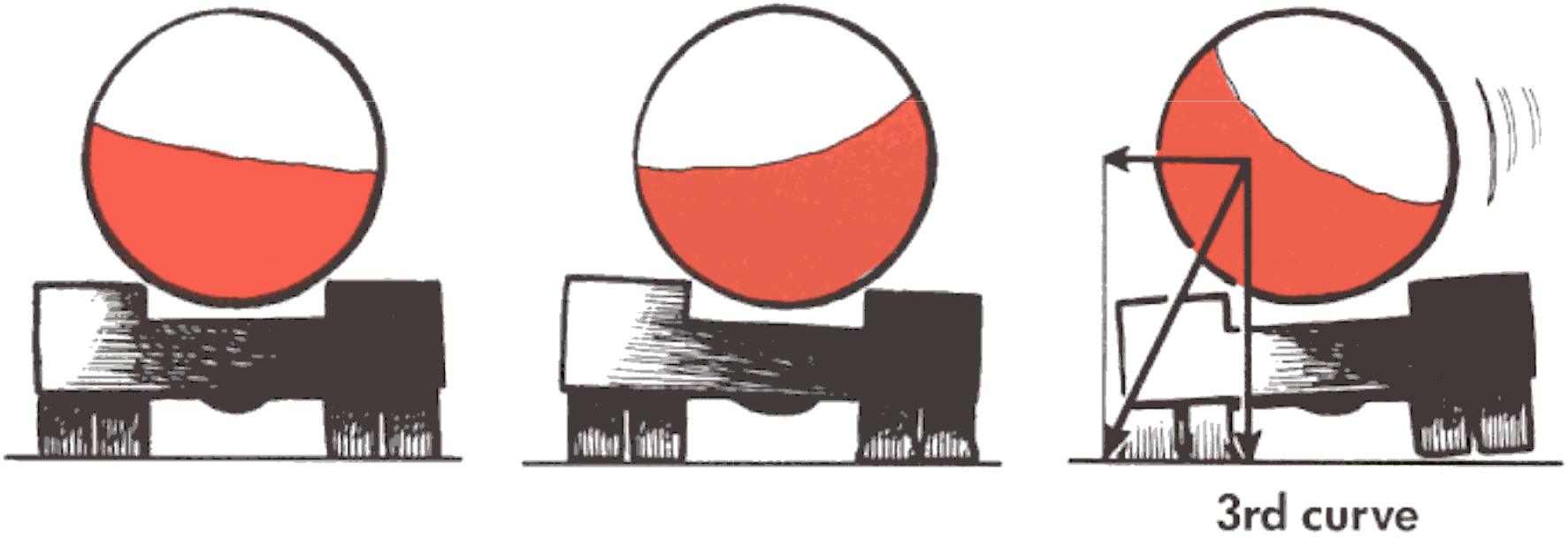
- **The stability of a trailer can be compared to that of a three-wheeled vehicle such as a motorcycle with side car or a lift truck**



Stability of Cargo

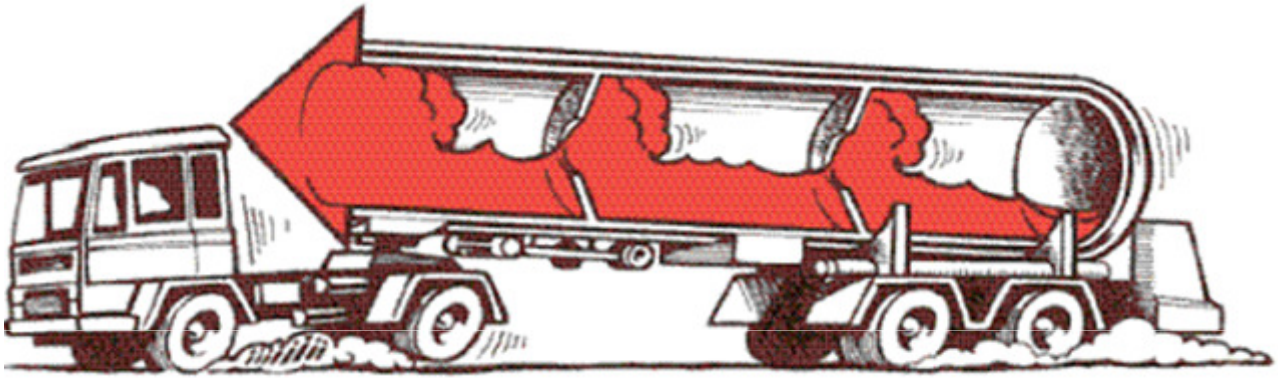
Liquid Slosh

- Movement of liquid from one side of a tank to another side



Stability of Cargo

- **Surging Liquid when Braking**



➢ When applying the brakes and turning, the liquid surges to the front and to the outside of the turn, **forcing the rear of the tractor in a straight line!**

Unlike a car, a trailer will rollover before it skids!

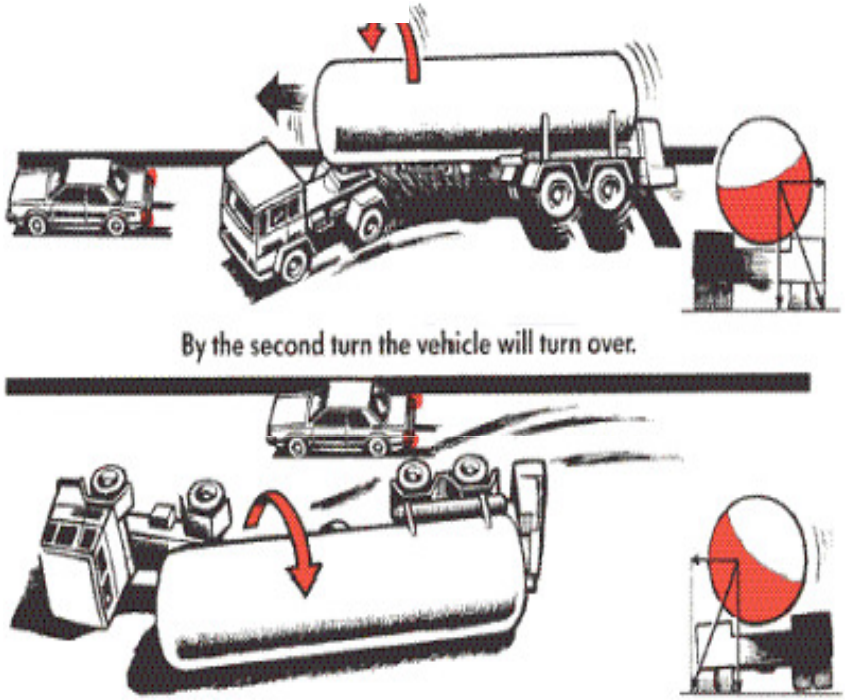
Stability of Cargo

Surging Liquid When Turning

- Slosh occurs **in a partly filled tank** when in a turn

- Surging liquid will create a **sideways force** which lifts the semi-trailer from the road and can easily turn it over

- The effect is **multiplied in S-bends and roundabouts**. In a series of turns, by the third turn or curve the liquid will move back to the first side, and can now be in phase with the vehicle‘s movement to cause a turnover (if the speed is sufficient)



- **Modern tractor/trailer combinations** isolate the driver from the “forces at work”, **giving very little feedback about dangerous conditions**

Profile	No Roll	Roll 1st Event	Roll Later Event	Total Rollovers	Total Crashes	Percent Rollover Crashes	Percent of All Rollovers
Van							
Level	6,711	127	508	635	7,346	8.6%	59.3%
Grade	2,217	122	275	397	2,614	15.2%	37.1%
Hillcrest	183	4	11	15	198	7.6%	1.4%
Sag	23	1	2	3	26	11.5%	0.3%
Unknown	191	5	16	21	212	9.9%	2.0%
Total	9,325	259	812	1,071	10,396	10.3%	100.0%
Tank							
Level	1,010	101	177	278	1,288	21.6%	57.7%
Grade	280	87	99	186	466	39.9%	38.6%
Hillcrest	33	7	3	10	43	23.3%	2.1%
Sag	6	0	1	1	7	14.3%	0.2%
Unknown	26	2	5	7	33	21.2%	1.5%
Total	1,355	197	285	482	1,837	26.2%	100.0%

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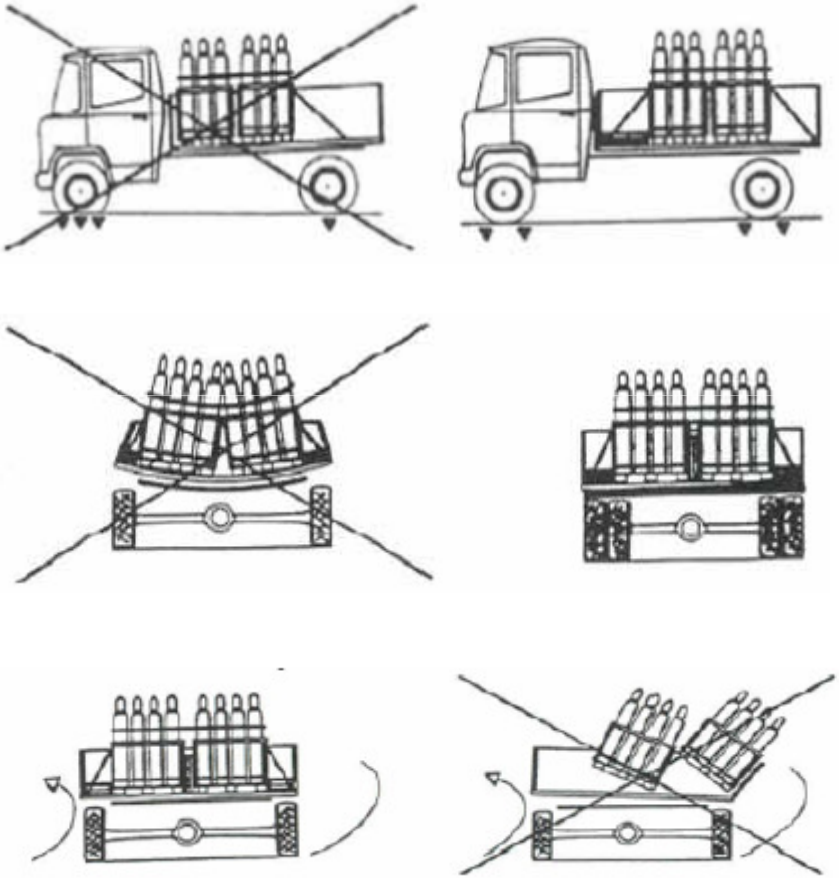
- **Higher Possibility with Tank**
- **Grade Road and Hillcrest have more likelihood**

***: Cargo Tank Roll Stability Study Final Report**

Stability of Cargo



- **Load Distribution**
- **Load Capacity**
- **Load Securement**

Safety Culture

Safety Culture

- Do journey plans include all hazards on the route? Route selection based on the risk assessment Vs Distance transported? How about the Cross-country track?
- Are journey plans updated with changing traffic patterns, customers, and so forth?
- Is there specific regulation on driving at night?
- Does the driver follow the journey plan? How to track the actual Vs planned?
- Are the principles of behavior-based safety implemented?
- Are messages about safety ambiguous?
- How is the driver training conducted?

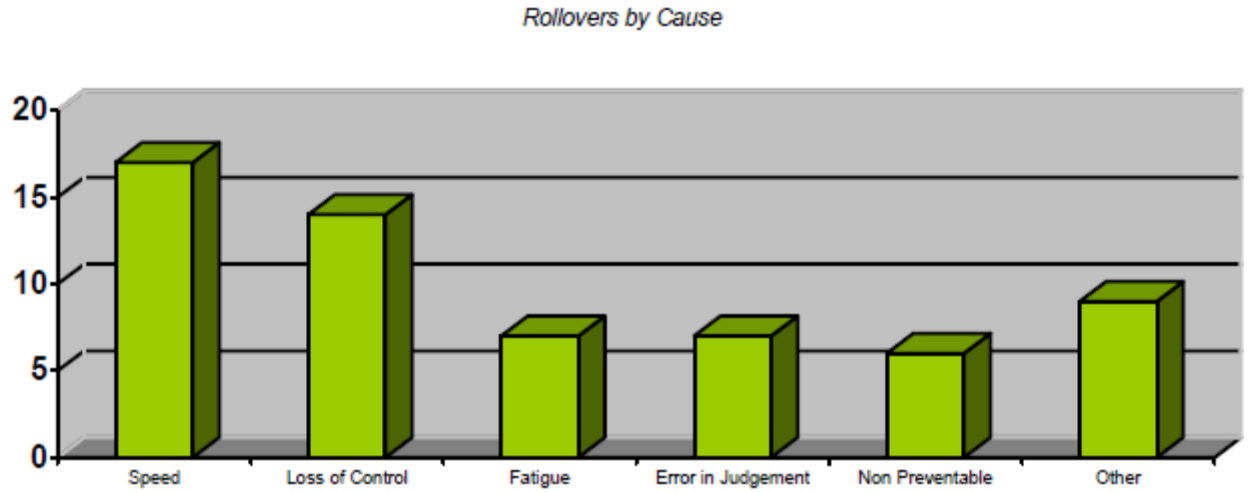
Poor Vehicle Maintenance

Poor maintenance issues may lead to rollovers. These may include:

- Under or over inflated tires reduce truck handling
- Incorrect brake adjustment and improper balance between tractor and trailer brakes
- Poorly adjusted and worn suspension components

Vehicle Operation / Driver Behaviours

Rollover Causes



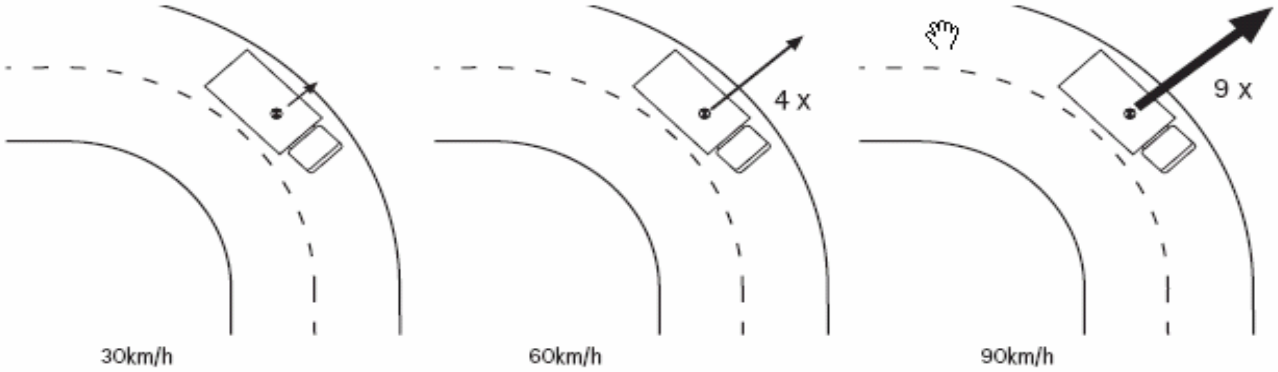
- Trailer high centre of gravity contribute to rollovers but are not the cause

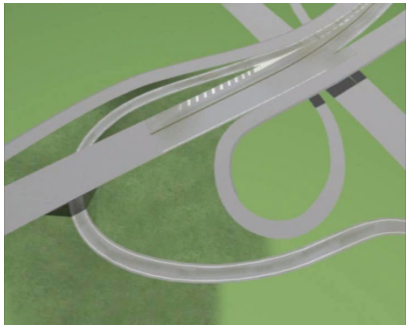
- Detailed studies within the industrial gases industry indicates that the major causes for rollovers are **excessive speed, lack of control, driver fatigue and error in judgment** *

- Rollovers can initiate also at **relatively low speeds …**

*: **EIGA Safety Newsletter SAG NL 88/09/E**

Vehicle Speed and Cornering

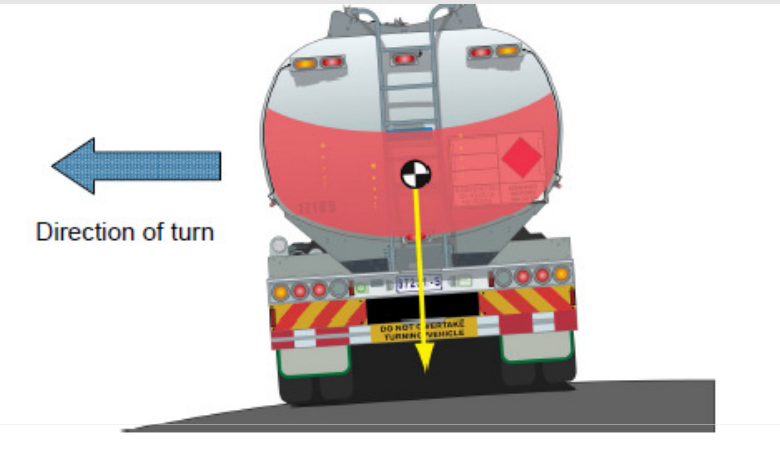




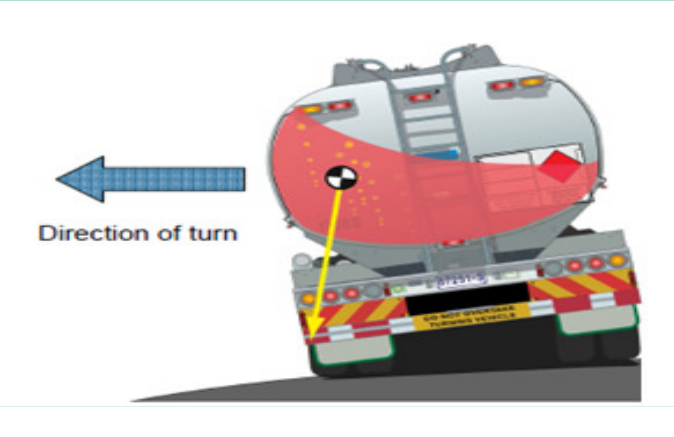
Video

- As the speed increases, the trailer tracks wider and forces increase on rear axle
- **If you double your speed**, the overturning force will be four times higher!
- If the driver takes evasive action these forces are further multiplied
- The moving liquid will cause a rollover!

The Effect of Road Camber



■ On a properly cambered turn, at the design speed, the centrifugal forces and the gravitational effect will be equal



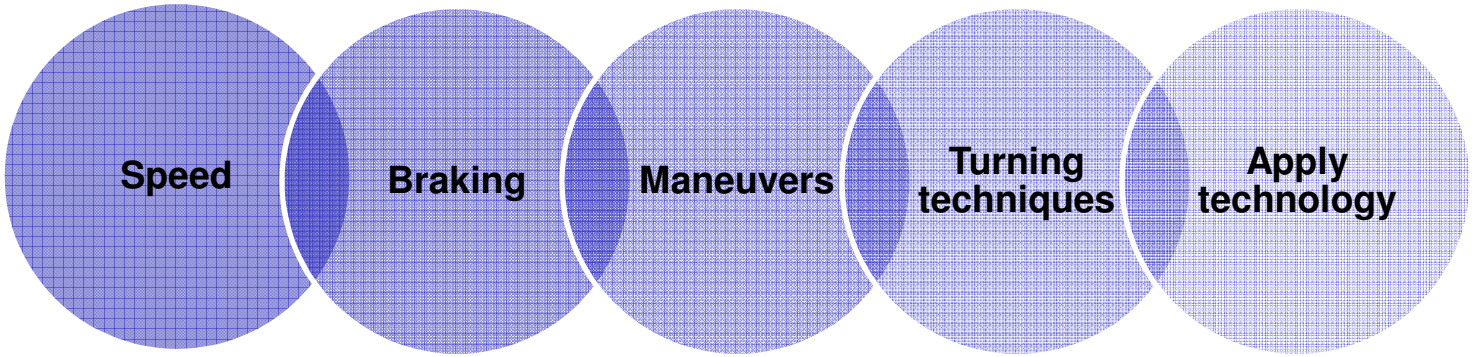
■ At speeds below the road design speed at a road camber, the forces will not be in balance, and hence there will be a tendency to roll into the turn

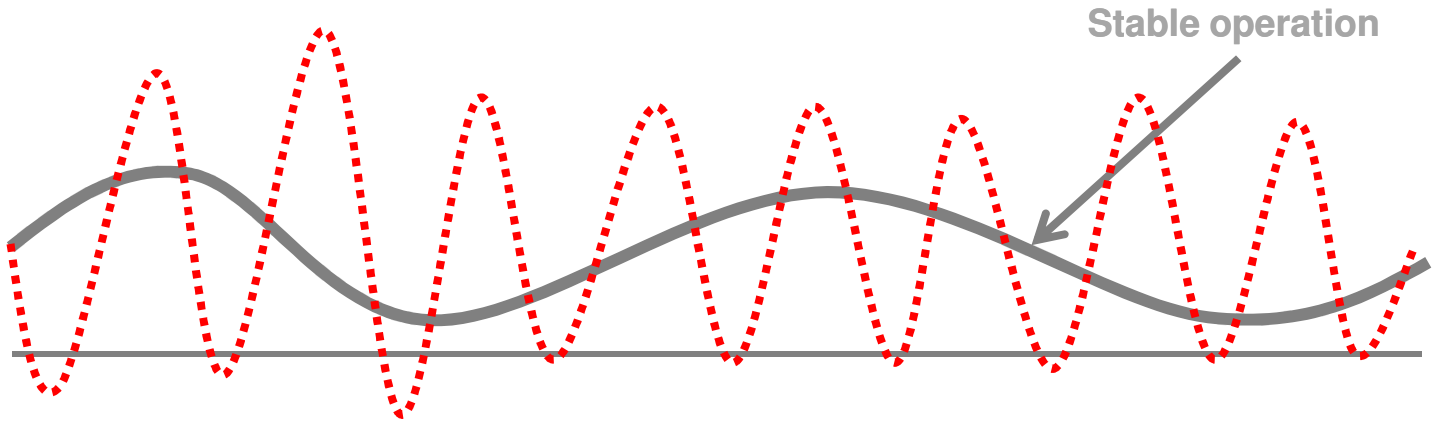
Sudden Maneuvers

- **Sudden maneuver may occur when:**
  - Driver is forced to brake and suddenly turn
  - Driver attempts to return to the road after drifting off of the pavement
  - Follow too closely and sudden stop while turning to avoid contact

Prevent from Vehicle Rollover

Control Vehicle to Avoid Sloshing





Select travel routes that are best suited to the type of vehicle and loads being driven in order to avoid adverse road conditions, such as sharp curves and steep grades that make rollovers more likely to occur

Avoid Sudden Maneuvers

- **Avoid the need to turn sharply to miss an obstacle**
  - Leave yourself plenty of clear vision ahead
  - Maintain a “Space Cushion” (distance between your vehicle and other traffic)
  - Plan an escape route
  - If you can’t see a clear safe exit, slow down and increase your following distance
  - If you do have left the paved surface, DON’T swing back sharply
  - If a rollover appears imminent, attempt to straighten out the vehicle and bring it to a gradual stop, even if it means driving off the pavement.
- **Avoid over-steering, over-accelerating and over-braking**

Prevent from Distraction

- **Driving is a full time job, keep your attention on the road and the area ahead**
- **Focus on the tasks at hand**
- Don't be distracted by things that happen or things you see either inside or outside the cab
  - Secure loose objects in the cab.
  - Ignore external distractions e.g. advertising signs.
- **Always maintain the big picture and you'll allow enough time to react**

Prevent from Fatigue

- As a professional driver you are expected to be **FIT for Duty** to drive
- Get sufficient rest before you commence driving
- Observe the Driving and Service Hours Regulations in your Company
- **Stay alert**
- **If you feel drowsy, STOP! For your own safety and the safety of the other drivers.**
- **Nothing cures fatigue but sleep**

Speed

- **Utilize the Smith System for defensive driving**
- **When upon the curves, ramps …**
  - Slow down **before entering turns, curves, exit ramps and winding roads, as a recommendation:**
    - ✓ At least 10 km/h below the posted advisory limit, OR
    - ✓ 10 mph (15 kmh) on curves, exit ramps and winding roads having no posted speeds
  - Don't shift in the curve
  - Look at both the speed limit sign and check your speedometer before you come to the curve
- **Do not judge your speed by what it feels like, you will probably be wrong**
- **Don't assume the route is safe because you have driven it before!**

Ditches

Don’t park near any ditches or roadside excavations, including:

- Soft shoulders
- Sloping surfaces
- Water-logged surfaces
- Embankments

Vehicle Maintenance Checks

To prevent the risk need check for the following:

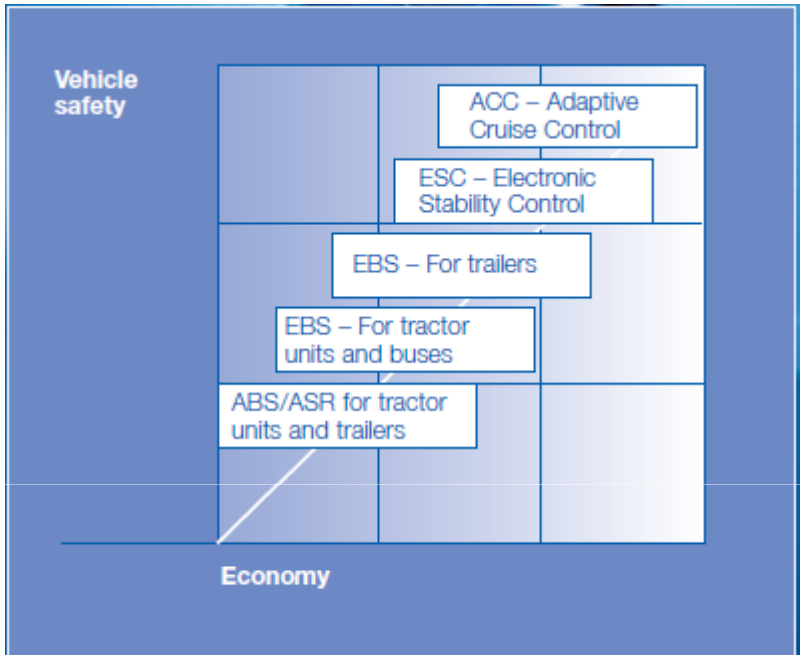
- Tire pressures
- Tire tread depth
- Incorrect brake adjustment
- Incorrect brake balance.
- Loose/worn suspension components.
- Cracked spring leaves.
- Deflated or damaged airbags

Vehicle Design to Reduce Rollover

- Minimize (lower) vehicle's center of gravity
  - Lower tractor's 5th wheel
  - Lower Chassis
  - Lower Piping …
- Maximize the width of the axles
- Provide liquid tankers with baffle plate against liquid surge
- Equip vehicle with designs to improve vehicle stability and technology to prevent overturns

Vehicle Stability System

- ABS - Anti-lock Brake System
- EBS - Electronically controlled braking system
- EBS = ABS + LSV + RSS + CAN
  - LSV - Load Sensing Valve
  - RSS - Rollover Stability System
  - CAN - Controlled Area Network



Tractor	+	Trailer	=	Result
ABS	+	0	=	Worse, possibly Jack-Knife
0	+	ABS	=	Good
ABS	+	ABS	=	Better
EBS	+	ABS	=	Very good
ABS	+	EBS	=	Excellent
EBS	+	EBS	=	Perfect

*: **Information resource: Wabco, Haldex**

Vehicle Stability System

- **Roll Stability Support (RSS) for Trailer**

  - Part of ESP for the whole Truck / Trailer combination when the Tractor and Trailer have EBS systems connected

  - **Designed to reduce roll-overs, jackknifes, spin outs, and drift outs**

  - Systems monitor vehicle center of gravity, lateral acceleration, wheel speed, steer angle and yaw rate

  - Does not require driver intervention – systems automatically activate and de-activate

Video

*: Video Resource: Wabco Holding Inc.

Driver's Are the Key!

- Vehicle Safety Technology can help in avoiding a rollover. **But they are not the "Magic Bullet", they do not replace the driver!**
- Drivers control vehicle speed
- Drivers control turning techniques
- Drivers anticipate minimizes need for sudden braking, anticipation reduces the needs for sudden maneuvers
- **NO complacency**
- **Apply the defensive driving skill, stay alert, remain in control**

Reference

- **EIGA Safety Newsletter SAG NL 88/09/E**
- **Cargo Tank Roll Stability Study Final Report -** Prepared for the United States Government by **Battelle**