



# Crashworthy End Terminals and possible innovative applications

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# Summary



- Definition and purpose of an End Terminal
- Common uses of the End Terminal: longitudinal and median barriers
- Possible innovative applications



# Purposes

- Show the advantages to install an End Terminal in order to protect different typologies of fixed obstacles.
- To make clear the advantages to install an End Terminal which meets the Part 7 of the EN 1317 standard.
- To show the best solution for the protection of begins of side and median barriers, working zones, trees and poles.



## Definition

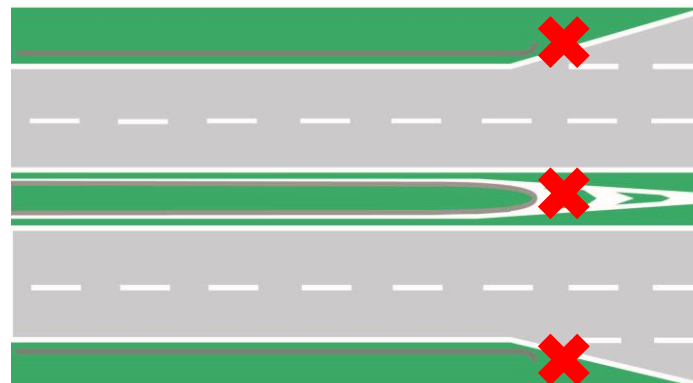
**Terminal:** Device installed at the beginning and/or end of a safety barrier to reduce hazards for passenger vehicles



# Definition

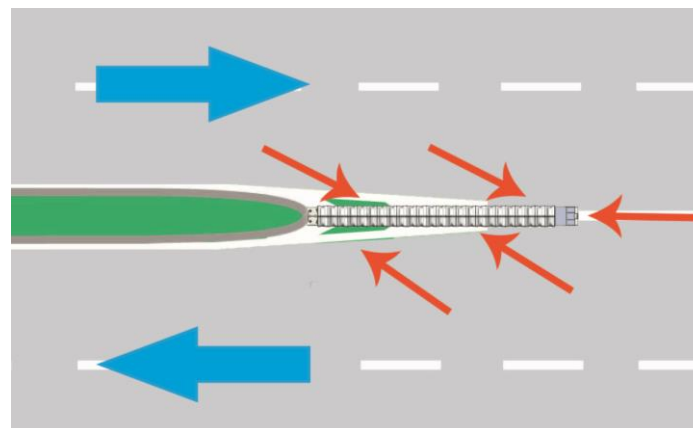


- **Double sided Terminal (DST):** They absorb the energy of the impact from both sides and therefore they can be installed both in front of the roadside barrier, and in front of the median barrier.



**Double sided End Terminal:** the picture on the top shows the points where it can be installed.

- **Bi-directional Terminal (BDT):** they absorb the energy of the impacting vehicles coming from both directions of the carriageway. For this reason, they can be installed both at the begin and at the end of the barriers.



**Bi-directional End Terminal:** The big arrows show the direction of travel, while the little arrows show the vehicle direction at the moment of the impact against the End terminal.



# Terminals $\neq$ Crash Cushions



The main difference between  
Terminals and Crash Cushions is:

- a Terminal is always connected to a barrier, however a crash cushion can be not connected to the obstacle

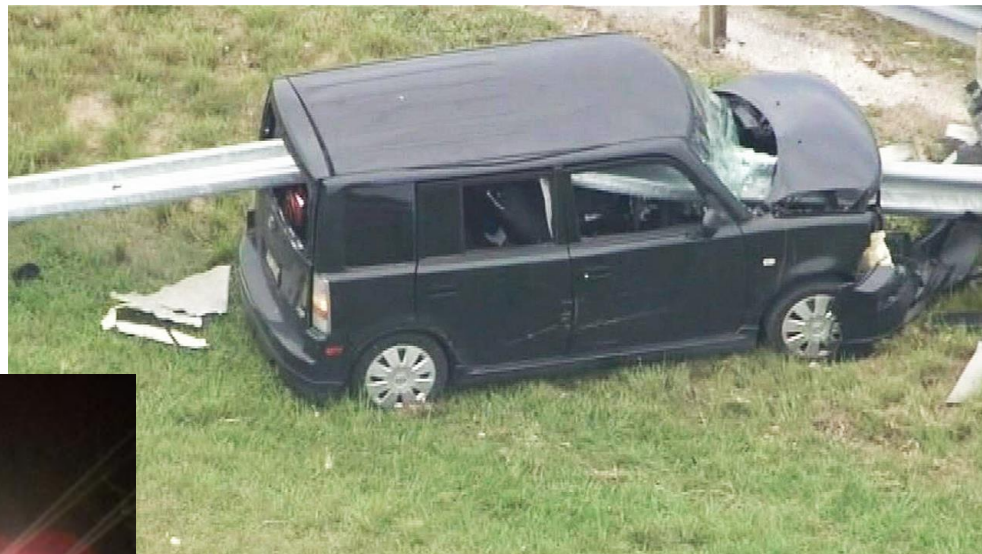
The innovation is  
a Terminal that works as a Crash Cushion



## PROBLEM 1: begin of longitudinal barrier



A longitudinal barrier can shear off a vehicle side to side.



## PROBLEM 2: concrete or steel median barrier



## PROBLEM 3: working zone longitudinal barrier



The Problem



The Fatal Risk



## PROBLEM 4: poles and trees protection



Poles impact are very dangerous for the vehicles as well as the passengers.

**Problem: a dangerous pole without protection in the middle of the carriageway.**





# PROBLEM 4: poles and trees protection



## The Fatal Risk





## PROBLEM 4: poles and trees protection



### The Fatal Risk



An example of crash test against a pole at 50, 70, and 90 Km/h



The only solution is :

# To shield the hazards with a crashworthy device

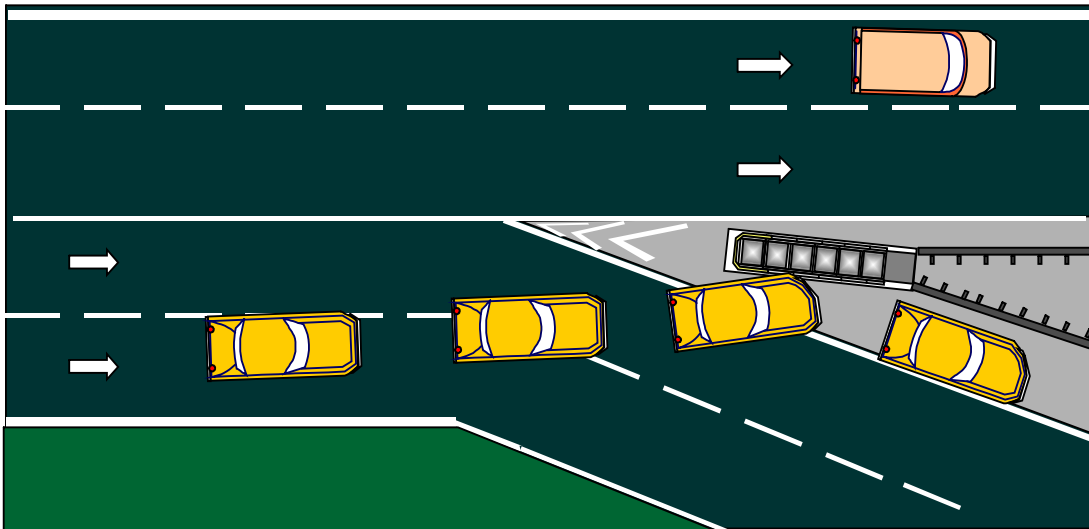
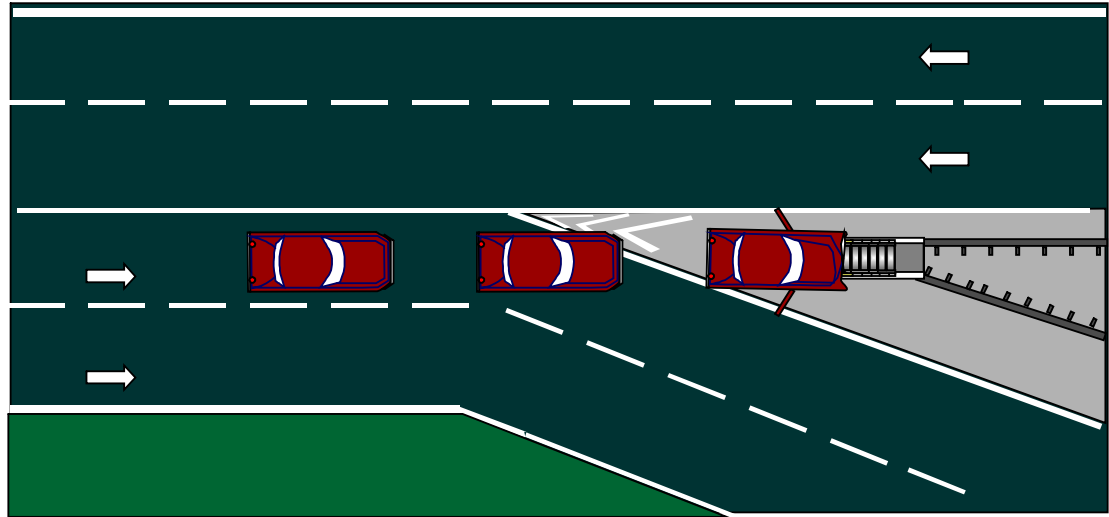




# The crashworthy device function...



is to gradually absorb the kinetic energy in case of impact by decelerating vehicles



...and to redirect the errant vehicle back toward its original travel path.

# Shielding the hazards

## DO make a difference!



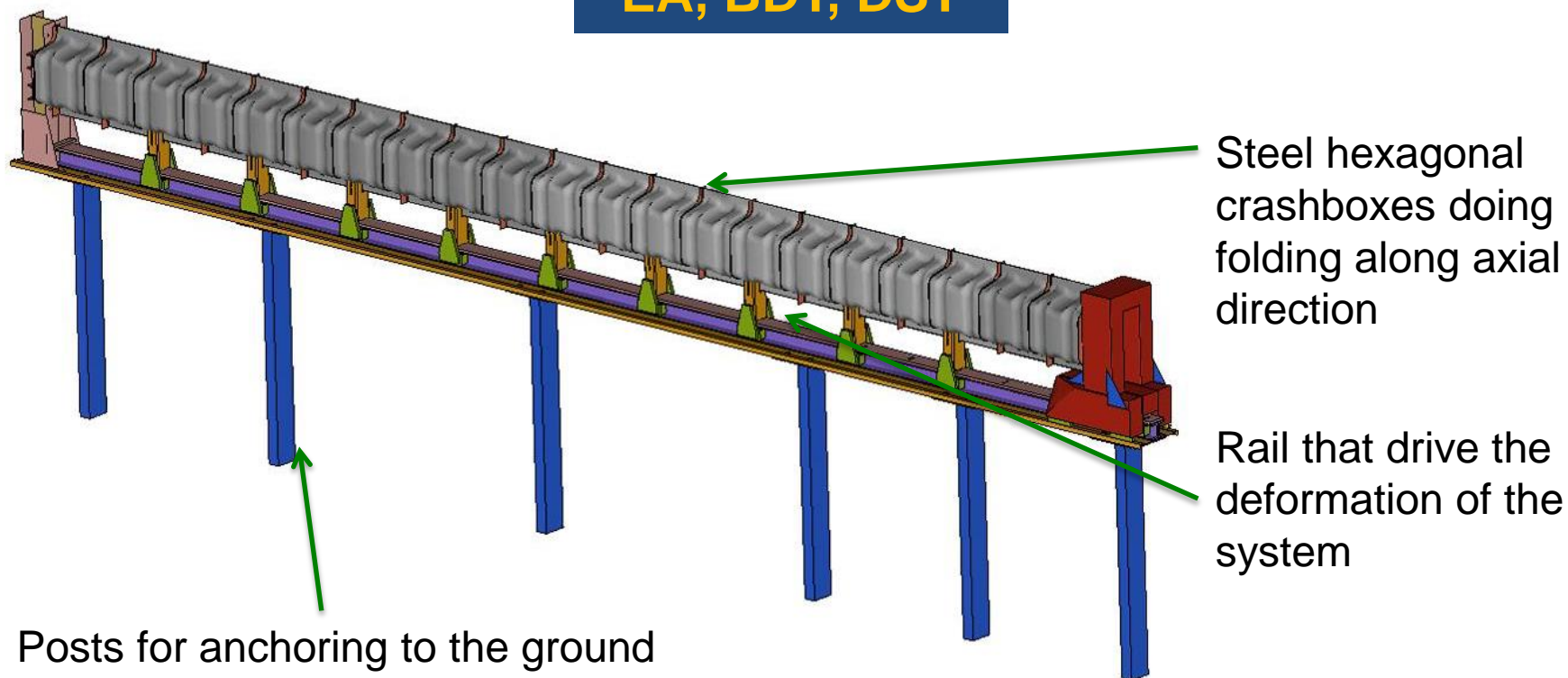
**NO PROTECTION**



**WITH PROTECTION**

## Description of the VRS used for this Research

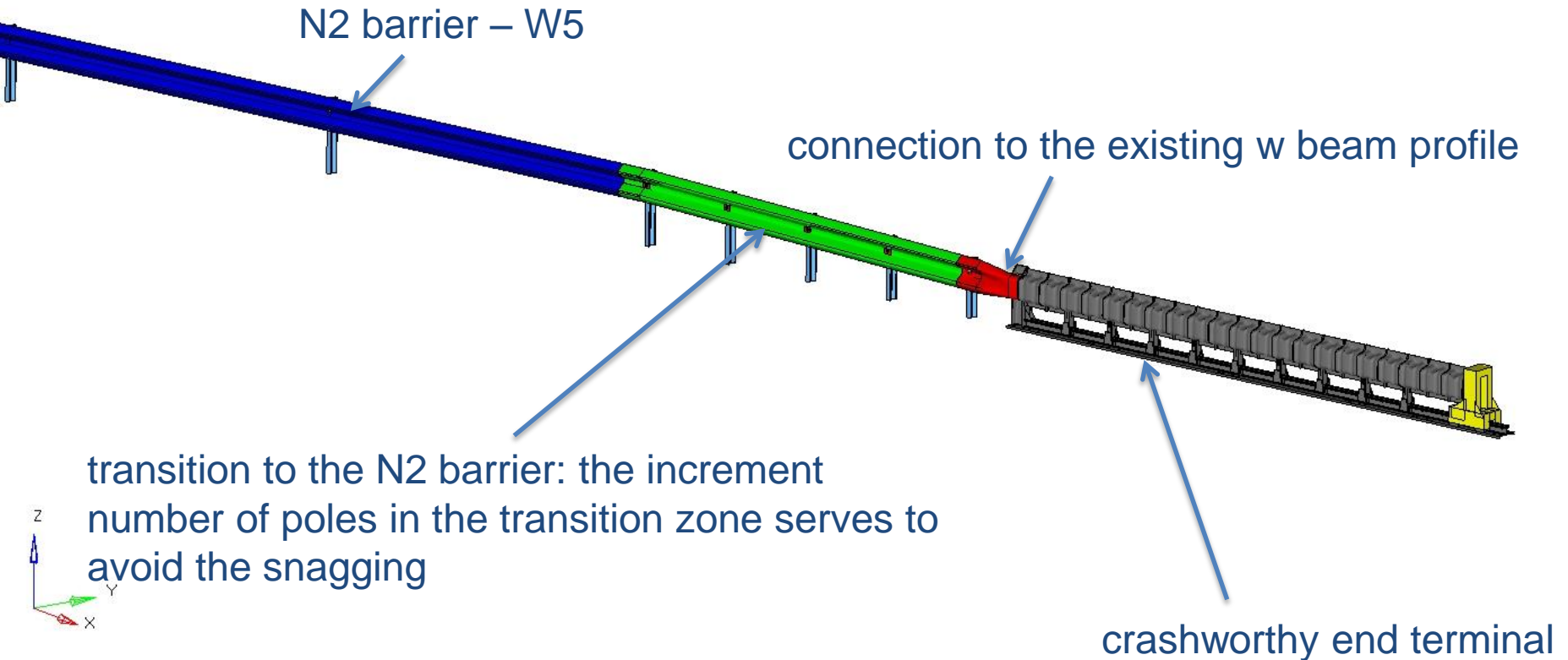
**EA, BDT, DST**



# Solution to problem n. 1: end terminal of lateral barrier



## Solution to problem n. 1: end terminal of lateral barrier



## The snagging problem

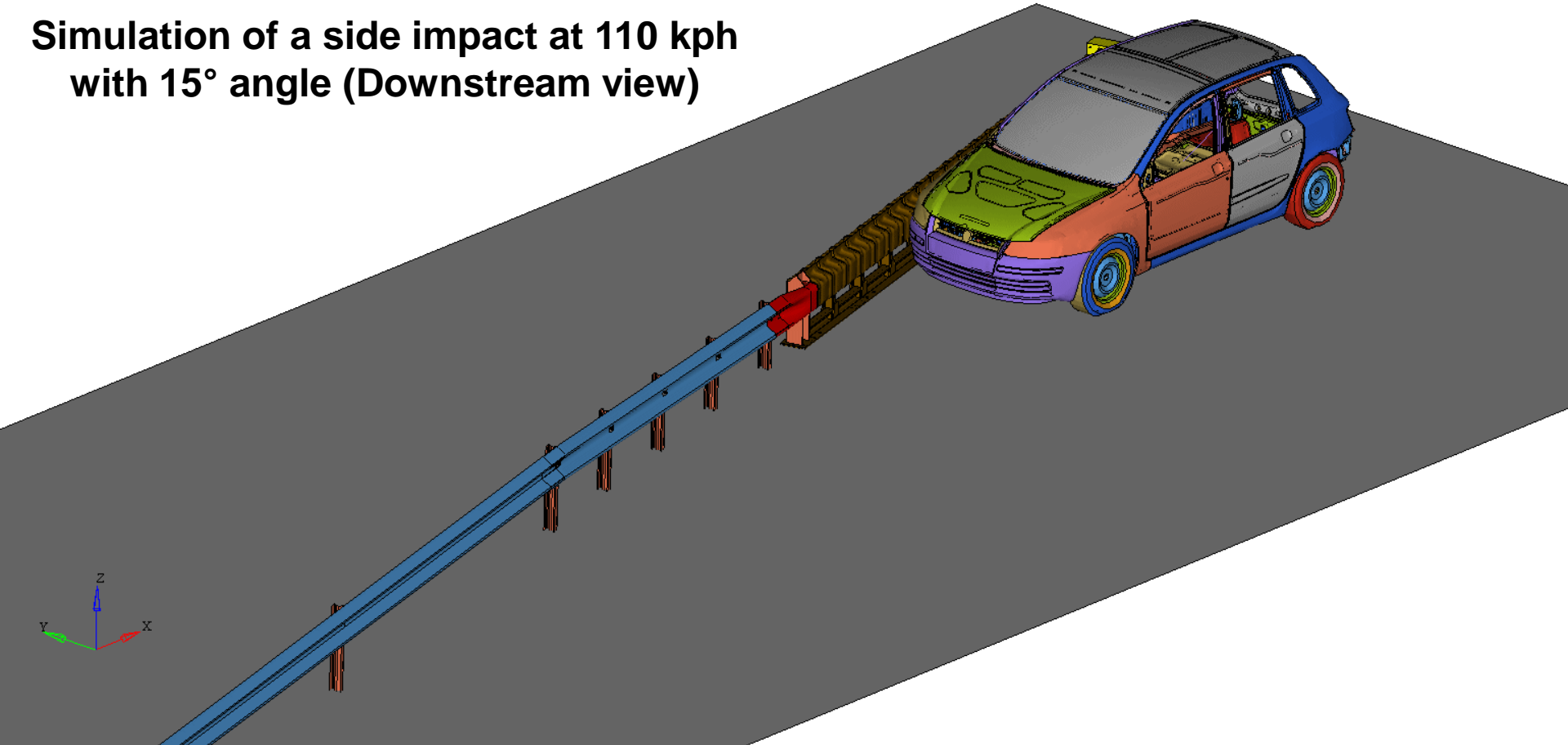


### Simulation of a reverse side impact at 110 kph with 15° angle (Downstream view)



# Solution to problem n. 1: end terminal of lateral barrier

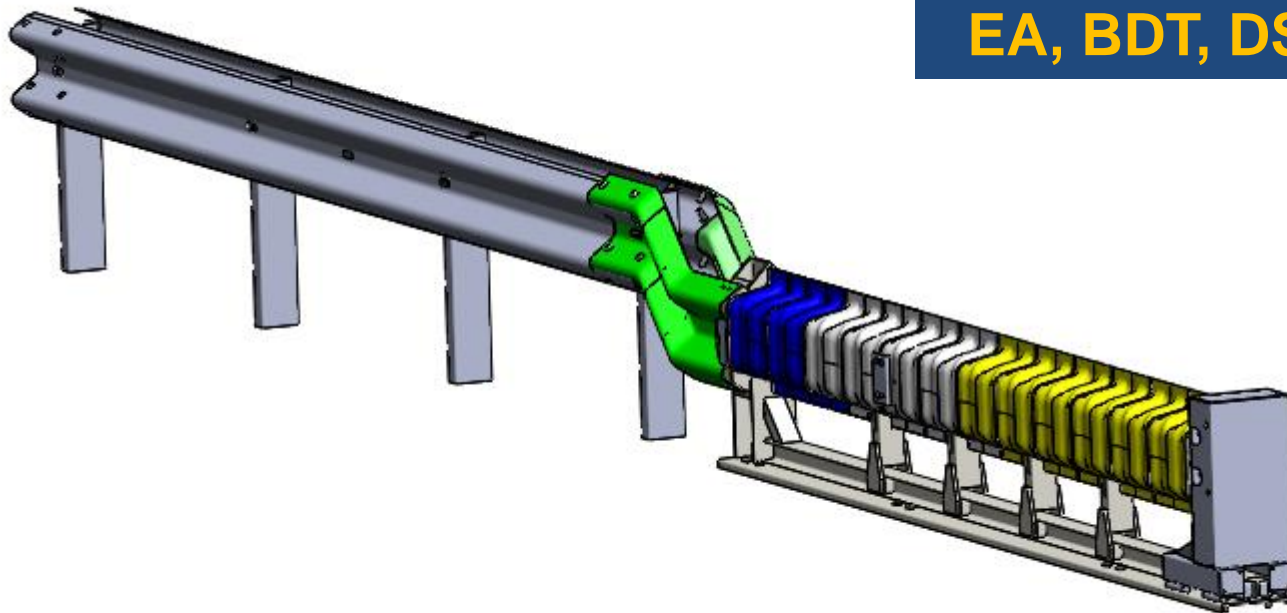
**Simulation of a side impact at 110 kph  
with 15° angle (Downstream view)**



## PROBLEM 2: concrete or steel median barrier



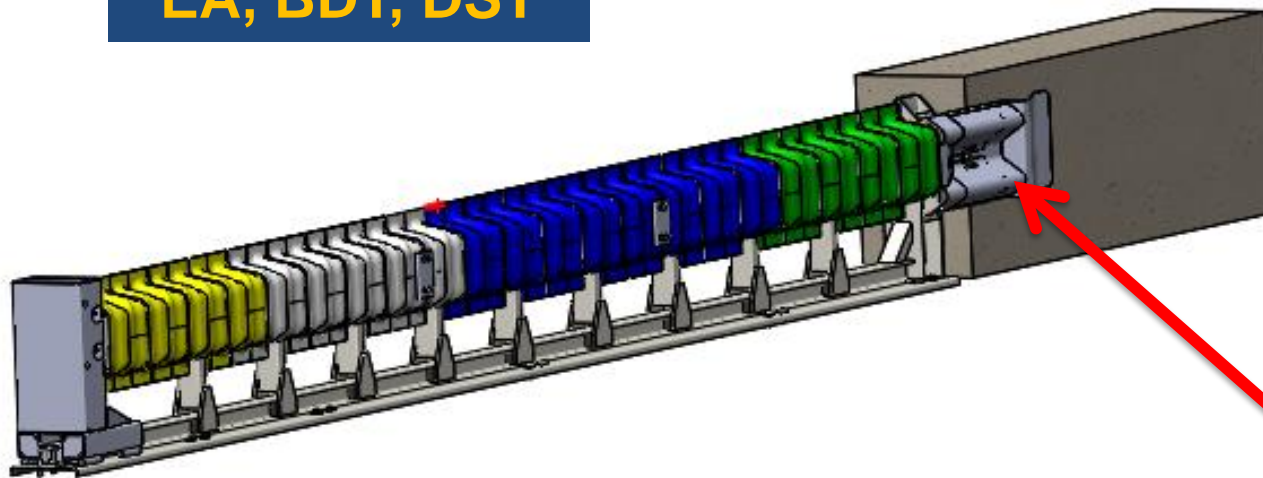
# Solution to problem n. 2: end terminal of median barrier



**EA, BDT, DST**

# Solution to problem n. 2: end terminal of median barrier

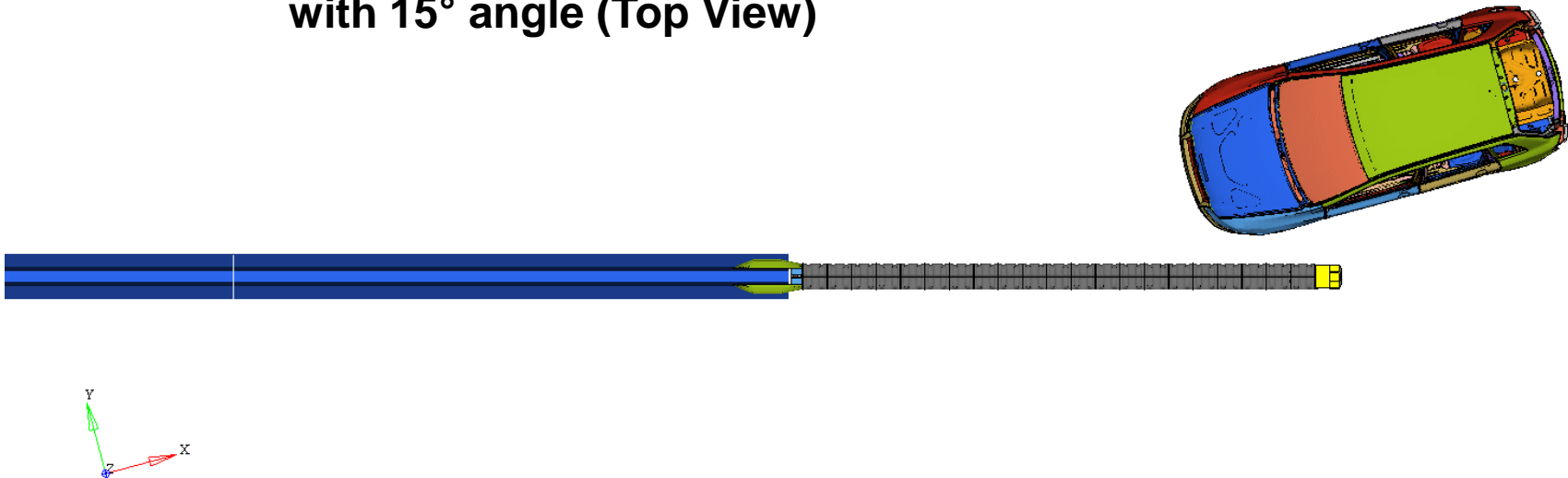
**EA, BDT, DST**



End terminal/Concrete barrier  
**SPECIAL CONNECTION**

# Solution to problem n. 2: end terminal of median barrier

**Simulation of a side impact at 110 kph  
with 15° angle (Top View)**



## PROBLEM 3: working zone longitudinal barrier



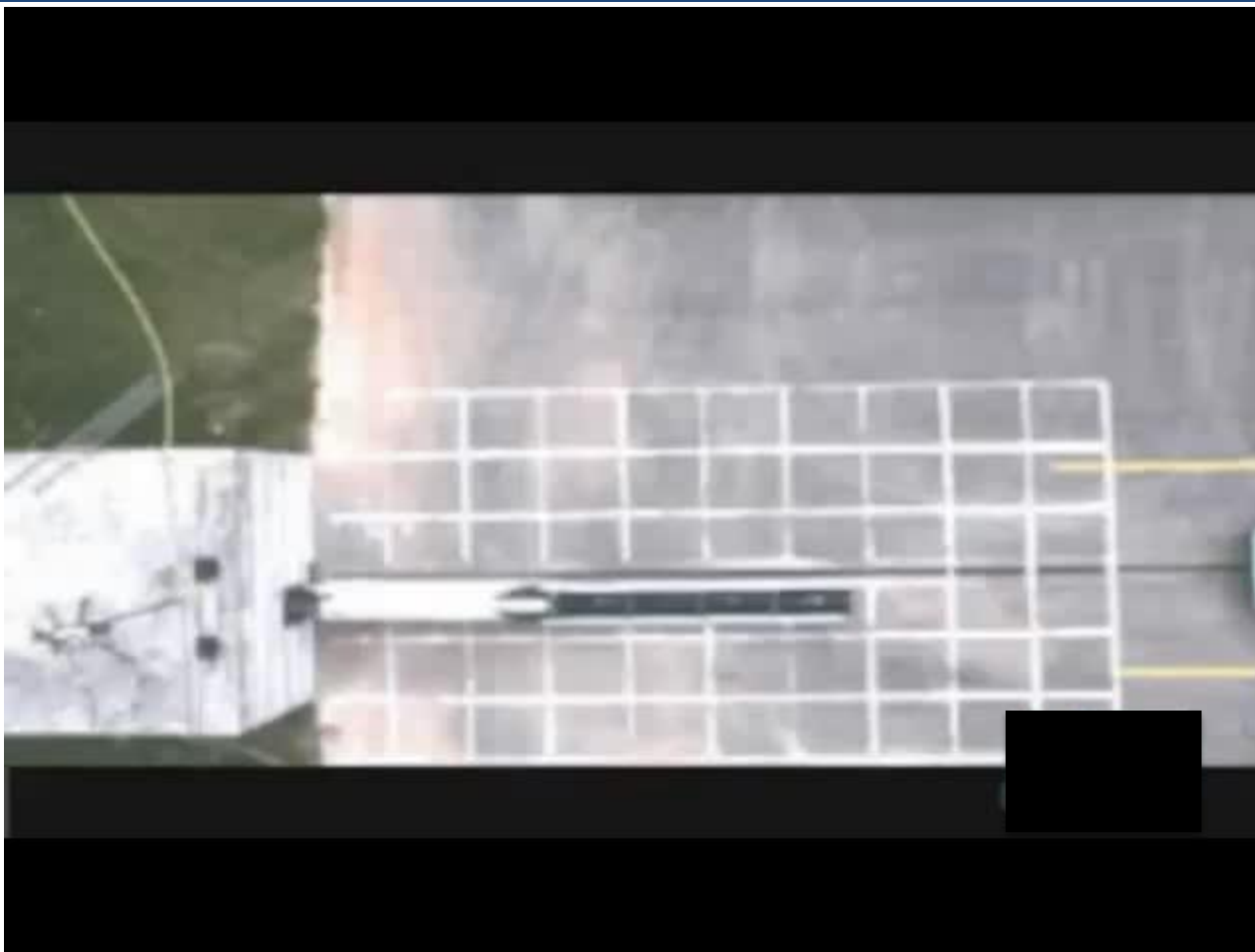
The Problem



The Fatal Risk



## PROBLEM 3: working zone longitudinal barrier





# Solution to problem n. 3: working zone

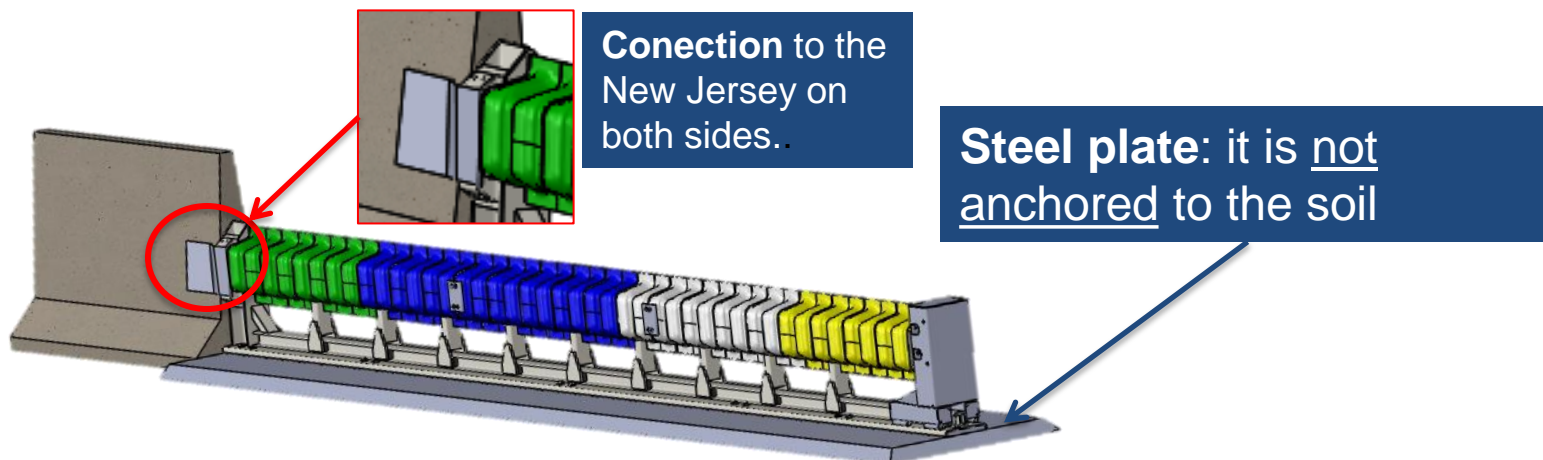


The system should be:

- anchorless
- easily removable
- able to sustain both frontal and even side impacts

## The solution:

- VRS supplied with a **steel plate** and fixed with a transition to the obstacle.
- Placed in front of the obstacle without fixing to the ground.
- Even absorbs the side impacts.

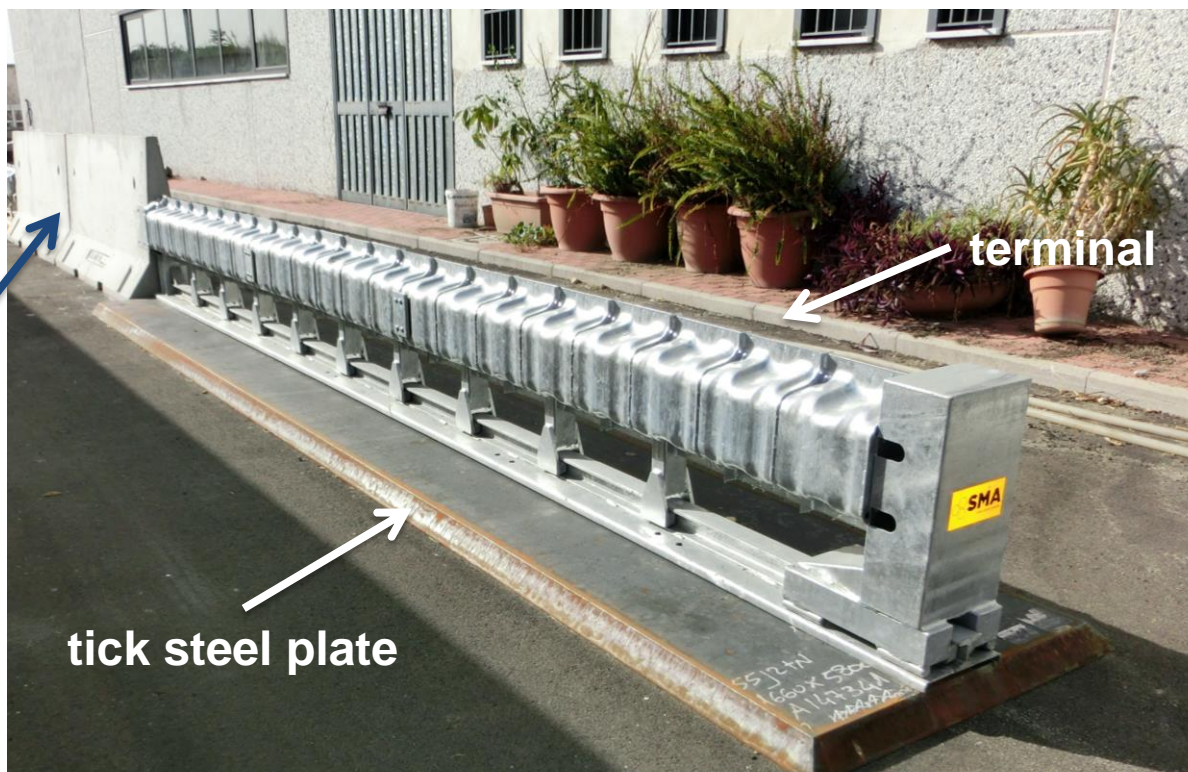




# Solution to problem n. 3: working zone



temporary  
concrete  
barrier



thick steel plate

terminal

The first redirective solution for working zones

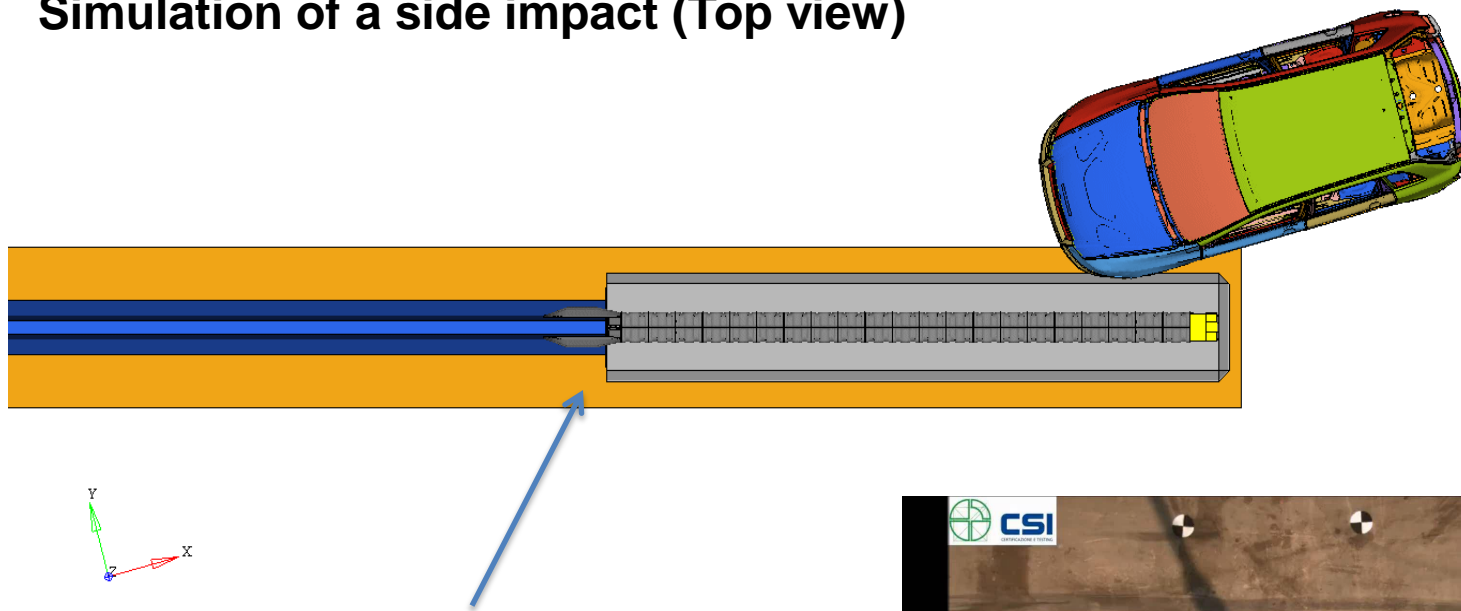


# Solution to problem n. 3: working zone

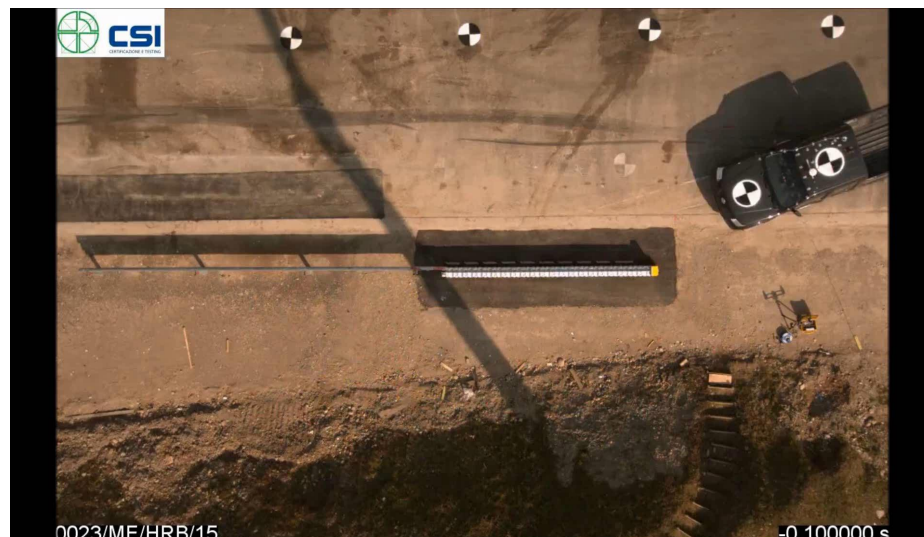


## ANCHORLESS REDIRECTIVE NON GATING TERMINAL/CRASH CUSHION

Simulation of a side impact (Top view)



The basement steel plate makes small movement that allows the terminal to continue working





# PROBLEM 4: poles and trees protection



## The Fatal Risk

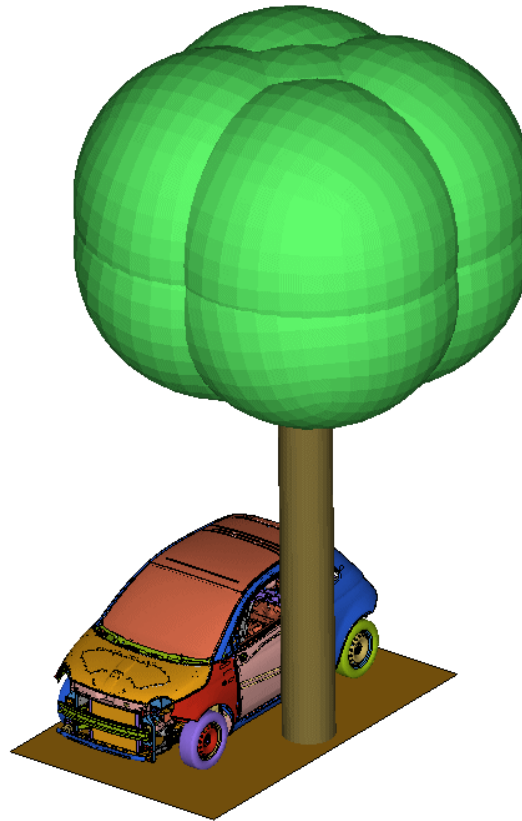




# Solution to problem n. 4: poles and trees

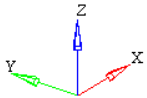


## Impact at 70Km/h



the worst case is the side impact of the vehicle against the pole or the tree

It is not easy to manage this kind of impact. The crashworthy device are generally designed for head on impact and lateral impact with an angle of  $15^\circ$ , very far from  $90^\circ$





# Solution to problem n. 4: poles and trees



Impact at 70Km/h



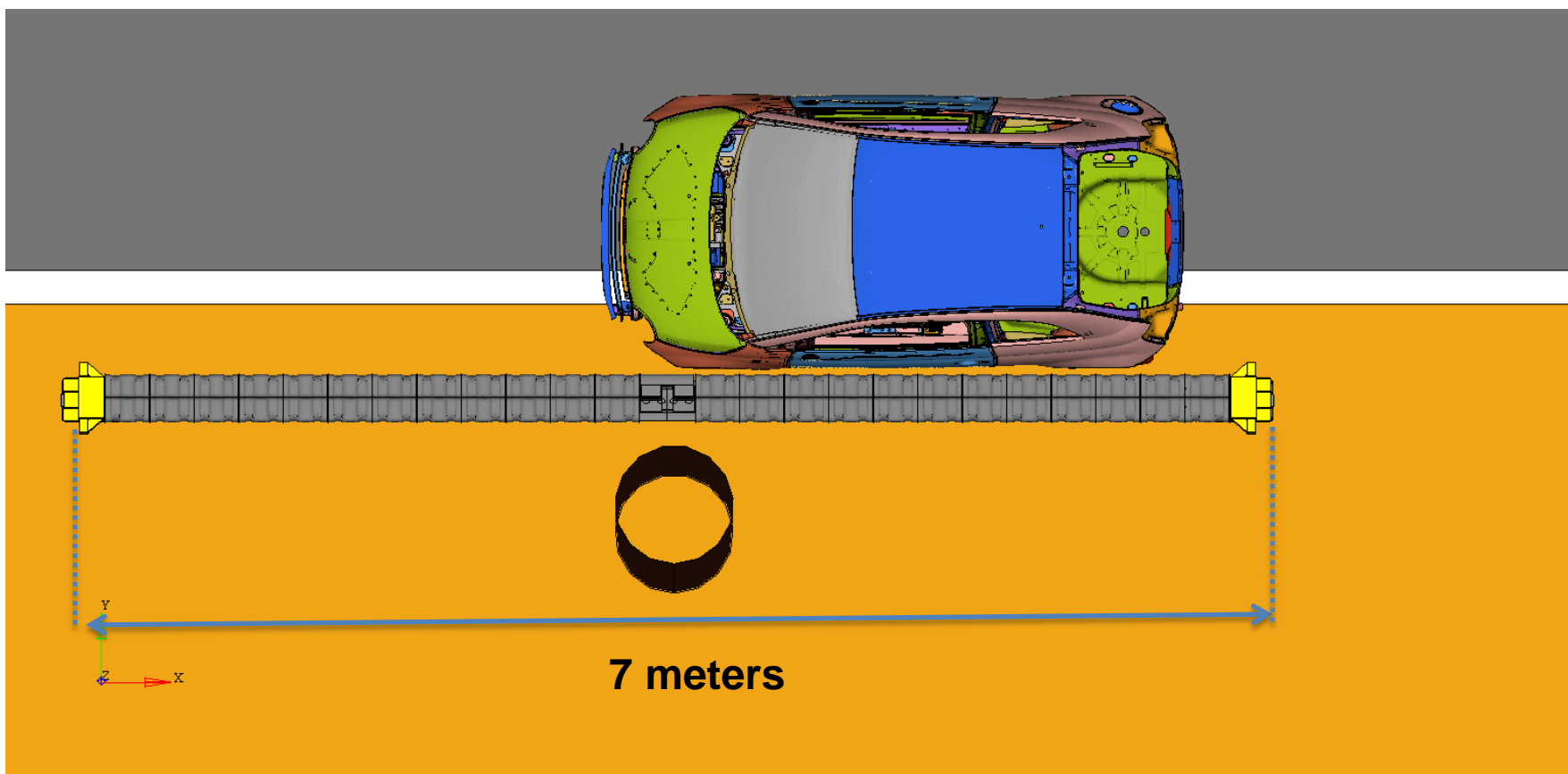
the solution is to put **2 terminals** working as small width crash cushions



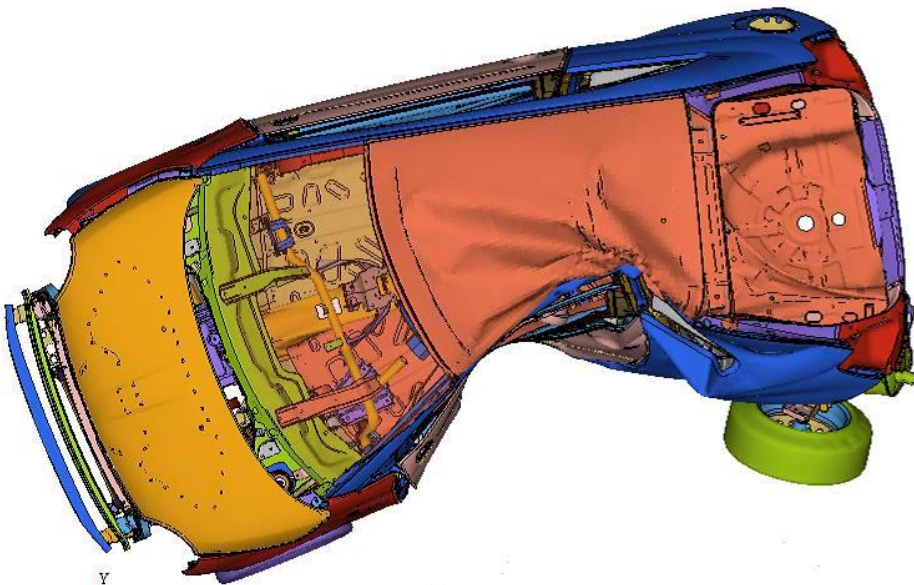
# Solution to problem n. 4: poles and trees



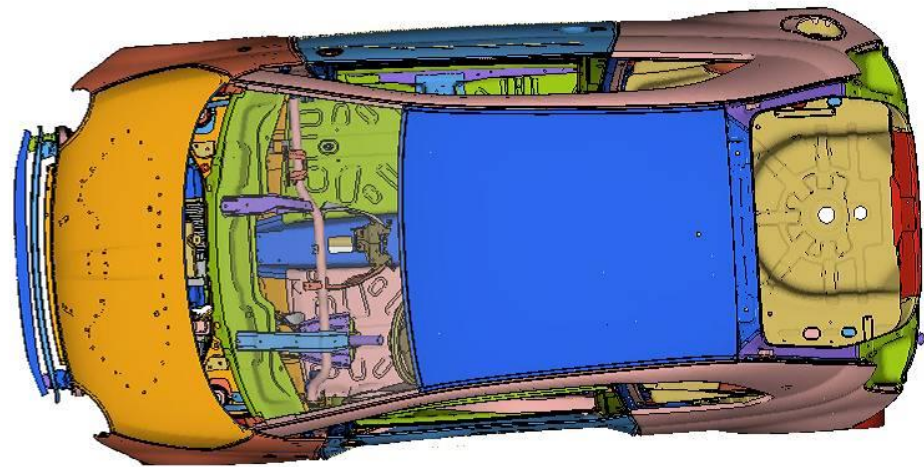
**Simulation of lateral sliding impact at 70 kph 30° angle**



# Solution to problem n. 4: poles and trees

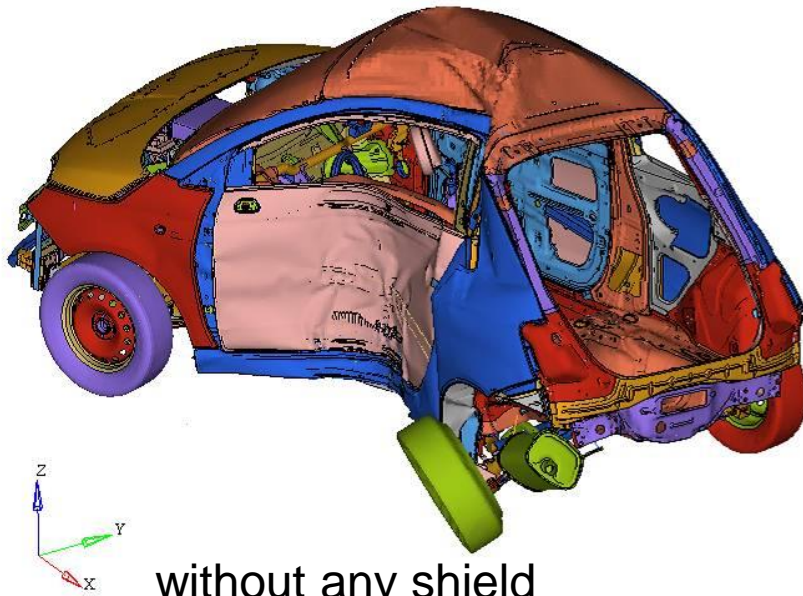


without any shield

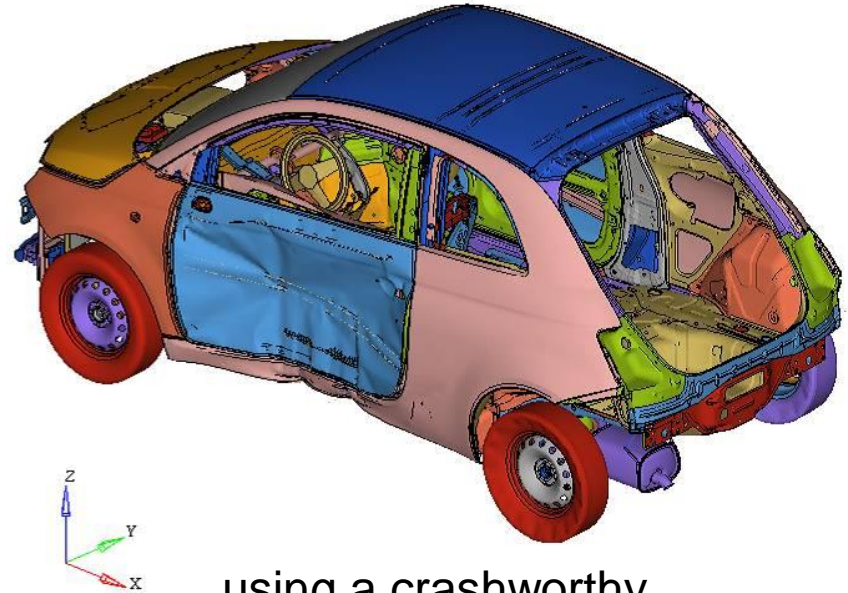


using a crashworthy  
terminal as a shield

# Solution to problem n. 4: poles and trees

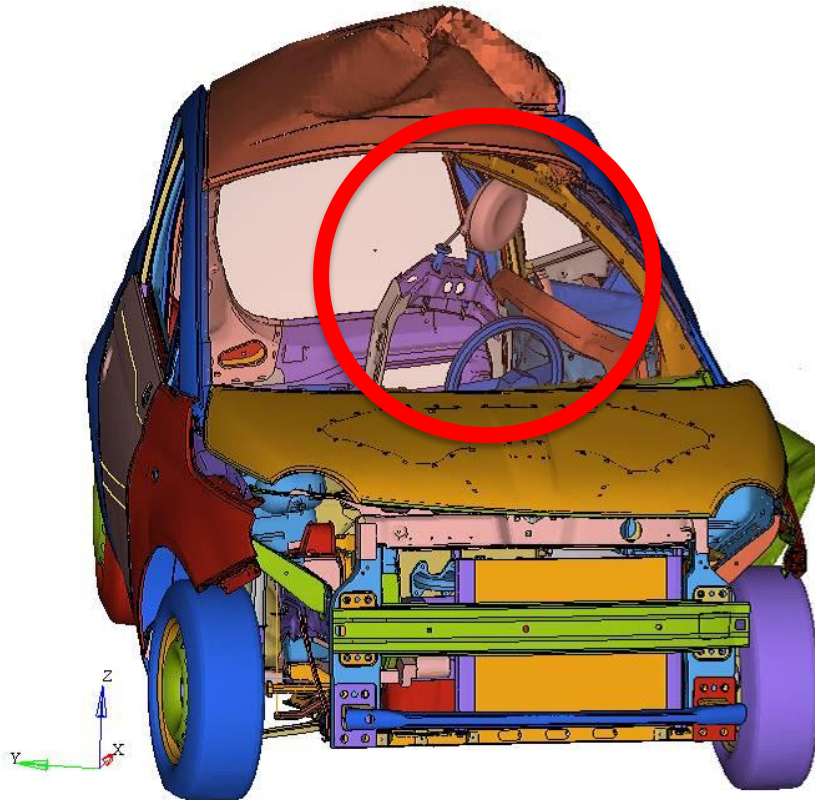


without any shield

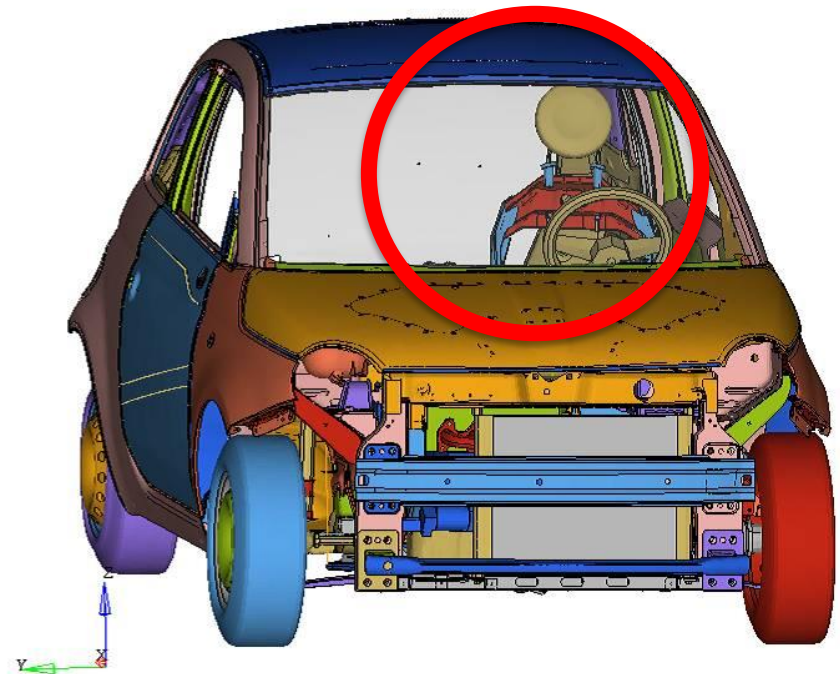


using a crashworthy  
terminal as a shield

# Solution to problem n. 4: poles and trees



without any shield



using a crashworthy  
terminal as a shield



# DO SELECT A **CERTIFIED** PRODUCT TO SHIELD THE HAZARDS



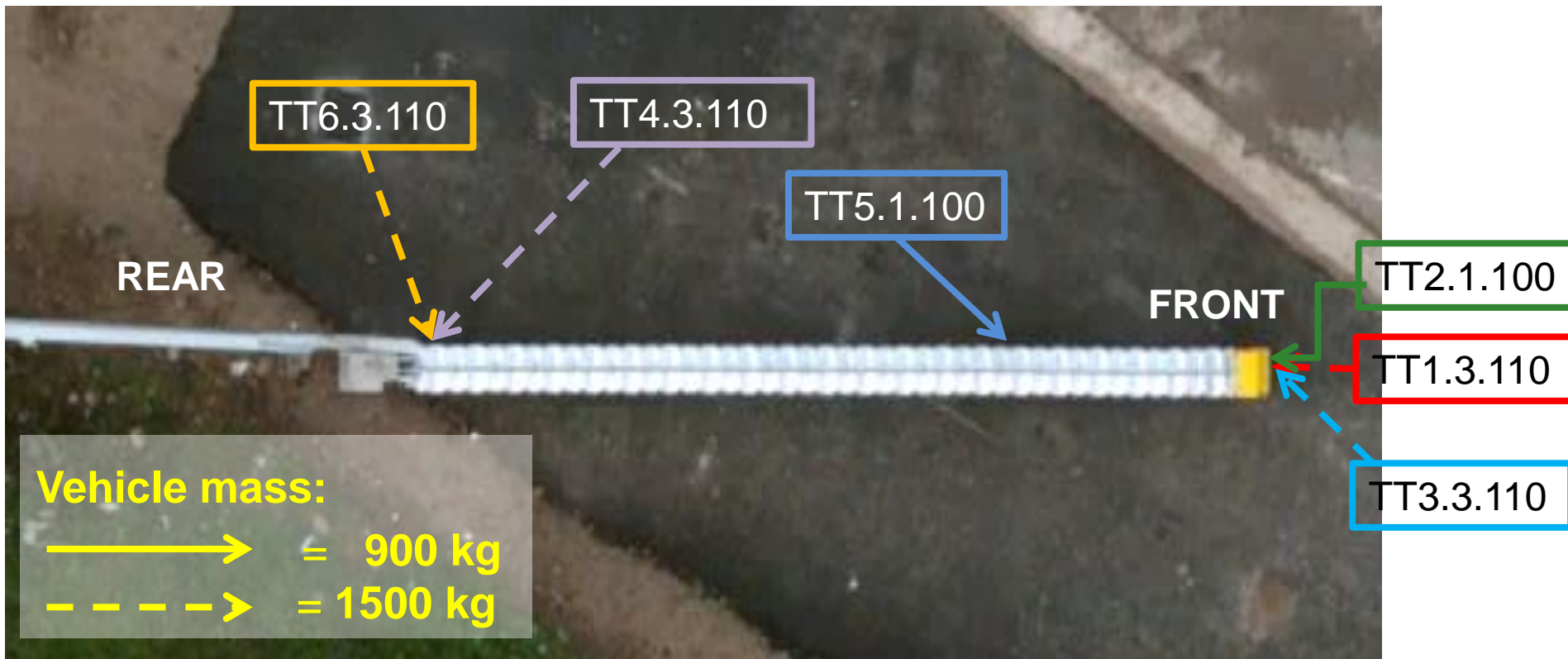
## EN 1317 part 4 and 7: Crash Test table for a T4 (110kmh) End Terminal

Test code	Approach	Vehicle mass in kg	Speed km/h	Normative
TT1.3.110	frontal, 0°, head centred	1 500	110	ENV 1317- 4 and prEN 1317- 7
TT2.1.100	frontal, 0°, offset by ¼ of the vehicle width to the traffic side	900	100	ENV 1317- 4 and prEN 1317- 7
TT4.3.110	side, 15° 2/3 Ls	1 500	110	ENV 1317- 4 and prEN 1317- 7
TT5.1.100	side, 165° 1/2 Ls	900	100	ENV 1317- 4 and prEN 1317- 7
TT6.3.110	side, 165° at the critical impact point	1 500	110	<b>only prEN 1317-7</b>
TT3.3.110	head (centre) at 15°	1 500	110	<b>only prEN 1317-7</b>

All the tests are mandatory



# EN 1317 part 4 and 7: Crash Test table for a T4 (110kmh) End Terminal





# DO SELECT A **CERTIFIED** PRODUCT TO SHIELD THE HAZARDS



2.1.100





# DO SELECT A **CERTIFIED** PRODUCT TO SHIELD THE HAZARDS



1.3.110





# DO SELECT A **CERTIFIED** PRODUCT TO SHIELD THE HAZARDS



6.3.110





# DO SELECT A **CERTIFIED** PRODUCT TO SHIELD THE HAZARDS



3.3.110

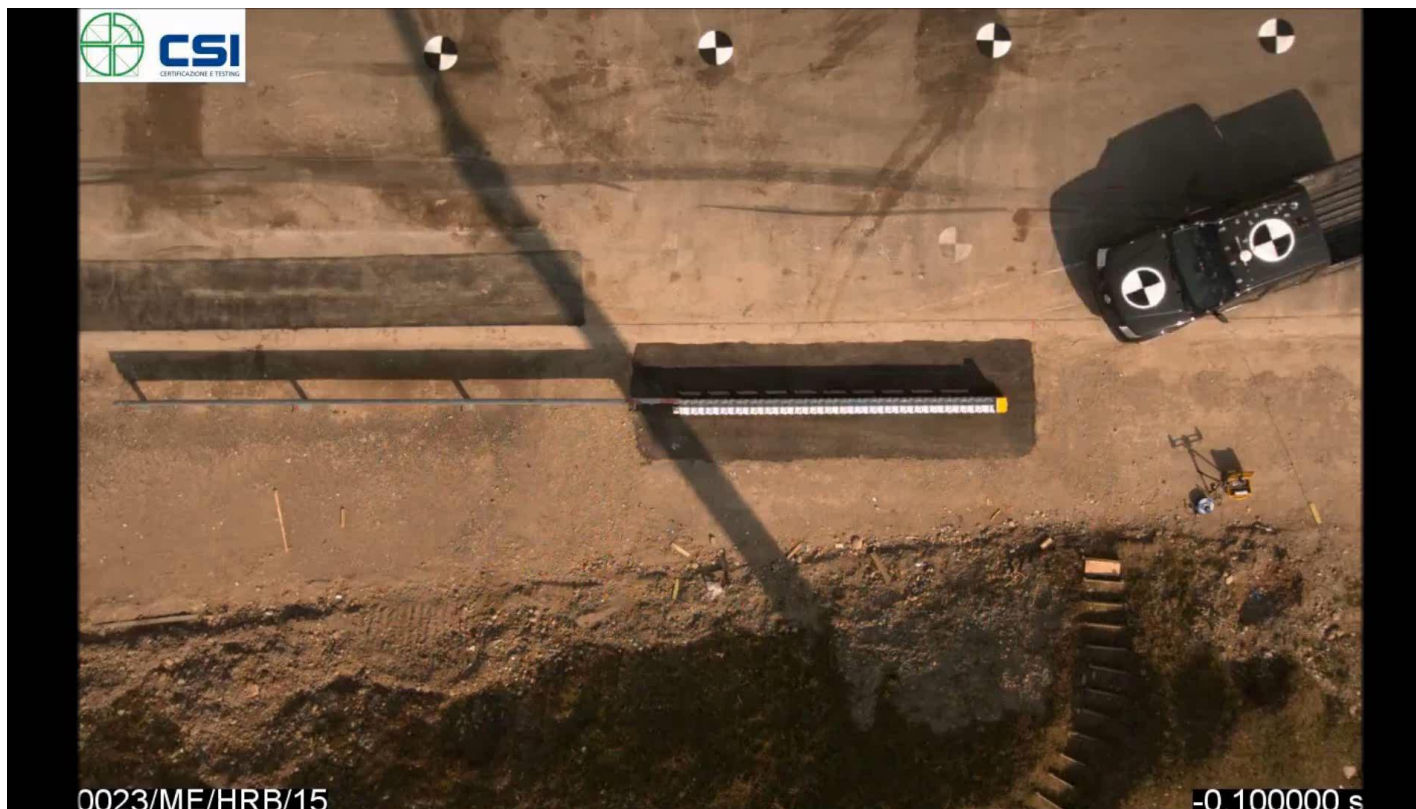




# DO SELECT A **CERTIFIED** PRODUCT TO SHIELD THE HAZARDS



TL 3.37





# DO SELECT A **CERTIFIED** PRODUCT TO SHIELD THE HAZARDS

