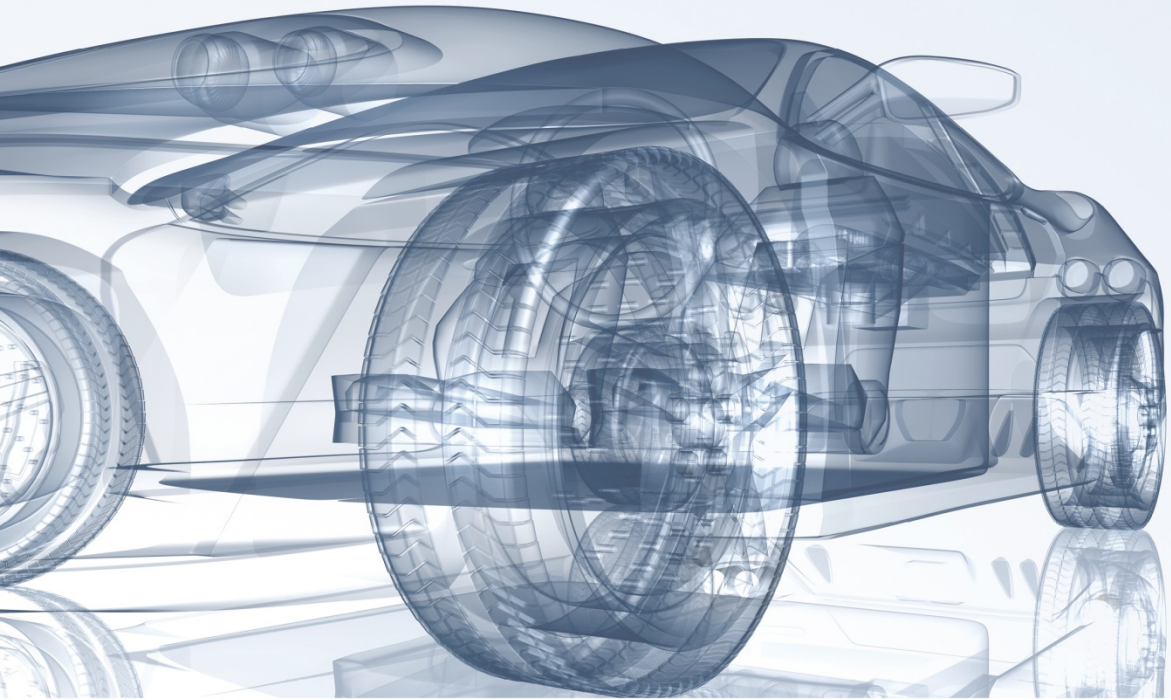
evs 30



The 30th International
Electric Vehicle
Symposium & Exhibition

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Messe Stuttgart, Germany

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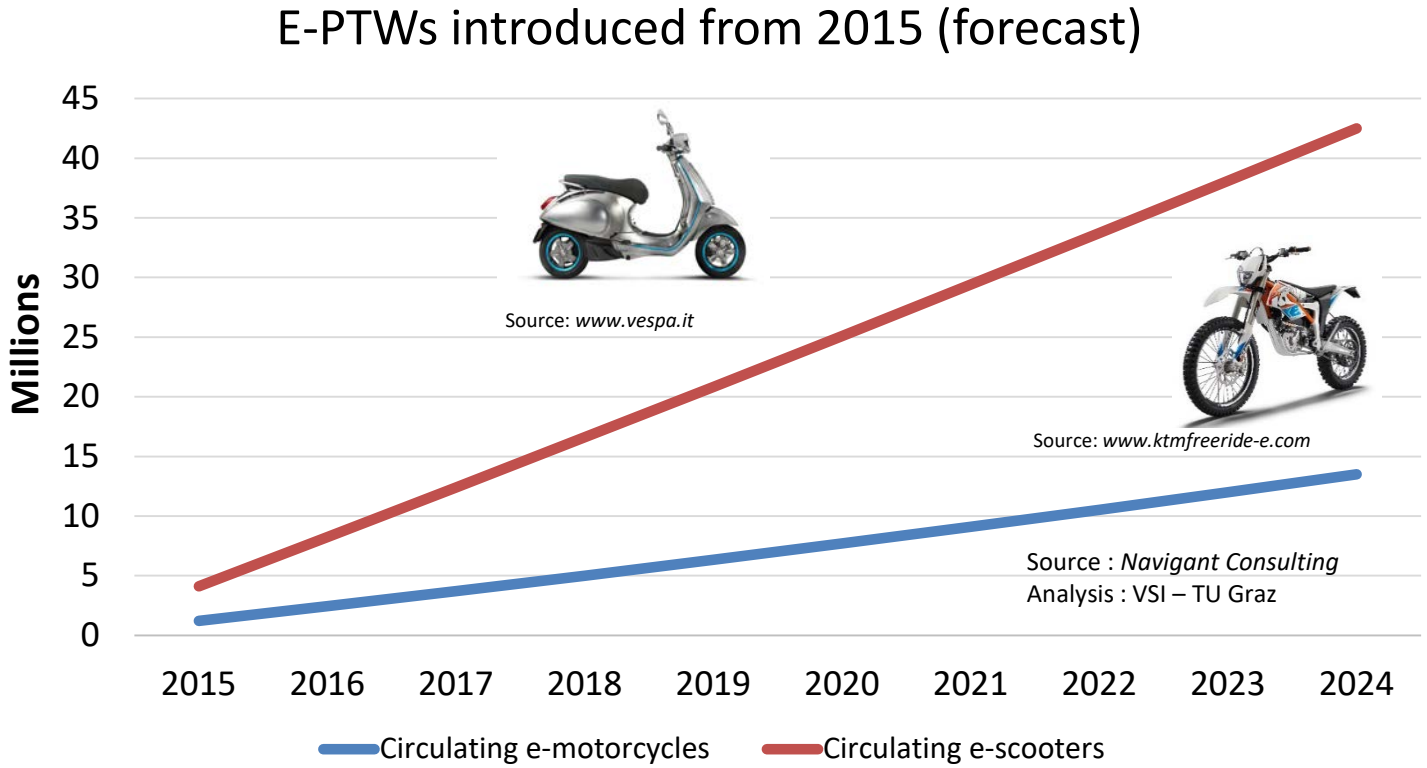
W I S S E N ▪ T E C H N I K ▪ L E I D E N S C H A F T

TU Graz

Battery Safety Evaluation of Electric Driven Motorcycles from the Perspective of Accident Research

Motivation

In the next years the number of E-PTWs on the road is forecasted to increase



Motivation

Reduced protective structure in case of crash

Source: *www.ktmfreeride-e.com*

High energy battery packs

Test procedures just at traction battery level

Source: *www.wort.lu*

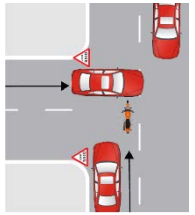
How can the crash safety of a traction battery of an e-motorcycle be assessed?

Method

Analysis of the actual accident statistic

Definition of relevant scenarios

Reproduction of the scenarios
in entire vehicle crash tests



Source: www.motorbikeclaims.org.uk

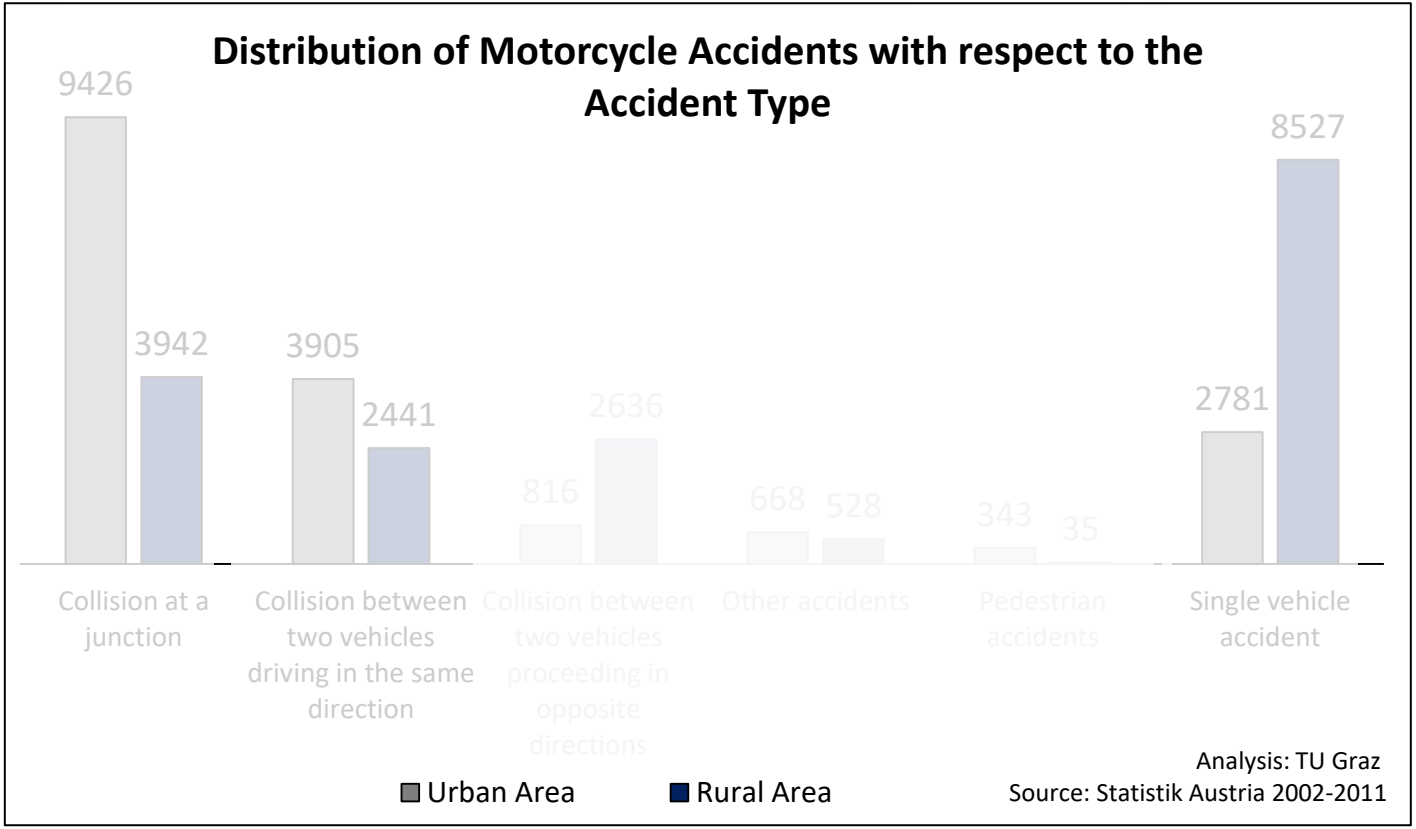
Test vehicle: KTM FREERIDE E

Source: *www.ktmfreeride-e.com*

Analysis of accident scenarios

Three different frequent crash configurations are detected:

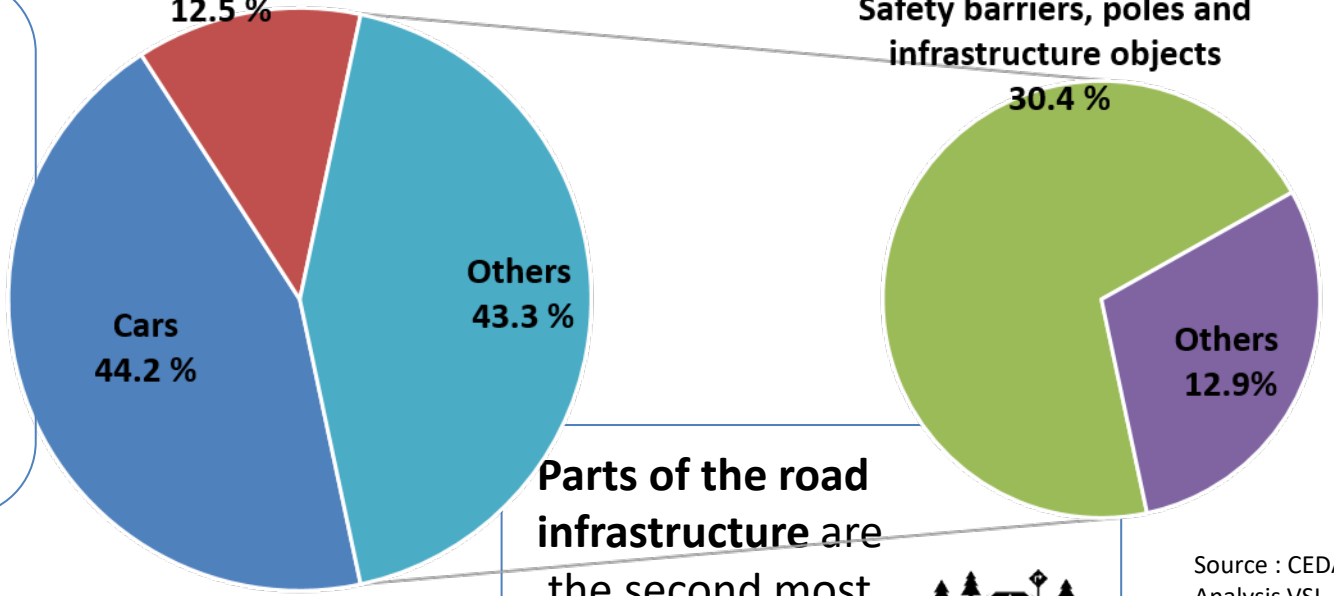
- Collision at a junction
- Single vehicle accident
- Collision between two vehicles proceeding in the same direction



Analysis of accident scenarios

Passenger cars are the most frequent collision partners for motorcycles

Collision partners

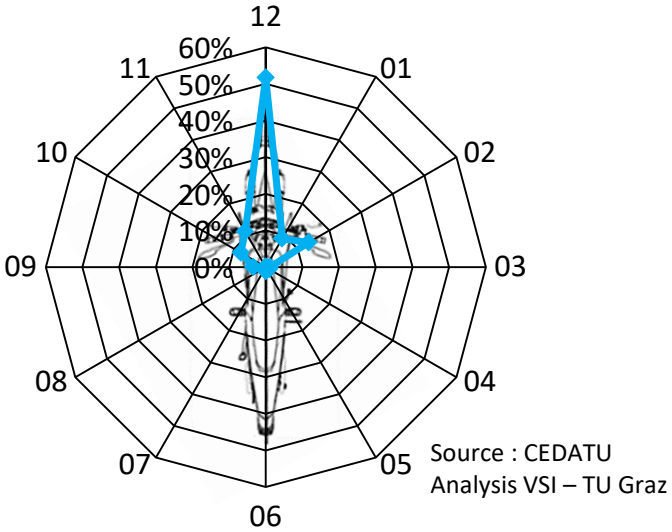


Parts of the road infrastructure are the second most frequent collision partners for motorcycles

Source : CEDATU
Analysis VSI – TU Graz

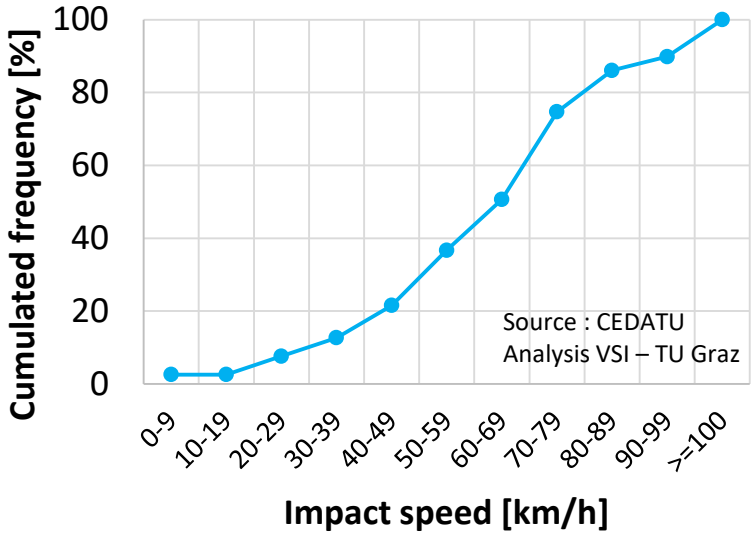
Analysis of accident scenarios

Impact direction



Most of the accidents happen with a direction of force **between 11 and 01 o'clock (-30° and 30°)**

Impact speed

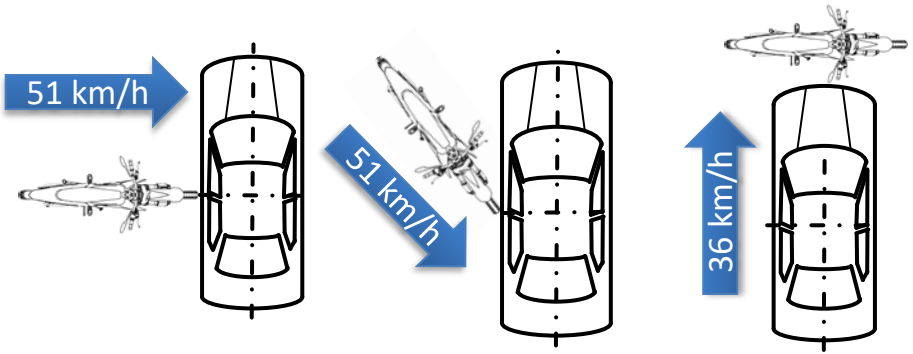


The median value of the impact speed lays in the range **60-69 km/h**

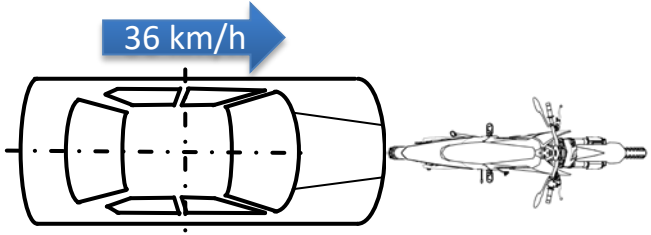
Relevant accident scenarios

Five relevant accident scenarios were defined for the entire vehicle crash tests

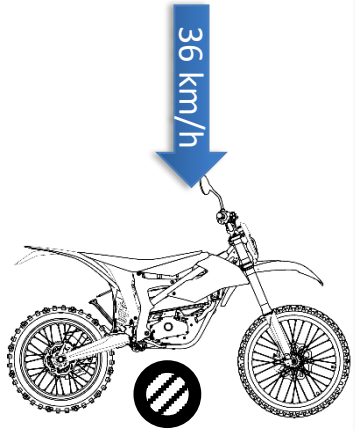
Collision at an intersection



Collision between two vehicles proceeding in the same direction



Single vehicle accident

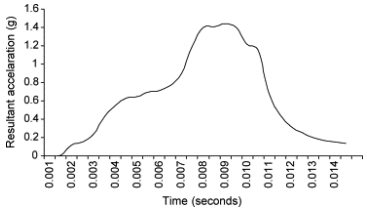


Possible dangers

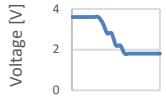
Relevant hazards for the rider and people nearby can arise in case of a road crash

Cell or traction battery deformation

High accelerations



Source: *www.sciencedirect.com*



Voltage drops

Loss of isolation

External short-circuits

Internal short-circuits

Malfunctioning of the vehicle

Electric shock

Source: *www.freepik.com*

Fire

Source: *www.insideev.com*

Explosion

Entire vehicle crash test

In-crash measurements

Cell voltage

Cell temperature

Battery pack output voltage

Battery pack isolation

Acceleration at the traction battery

Post-crash measurements

3D scan of the battery pack

Observation of the inner cells

Entire vehicle crash test

Evaluation based on test data using the EUCAR Hazard table

Hazard Level		Classification Criteria, Effect
0	No effect	No effect, no loss of functionality
1	Passive Protection activated	No defect, no leakage, no venting, no fire or flame, no rupture, no explosion, no exothermic reaction or thermal runaway, cell reversibly damaged, repair of protection device needed
2	Defect Damage	No leakage, no venting, no fire or flame, no rupture, no explosion, no exothermic reaction or thermal runaway, cell irreversibly damaged, repair needed
3	Leakage > 50%	No venting, no fire or flame, no rupture, no explosion, weight loss ≤ 50 % of the electrolyte weight electrolyte = solvent + salt
4	Venting > 50%	No fire or flame, no rupture, no explosion, weight loss ≥ 50 % of the electrolyte weight
5	Fire or Flame	No rupture, no explosion, i.e. no flying parts
6	Rupture	No explosion, but flying parts, ejection of parts of the active mass
7	Explosion	Explosion, i.e. disintegration of the cell

Source: *Sicherheitsaspekte beim Testen von Lithium-Ionen Batterien, R. Groiß and A. Jossen*

Introduction of extra safety criteria in order to consider also:

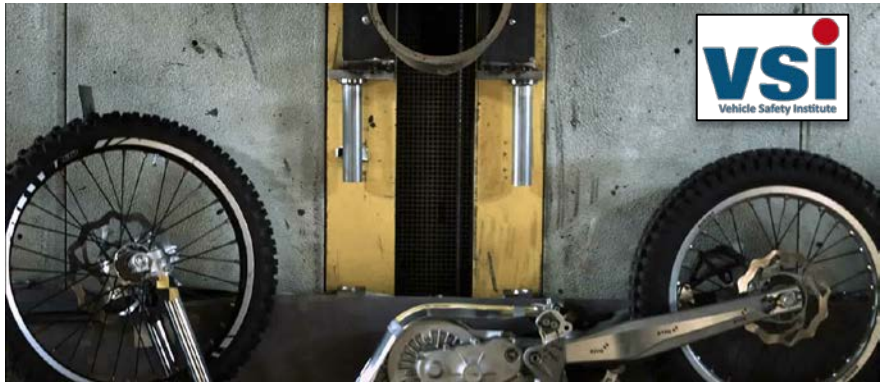
- **high accelerations**
- **reversible voltage drops**

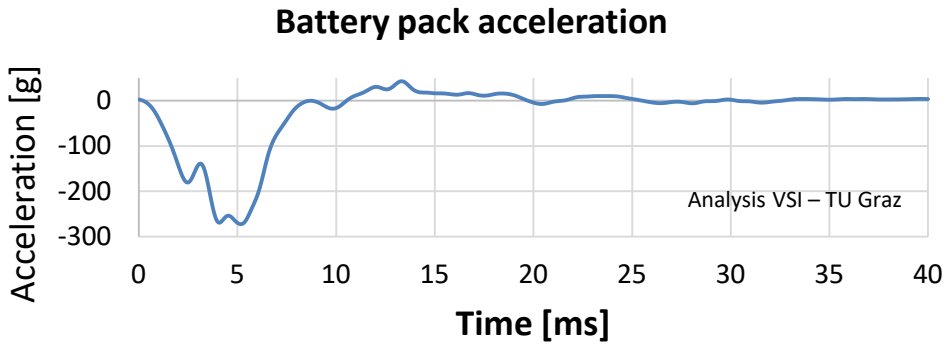
Entire vehicle crash test

Test results:

- No voltage drop
- No loss of isolation
- Maximal battery pack acceleration: 89 g
- No battery pack deformation
- No cell deformation

Entire vehicle crash test





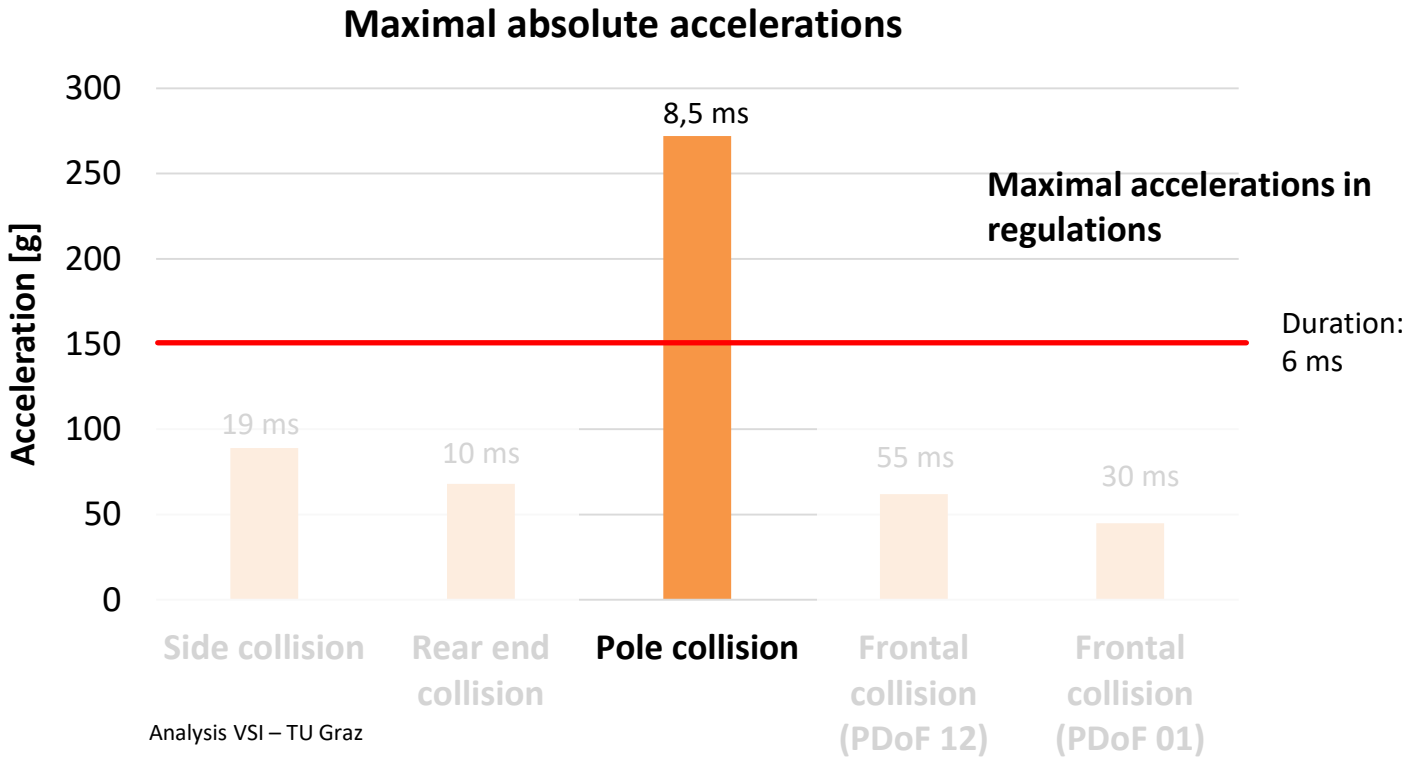
Test results:

- No voltage drop
- No loss of isolation
- Maximal battery pack acceleration: 272 g
- No battery pack deformation
- No cell deformation

Entire vehicle crash test

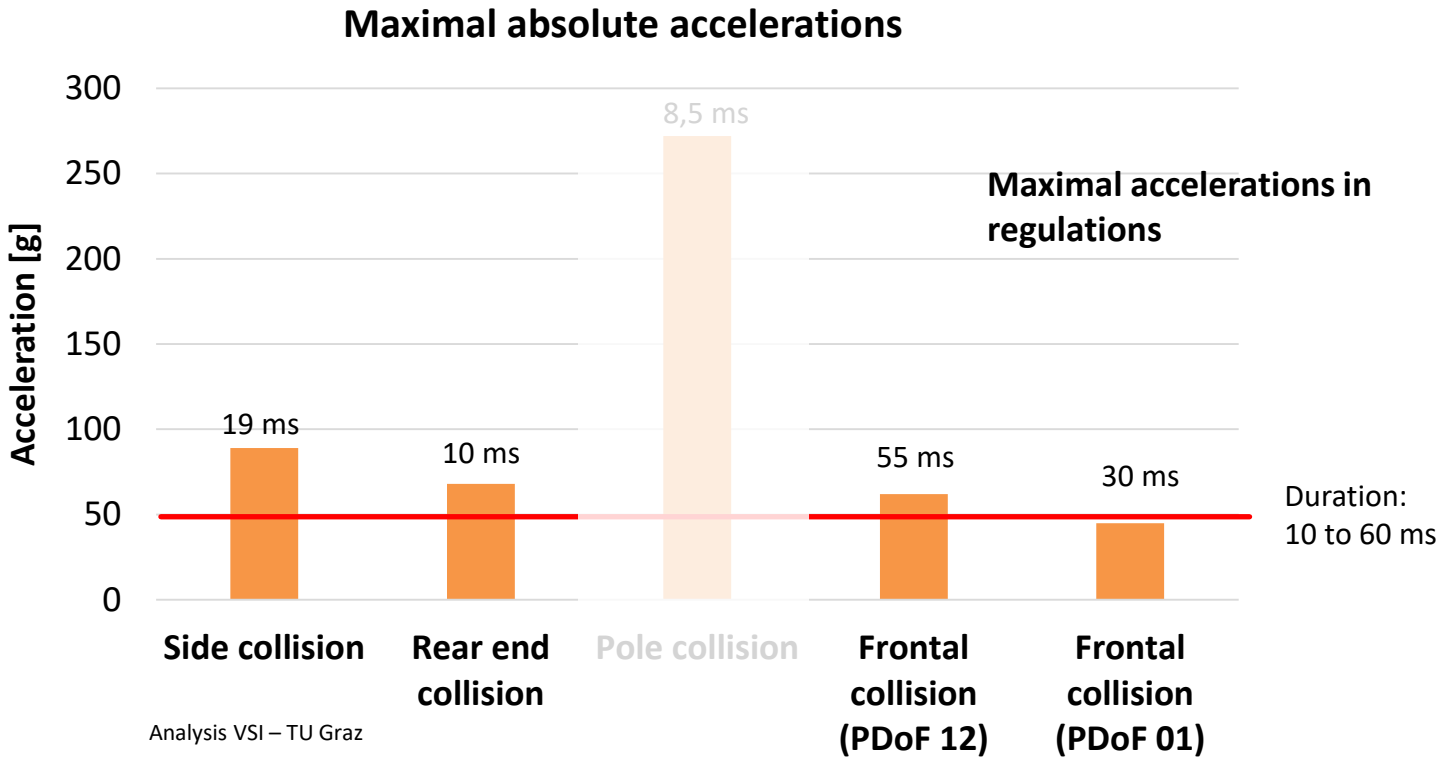
	Voltage drops	Deformation of the traction battery	Acceleration [g]
Frontal collision 12 o´clock 	No	No	62
Frontal collision 01 o´clock 	No	No	45
Side collision 	No	No	89
Rear collision 	No	No	68
Pole collision 	No	No	272

Entire vehicle crash test



Entire vehicle crash test

The maximal acceleration that the traction battery can achieve is currently underestimated, both for long or reduced durations



Conclusion and outlook

Relevant hazards can arise from the **damage of the traction battery** of an electric vehicle.

Source: *www.insideev.com*

Entire vehicle crash tests of relevant crash configurations were developed in order to **evaluate the safety of the traction battery**.

The results proved the **safety of the test vehicle** but highlighted an **underestimation of the acceleration pulses** in the actual regulations.

Thank you for the attention

Acknowledgment