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**WCC GST SAFETY WORKSHOP**

**TABLE TOP EXPO**

November, 14-16, 2018  
Monterrey - Mexico

# Technology in the Transport of Hazardous Products

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55 41 99996-2526

**2018**

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## RISK N°1: ROLLOVER



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**Rollover is one of the most common accidents and one that brings more serious consequences.**

**For Science, understanding a phenomenon is to be able to predict it.**

**Understanding how a rollover occurs is key to be able to avoid it.**

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# Why does the truck overturn so easily?

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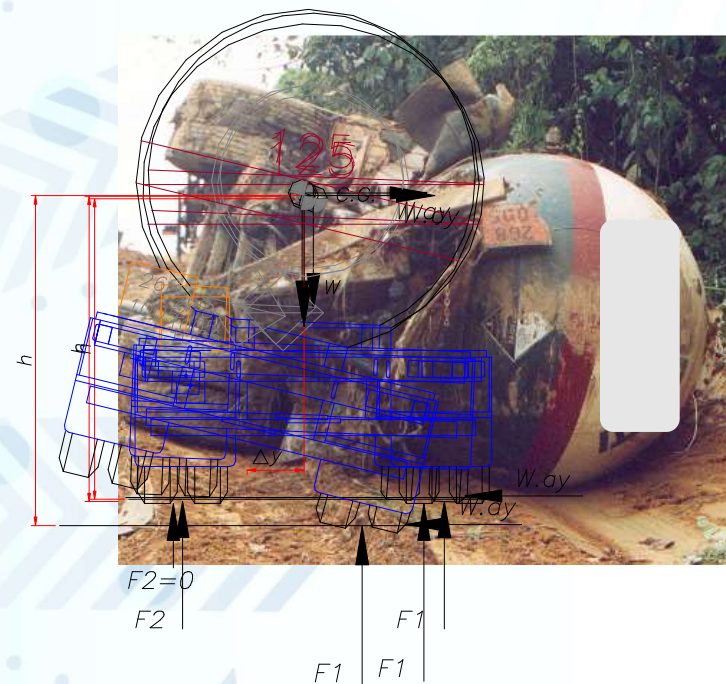
The main difference is as follows:

When the car driver is speeding, the tires squeal, then the vehicle skids and, upon finding some obstacle (a curb), it may overturn;

But loaded truck is different: it always **OVERTURNS BEFORE SKIDDING.**

This is why it is so common: the truck driver **CANNOT** make a mistake when it comes to speed.

If he makes one: he overturns.

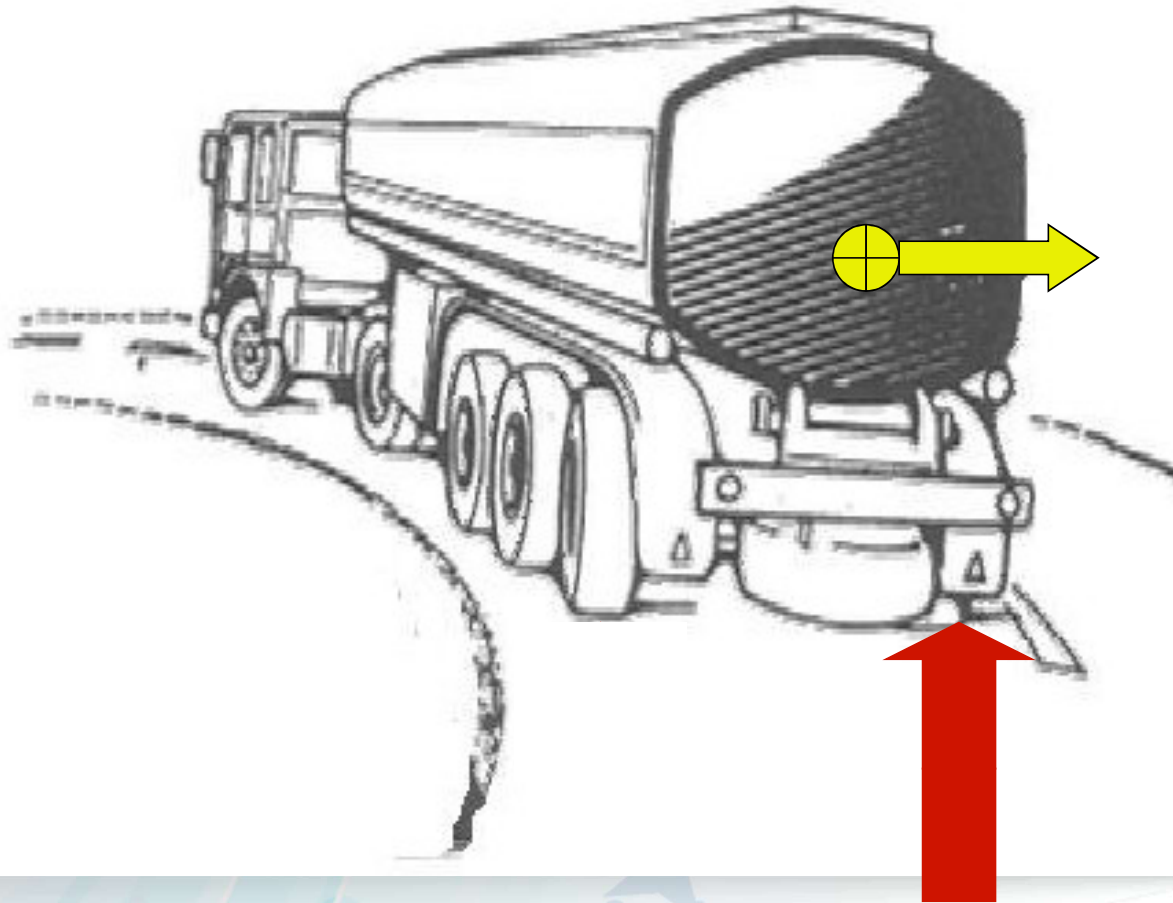


# HOW THIS TYPE OF ACCIDENT OCCURS

In curves and maneuvers, the weight is transferred from the inner side to the outer side of the turn and the truck driver does not notice it.

When the weight on the inner tires zeroes, the Rollover takes place.

In the tractor-trailer combination, the trailer's tires are always the first ones to leave the ground. It is considered irreversible when the traction tires of the tractor leave the ground.



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proximado



011



Typical marks on the turns (by the inner side):

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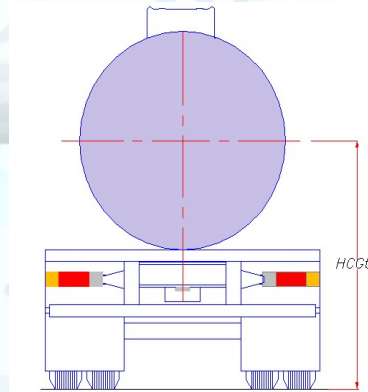
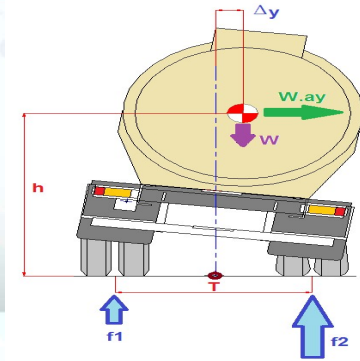
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# SRT

$$a_y = \frac{\left(\frac{T}{2} - \Delta y\right)}{h}$$



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SRT (in g) aprox.

**Tipo:**

truck 4x2

Truck 6x2

Tractor Trailer 3S3

Spaced axle trailer

B-train\*

Doubles\*

**SRT**

0,42

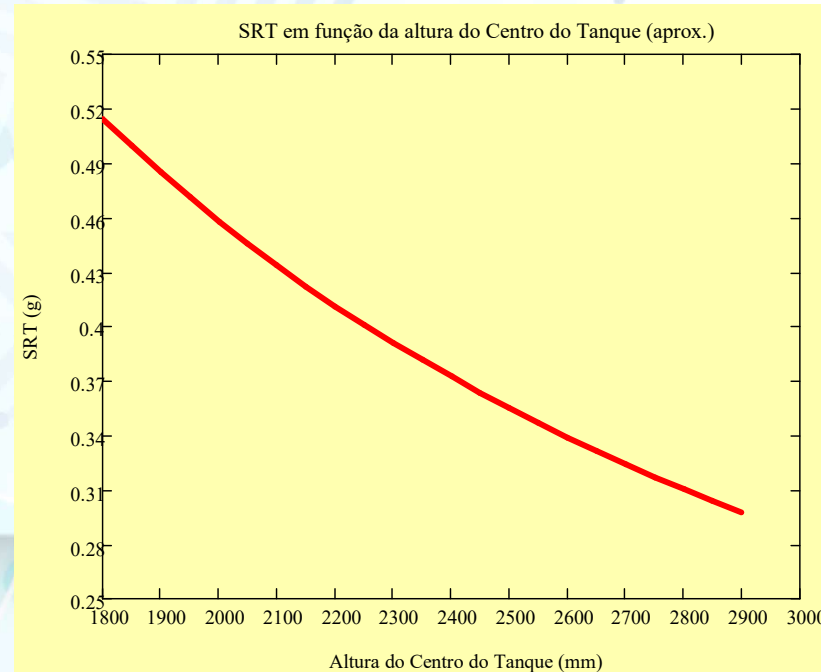
0,40

0,35

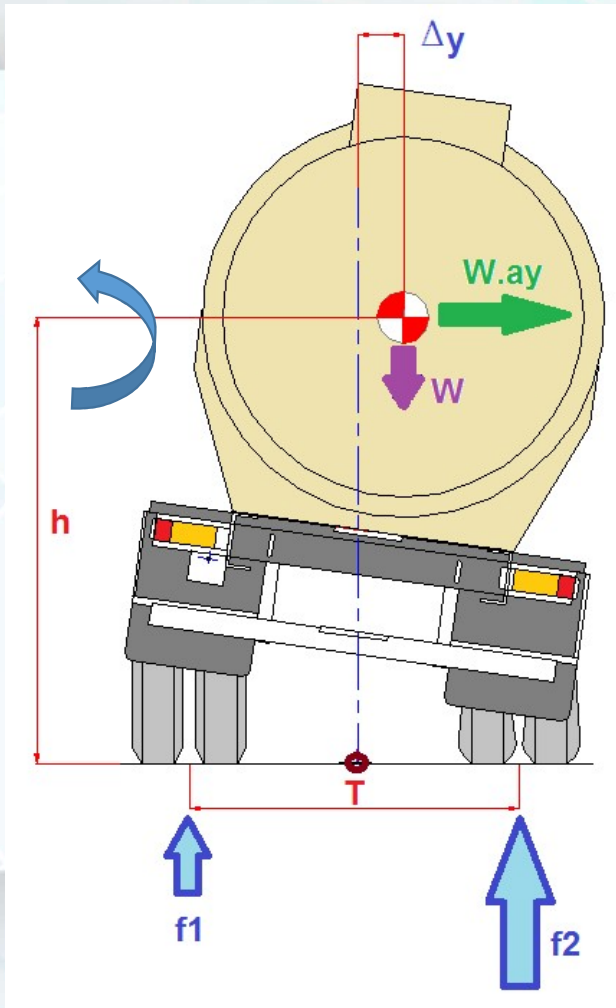
0,32

0,30

0,28

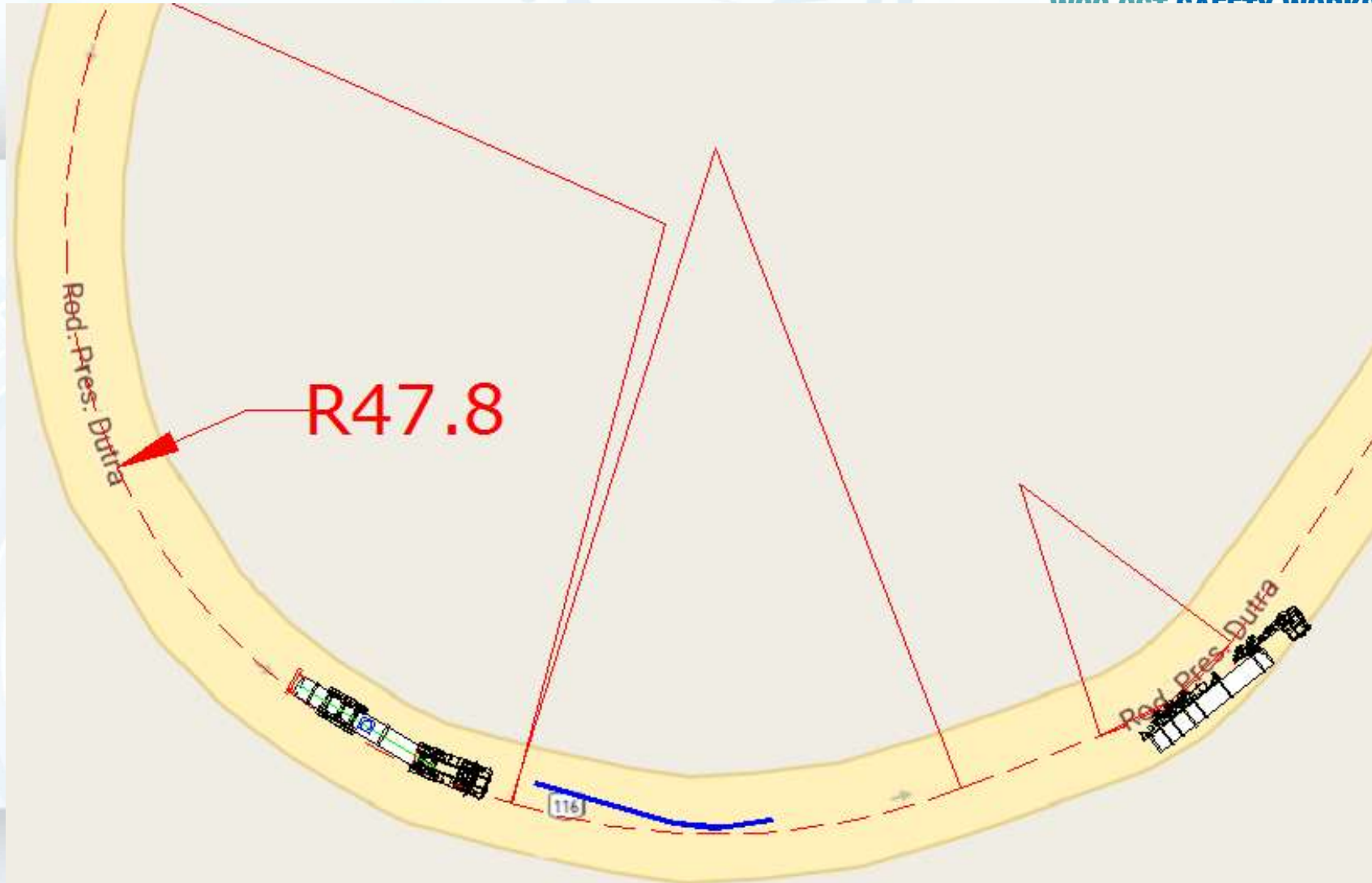


## PHYSICS OF ROLLOVER



Lateral acceleration  
generated in turning:

$$a_y = \frac{v^2}{R \cdot g}$$



# CRITICAL POINTS

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## Don't follow the signs

**THAT'S RIGHT:** a lot of maximum speed signs do not apply to loaded trucks.

They are intended for passenger vehicles.

Therefore, at critical points, trucks must drive below the speed posted on the signs.



At least 10 km/h below the speed.

And 20 km/h below, for combination vehicles, such as b-trains and road-train

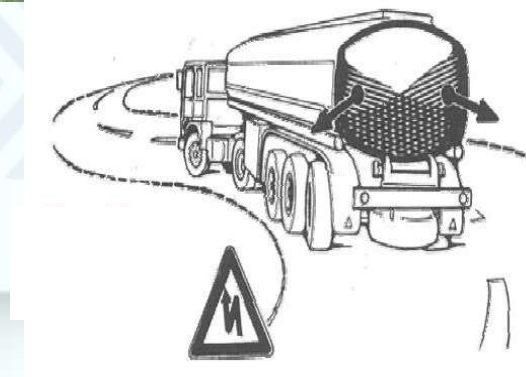
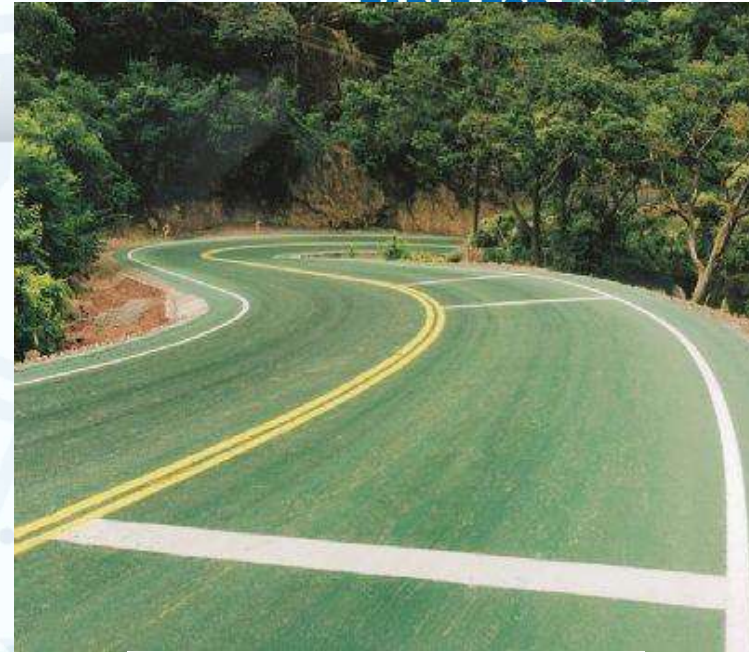




## OTHER POINTS

### Road geometry:

Not only the turn radii, but also the presence of a sequence of turns may lead to instability-related problems in combinations. A mix of the distance between turns and speed may cause the steering to enter into phase with the lateral movement of the semi-trailer. The entire combination may overturn even under low speeds. Observe the sequence of turns on a new highway.





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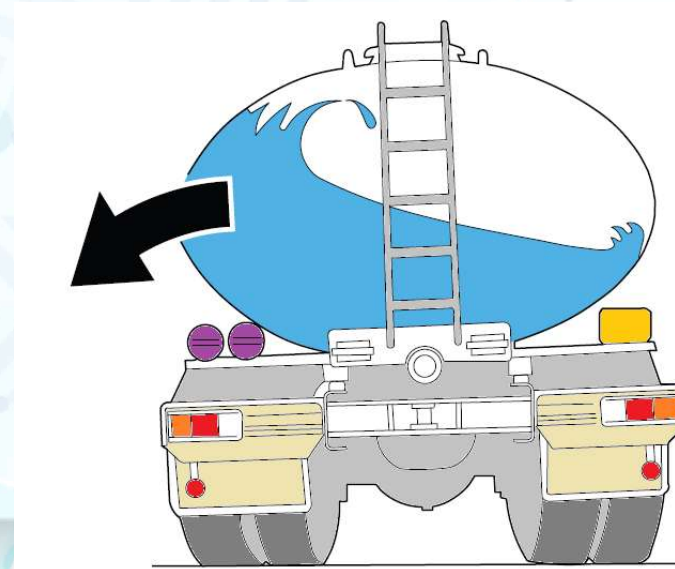
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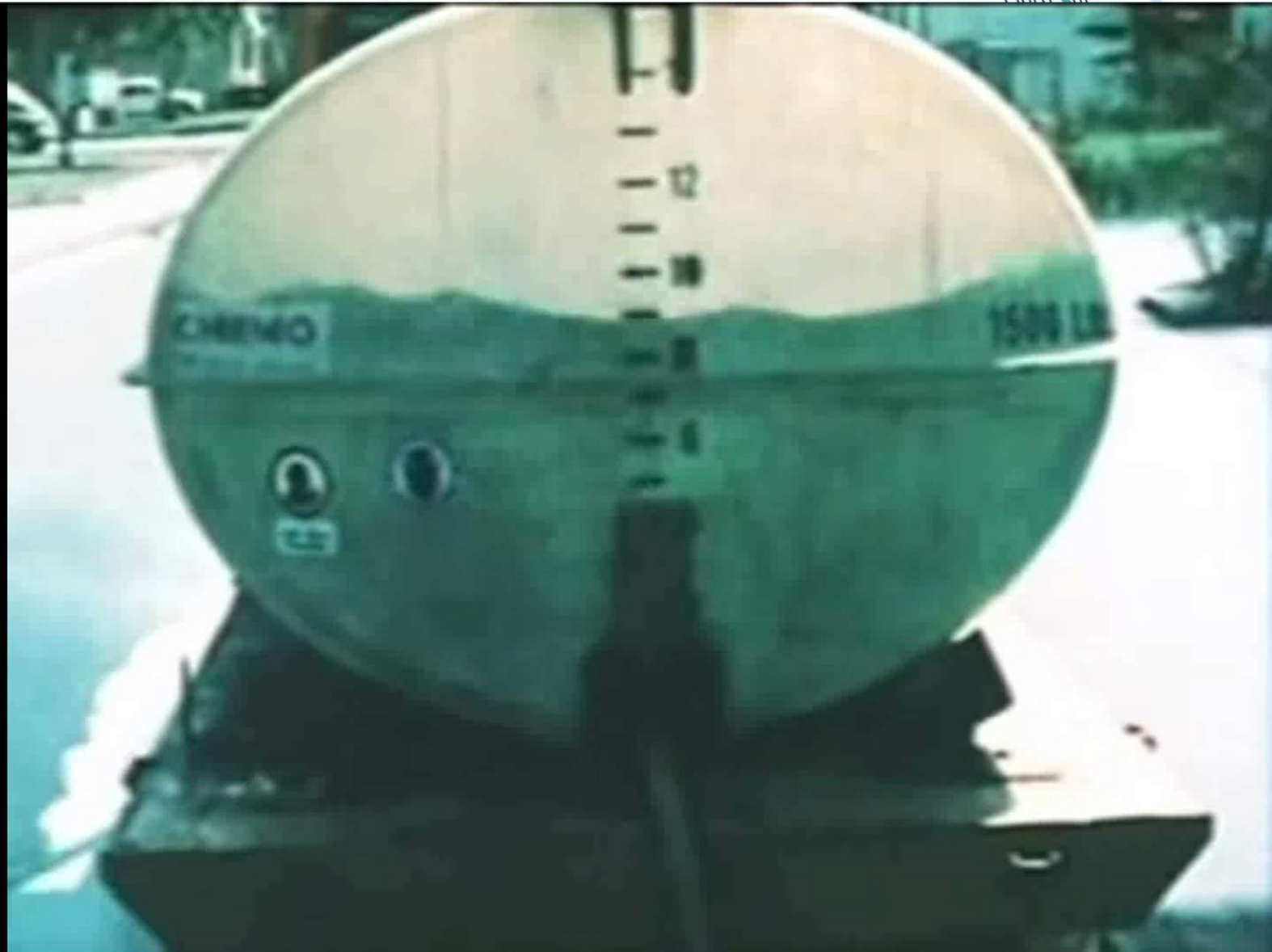
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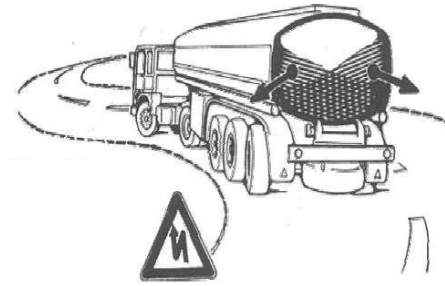
## Risk N°2: Driving with partial volume

The Rollover characteristics of a tank are strongly influenced by the free movement of the liquid within the cargo compartment. In a tank loaded with partial volume, this cargo movement is more intense, thus producing an effect known as "slosh". These are complex movements and depend basically on the tank's geometry and the liquid's viscosity.





## SLOSH FACTOR (*Transient Turning*) – Caso crítico



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### ***Slosh during a Lane Change Maneuver (evasive) (with frequency of 0.5 Hz).***

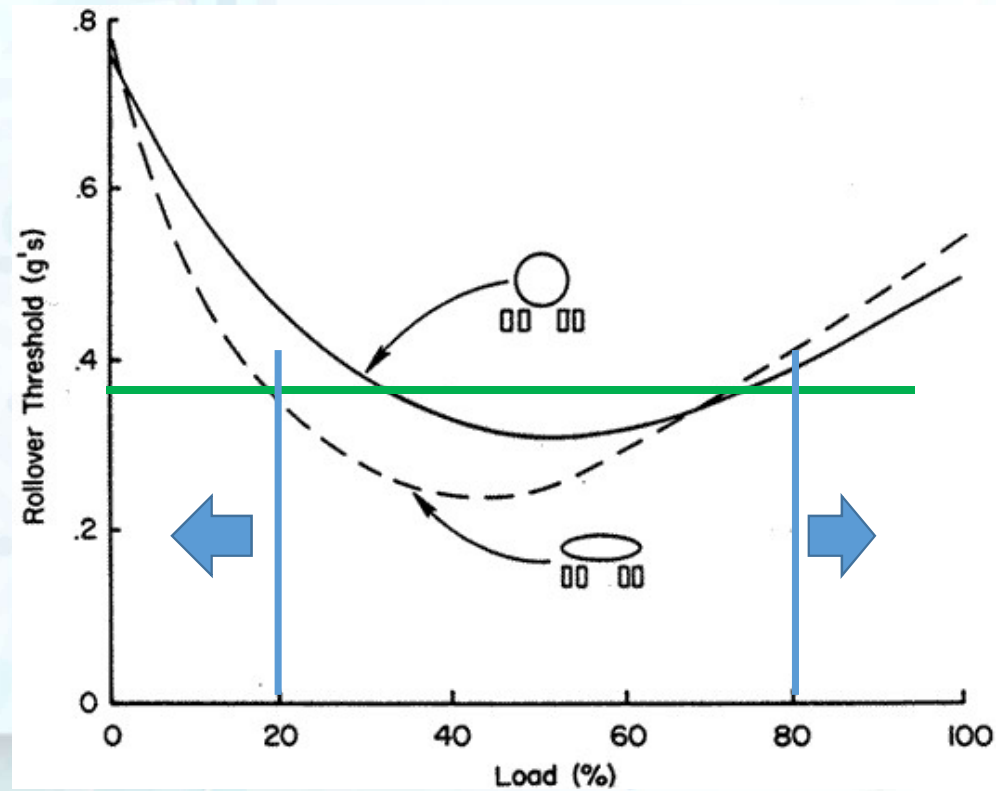
Cargo vehicles are classified according to their SRT, as:

Good - with SRT above 0.35 g's

Marginal - with SRT between 0.30 and 0.35 g's

Poor - with SRT below 0.30 g's

Observe that in the range above 20% of the volume and below 80%, the Rollover threshold is below the safety limit and it is smaller than that when completely full.



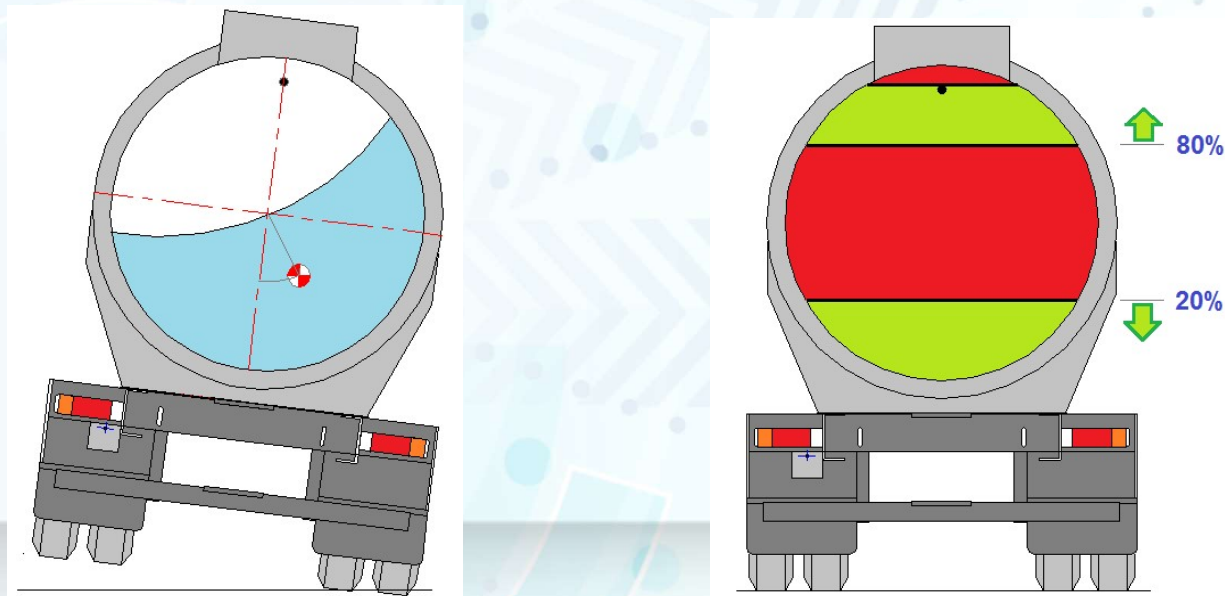


## Why 80/20?

- Above 80% of full volume: the liquid's mass is large, but the space for movement is small.
- Below 20% of full volume: the space for movement is large, but the liquid's mass is small in order to affect stability.

But, in the middle range (between 20% and 80%, specially between 40% and 60%), the mass is large and the space for lateral movement is also large, thus allowing the additional transfer of weight between the sides of the tank during turns and maneuvers.

ADR Code 4.2.2.3.4 requires for compartments above 7,500 liters.







## Risk N°3: Rearward amplification in doubles

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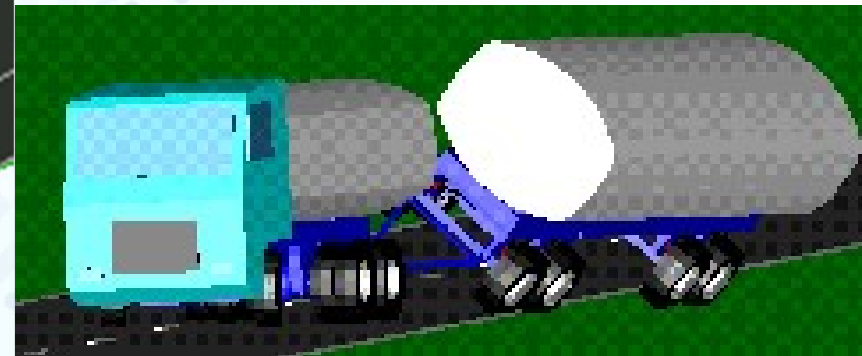
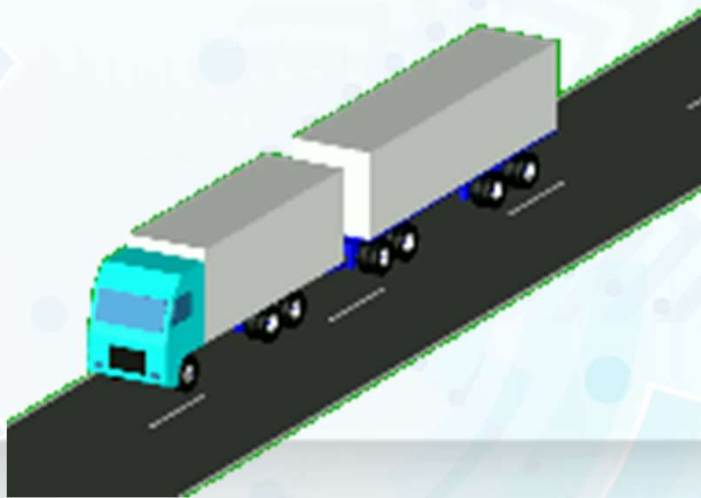
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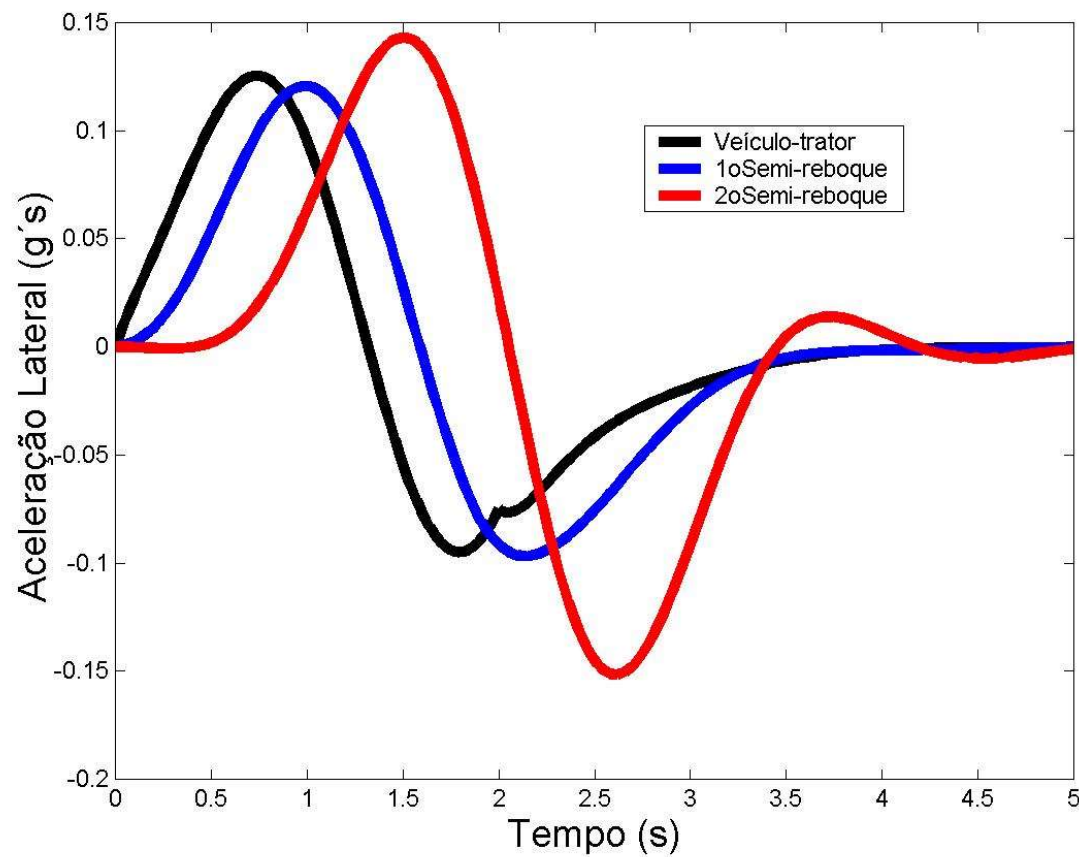
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Phenomenon known as "rearward amplification" or "Crack-the-whip Effect". This is the increase in the lateral displacement of the last unit in comparison with the lateral displacement of the first unit in turns or in evasive maneuvers. As a result of this amplification of the movement, the rearward unit of the combination is subjected to greater lateral accelerations than the tractor unit.



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Dynamic Simulation - Rearward Amplification - Lateral Acceleration - Sine  
Input - Speed of 80 km/h loaded -



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## Risk Nº 4: Downhill in a Mountain.

**Risk of brake overheating + small radius turns.**

**REDUCE SPEED BEFORE STARTING THE DESCENT: use engine braking and reduced gear**

**- The gear must ensure the speed and not the service brake. It is better to press down strongly once and engage a heavier gear. Start the descent at low speeds.**

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HOSTED ON

**Live Leak**

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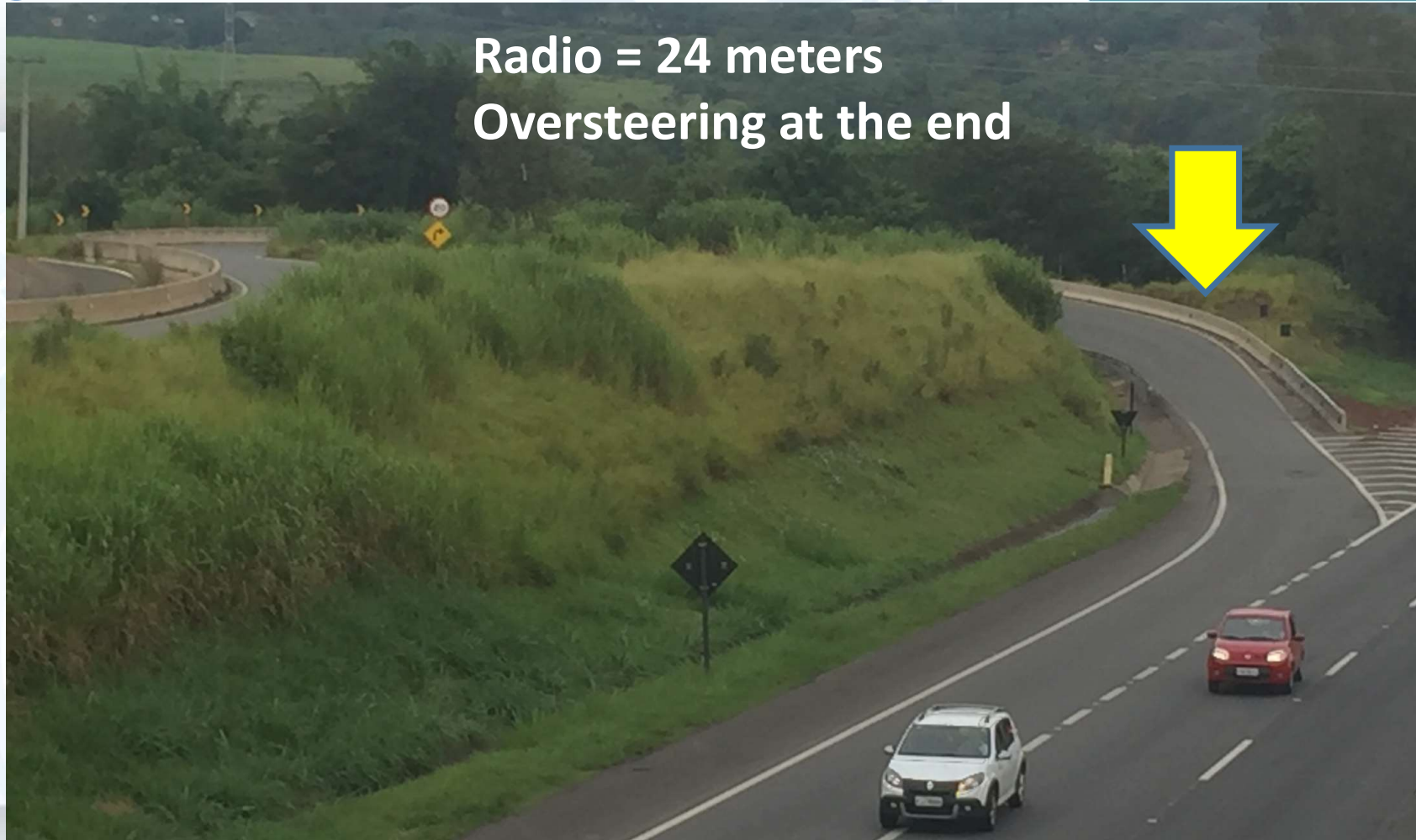
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# When the road causes changes in turn radius.

Radio = 24 meters  
Oversteering at the end



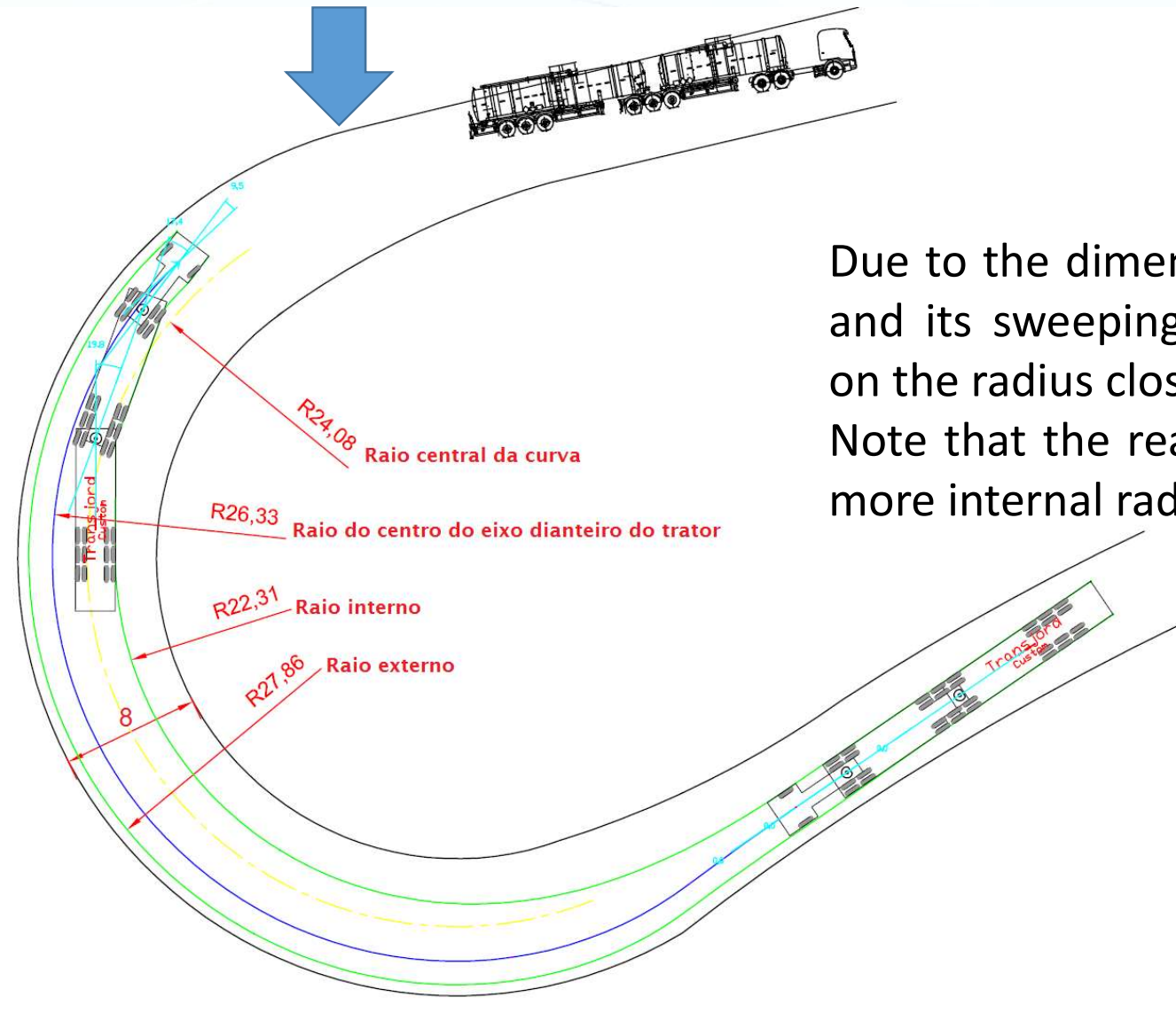
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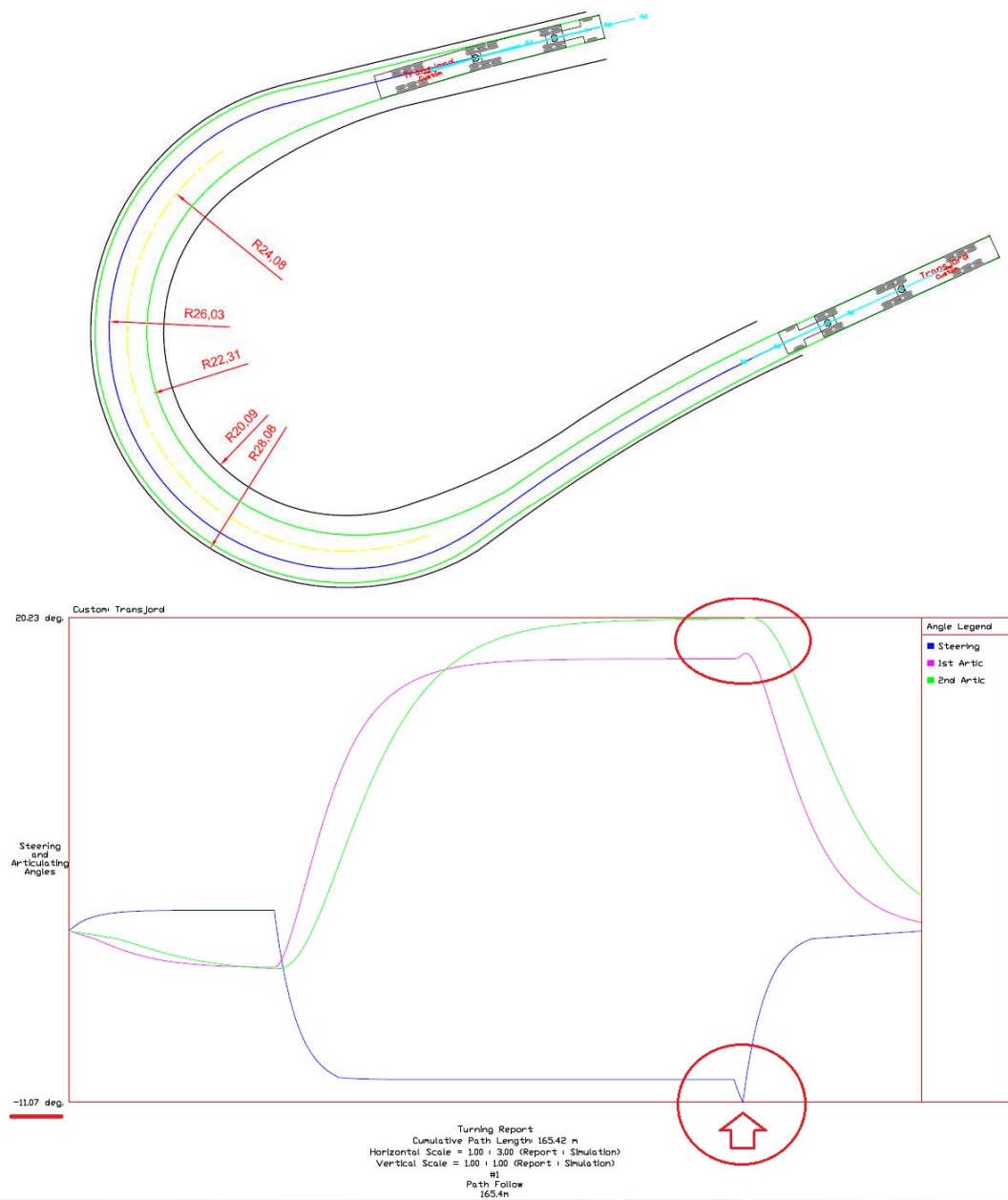


Due to the dimensions of the combination and its sweeping area, the tractor travels on the radius closer to the outer side. Note that the rear semi-trailer travels at a more internal radius than the tractor does.



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The oversteering proportionately reduces the radius of the vehicle's trajectory.

Therefore, depending on the oversteering, it is possible to expect greater lateral accelerations at the end of the ramp, wherein Rollover may take place.

# Dynamic Load Transfer Ratio

- Stability is associated with the Dynamic Load Transfer Ratio.
- It is related to the type and stiffness of the suspension. Values between 0 to 1. (Considered as satisfactory up to a maximum of 0.6). Air Suspension: more stable semi-trailer in regards to Rollover
- Axle beam acts as a torsion bar.

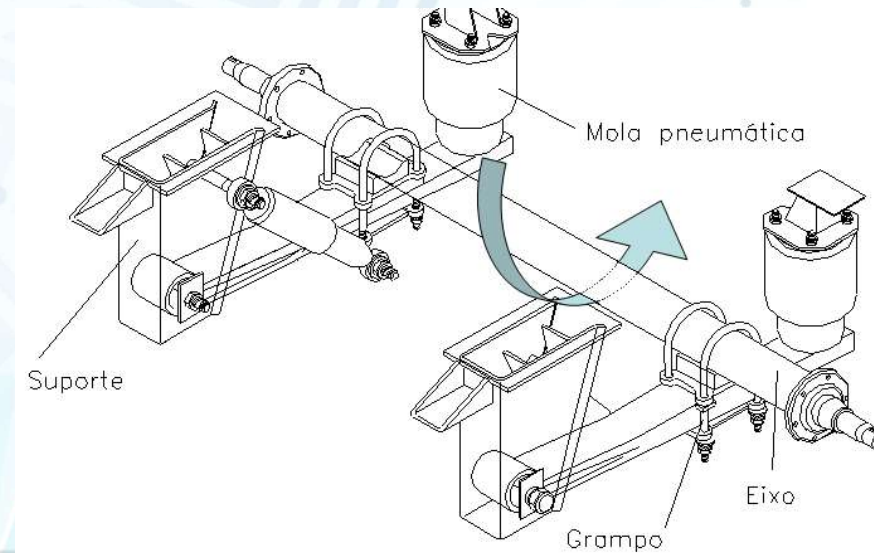
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# The aggravating factor of mechanical suspension.

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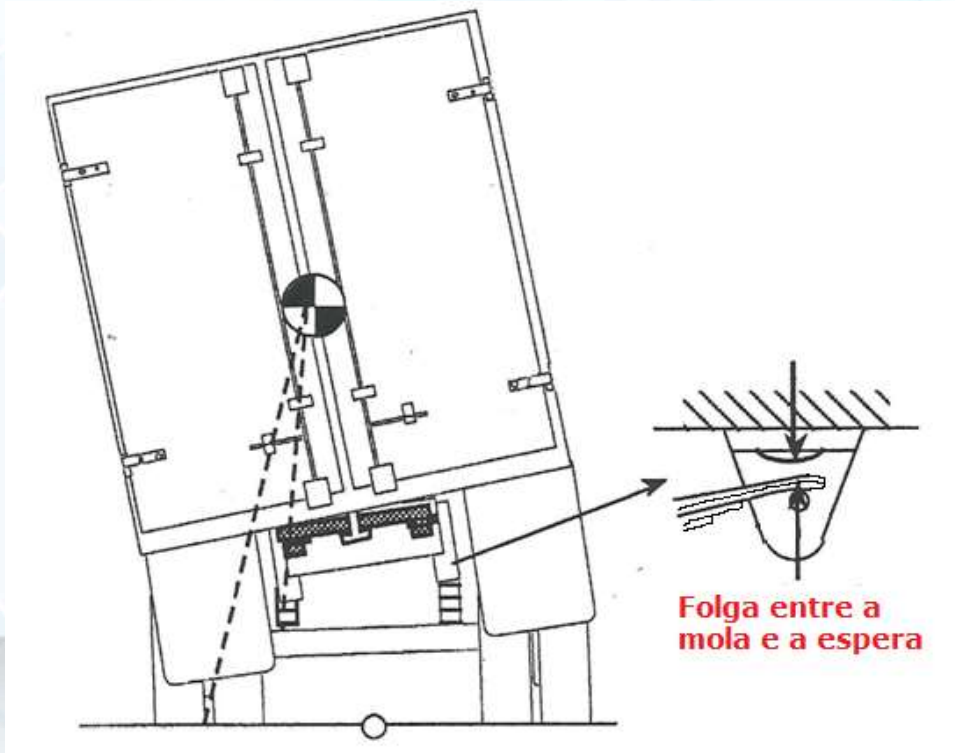
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The space between the spring and the buffer: it may worsen by up to 25% the Rollover Limit. The gap allows the initial inclination of the semi-trailer, collaborating towards the Rollover.



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## Risk N°. 5: SLEEPING - TYPICAL PHASES

1. Blinking takes longer (slower to reopen the eyes: they become “heavier”).
2. Changing the position of the seat.
3. Placing hands on the head.
4. "Adjusting" the seat.
5. Falls asleep (“unplugs the brain”).

If you notice the 1st phase of sleep: you must stop at a safe location. Drink water or coffee, go to the bathroom.

Upon returning to driving and if sleepiness is back, park at a safe location and SLEEP!

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FG +0.0

SG +0.0

Time

-9.25

Door View

2017-09-15 00:59:58 粵X26335



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## Risk N°6: INEFFECTIVE ROAD SIGNALLING:

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- Most turns on the roads do not have the objective indication of speed and, a lot of them, when it is indicated, the limit may be higher than the limit for certain vehicles.
- The current conventional telemetry and tracking systems are still not able to identify those critical turns and to inform the user which correct speed for the next turn to use.



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# Example of speed signaling for trucks

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But: what's the safety speed for next curve?

# The solution? TECHNOLOGY

Location (Latitude, Longitude)

Lateral acceleration x speed: turn radius

Altitude

Azimuth

Objective: to establish the safe speed for each turn per type of truck.



An equipment for automatic data acquisition of the road's geometry: it is like a geo-referenced scanner.



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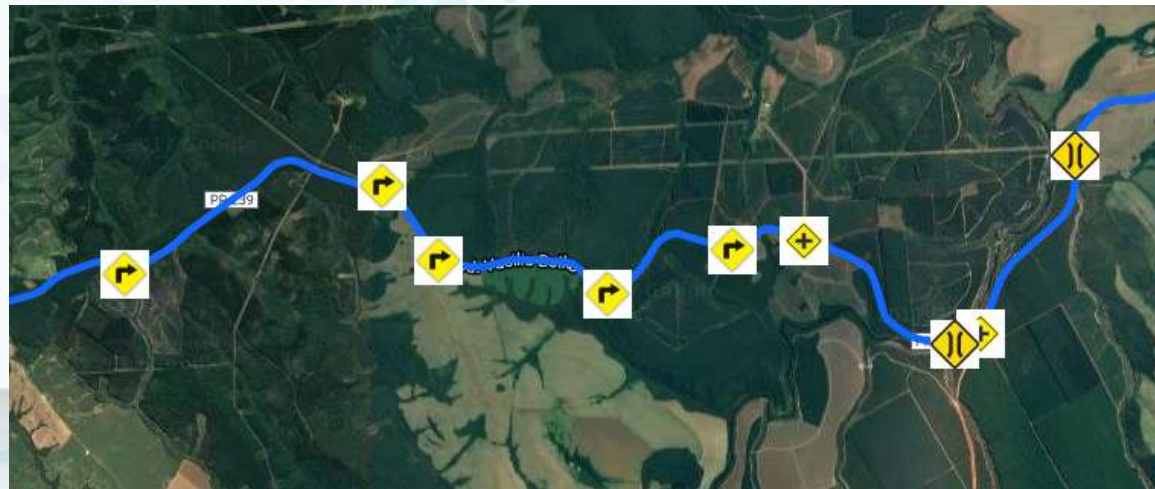
**REPORT GENERATED BY THE ROAD GEOMETRY DATA ACQUISITION SYSTEM AND WHICH IS LOADED INTO ANJO<sup>®</sup>**

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Datalog Time [seg.]	Acel Lat. Y [g-frc]	GPS Hora UTC [hhmmss.ss]	Latitude [deg]	Longitude [deg]	GPS Velocidade [km/h]	GPS Distancia [m]	GPS Azimute [deg]	Raio da Curva [m]	Max. Speed [km/h]	Descrição
21141.677	-0.30	134803.60	-25.571076	-48.839455	70.9	51466.29	0.623	131.67	68.5	Ponto Crítico
21288.477	0.27	135030.40	-25.567645	-48.811175	71.4	54552.65	0.439	148.51	72.7	Ponto Crítico
21307.977	-0.32	135049.90	-25.564956	-48.812780	72.4	54945.47	3.092	128.75	67.7	Ponto Crítico
21310.777	-0.34	135052.70	-25.564558	-48.813145	76.5	55002.01	3.309	135.38	69.4	Ponto Crítico

**ROTOGRAM ON GOOGLE MAPS:**

[https://drive.google.com/open?id=1gNOjOG3g4peVknWZpPrEf2dJC\\_w&usp=sharing](https://drive.google.com/open?id=1gNOjOG3g4peVknWZpPrEf2dJC_w&usp=sharing)



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On-board device. (ANGEL)



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# THE VEHICLES FOR THE FUTURE (Next)

It is recommended that the use of safer vehicles be encouraged when planning fleet renewal, preferably considering the following technical resources:

- The use of **air suspension** (with or without super-single tires) due to its greater stability against Rollover.
- The use of EBS type brakes with **stability control - ESC** in all vehicles of the combination or at least on semi-trailer tanks.

(Res. 641/16 – Mandatory from 2024 in Brazil)

In Europe, it has been mandatory for tanks since 2010.

- The use of **fatigue monitoring** (eye scanner) connected to the tracking system.
- The use of on-board technology to alert the approach of hazard points, known as "**spoken rotogram**" and telemetry for records (which we call ANJO).

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Thank you very much!

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