Aspects on the Secondary Safety of Motorcycles

Part 1: Motorcycle impacts on roadside barriers - new solutions based on real-world accident studies and crash tests

Part 2: Motorcycle Airbags - an option?

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FIM EUROPE

UEM European Motorcycle Union / Union Européenne de Motocyclisme

Mobility and Safety Conference, Lietuva, Vilnius, 30-06-2013

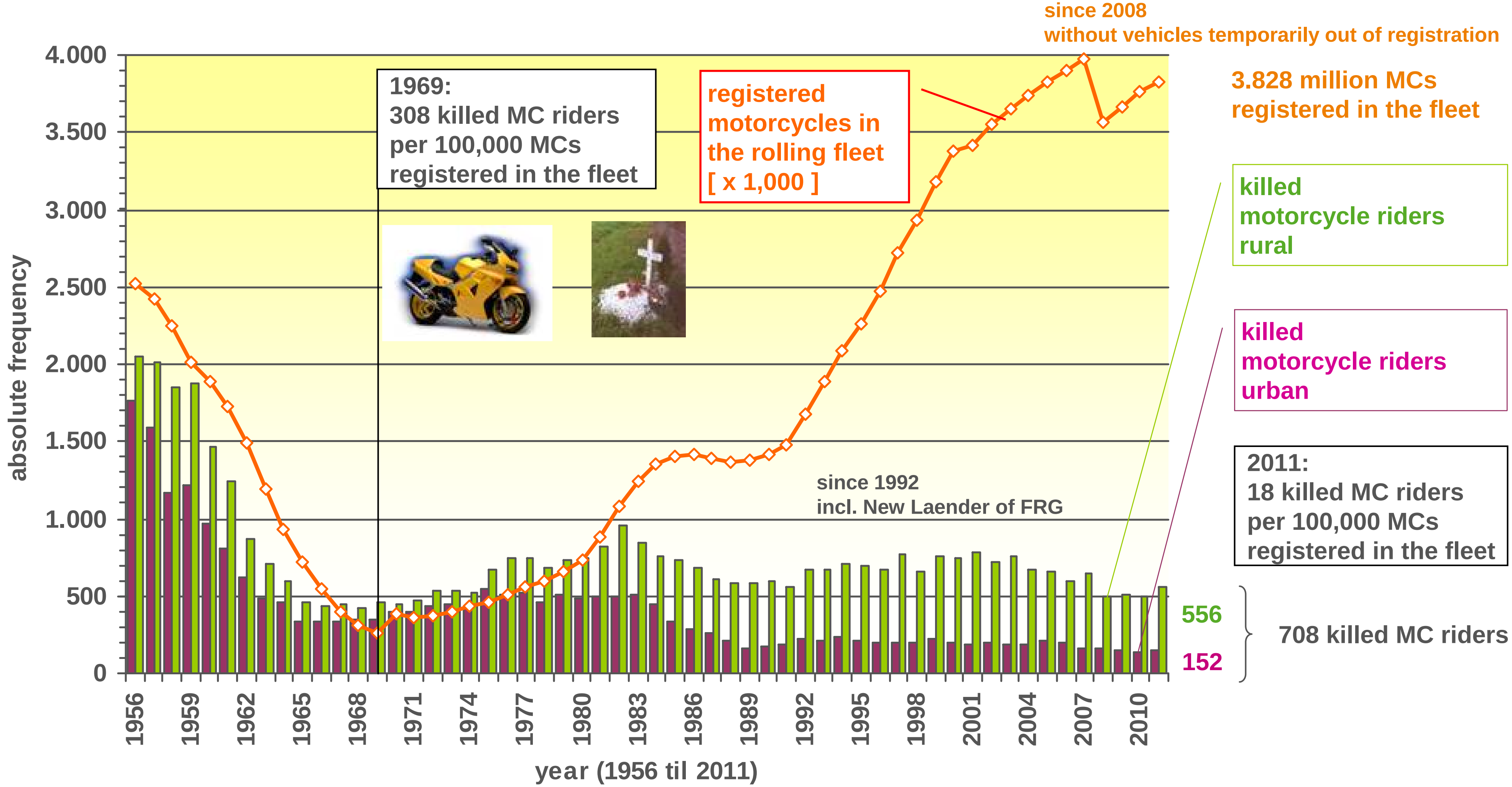
Aspects on the Secondary Safety of Motorcycles

Structure:

- Introduction
- Motorcycle Impacts on Roadside Barriers
  - Statistics and Real-World Crashes
  - Crash Tests
  - First Prototype of a “Motorcycle Friendly” Barrier
  - Further Developments and Status Quo
- Motorcycle Airbags – an Option?
  - Historical Background and Status Quo
  - Prototype of an Airbag for a Mid-Sized Touring Motorcycle
  - Crash Tests
  - Potential
- Summary

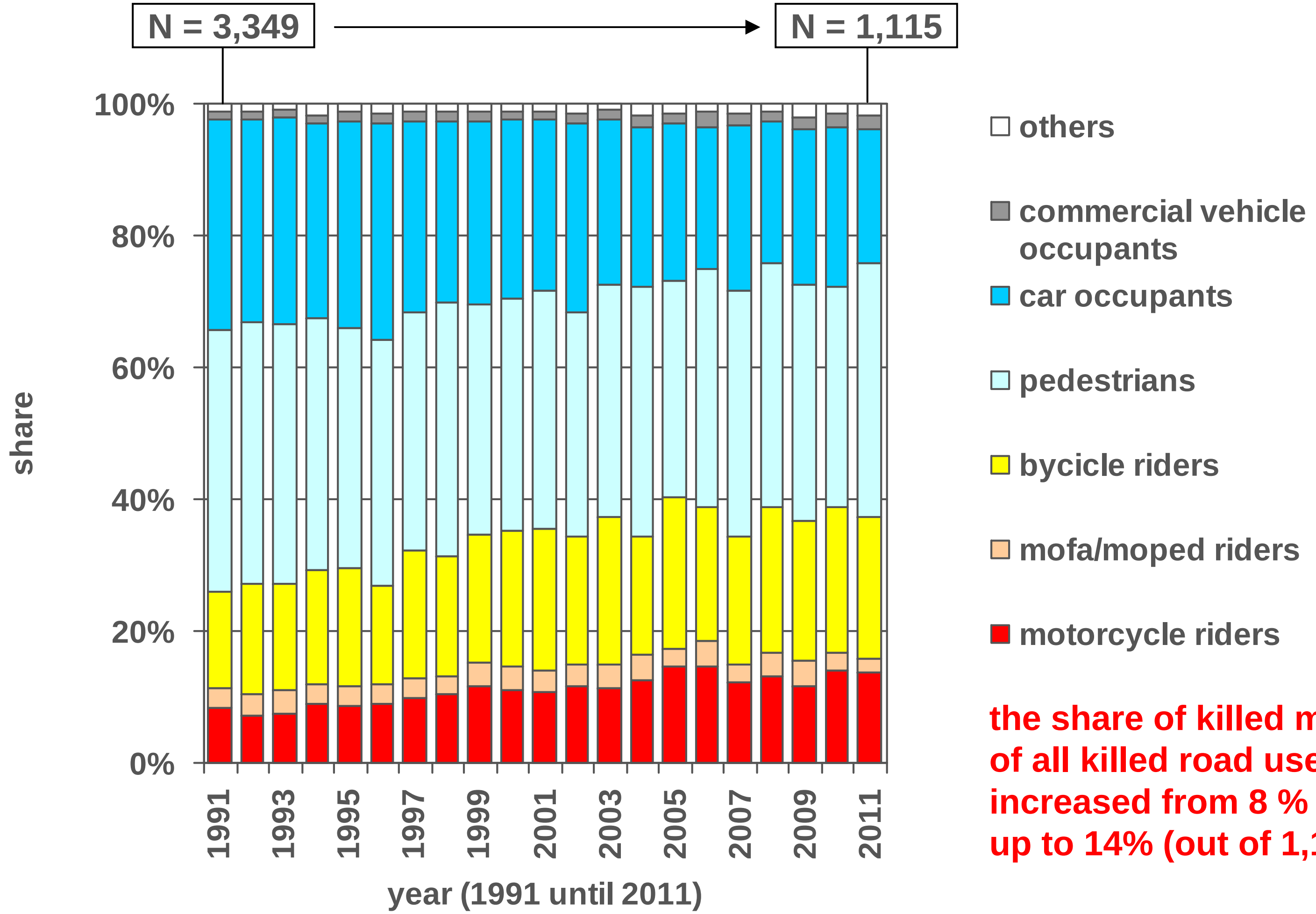
Introduction

Historic Evolutions of MC Fleet and Killed MC Riders in Germany



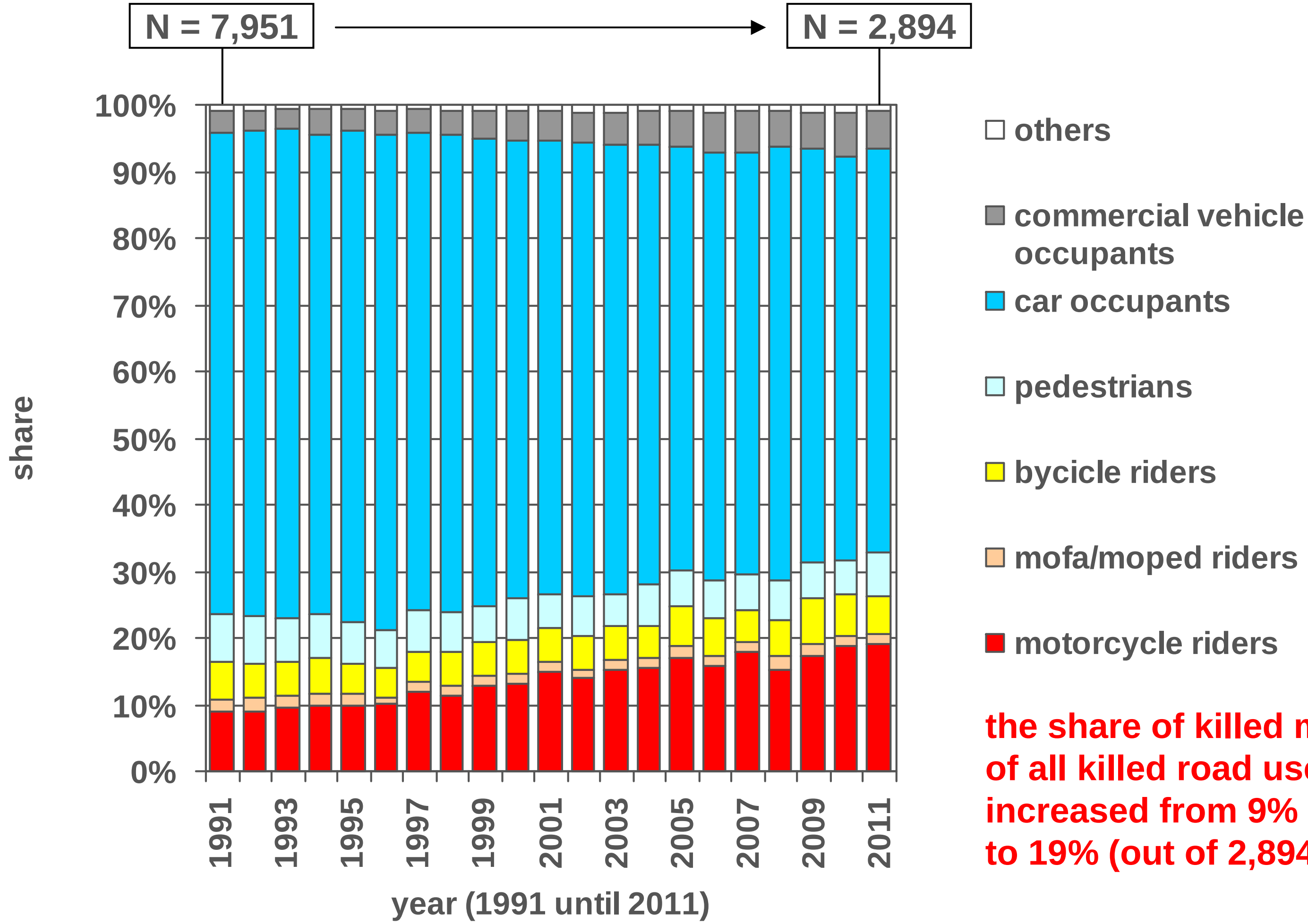
Introduction

Shares of killed Road Users Urban in Germany



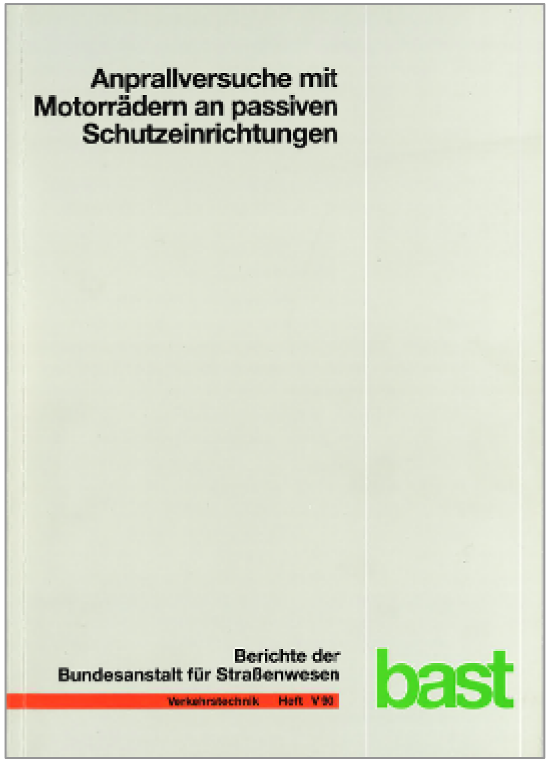
the share of killed motorcycle riders of all killed road users urban increased from 8 % (out of 3,349 fatalities) in 1991 up to 14% (out of 1,115 fatalities in 2011

Introduction
Shares of killed Road Users Rural in Germany



the share of killed motorcycle riders of all killed road users rural increased from 9% (out of 7,951 fatalities) in 1991 to 19% (out of 2,894 fatalities) in 2011

Motorcycle Impacts on Roadside Barriers
Reports



Heike Bürkle, Alexander Berg
September 2001, BASt V90

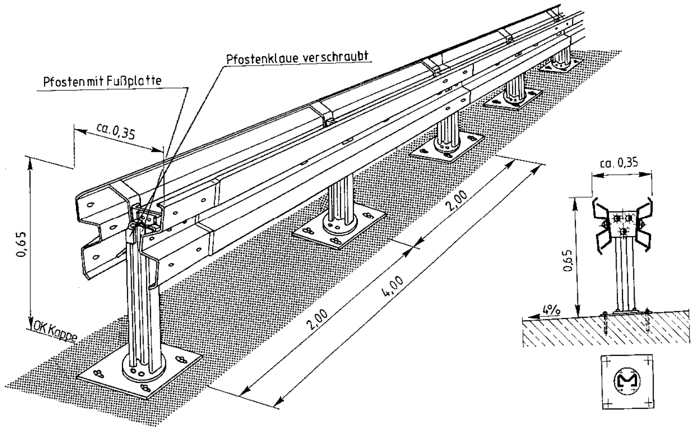
Marcus Gärtner, Peter Rücker
Alexander Berg
Juni 2006, BASt 940

Ralf Klöckner, Maike Zedler
April 2010, BASt V 193

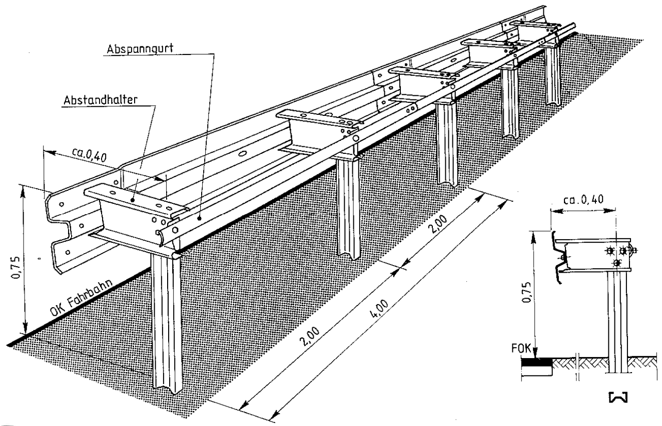
Motorcycle Impacts on Roadside Barriers
Barrier Examples

- **Steel-made roadside protection systems (examples)**

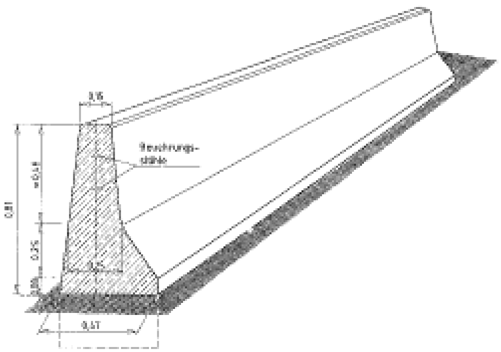
„Einfache Schutzplanke ESP“



„Einfache Distanzschutzplanke EDSP“



- **Concrete Barrier**

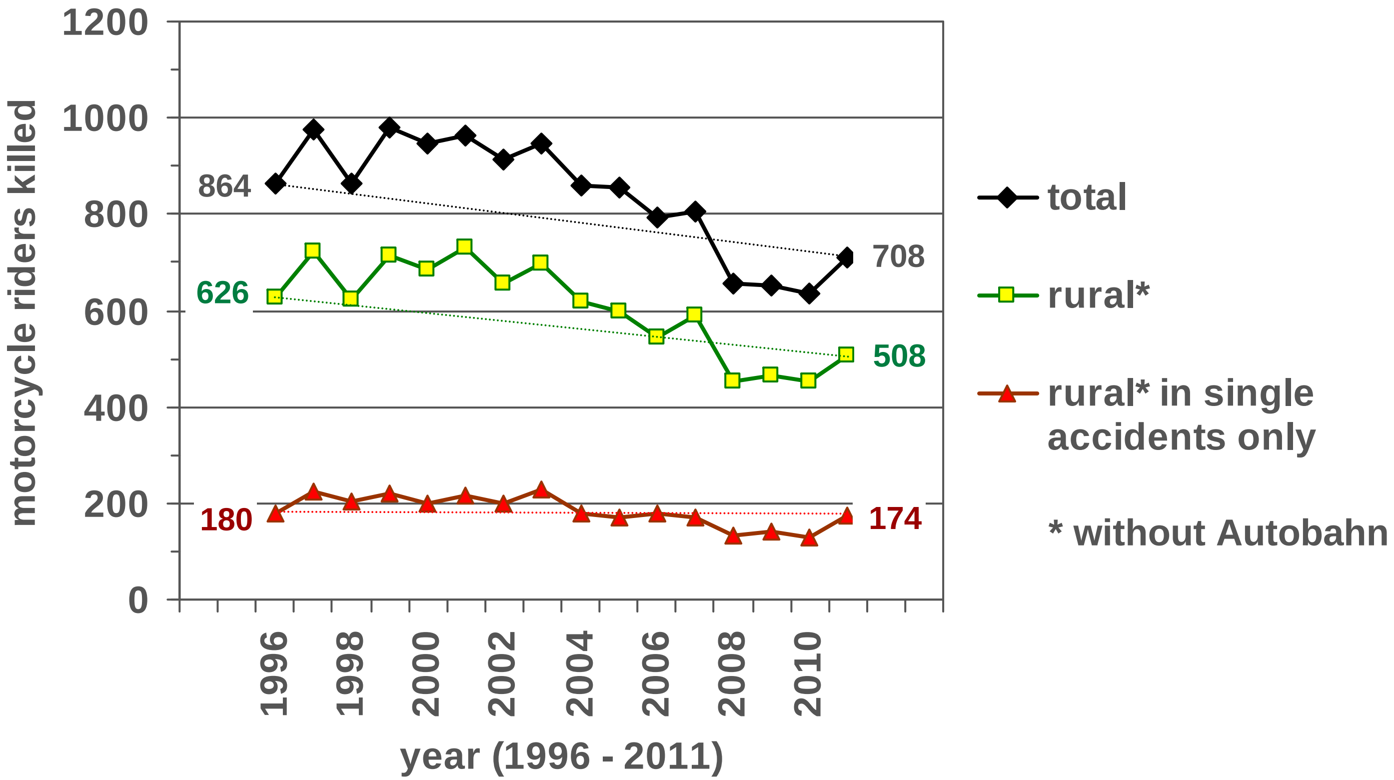


“New Jersey Profile“

Motorcycle Impacts on Roadside Barriers

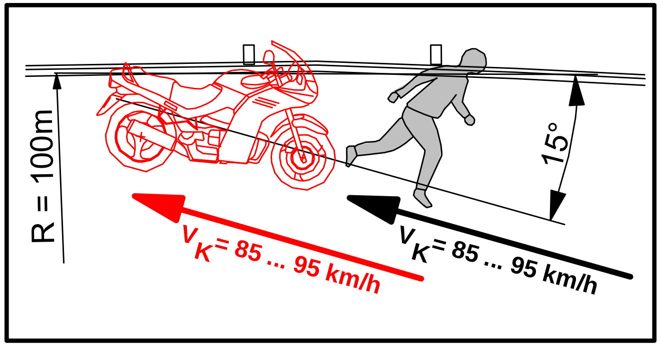
Figure of Killed Motorcycle Riders due to Barrier Impacts

- **German accident statistics**



Estimation Federal Highway Research Institute (BASt, 2002): "Approx. 50 killed motorcycle riders per year involved in single vehicle accidents with crashes into roadside protection systems" seems to be still valid today

Motorcycle Impacts on Roadside Barriers
Real-World Crash Example 1



Accident

- MC leaves the road in a left-hand curve
- single vehicle accident
- sliding into steel barrier
- einfache Schutzplanke (ESP)
- sigma post (no jacket)
- v_{MC} = 85 - 95 km/h

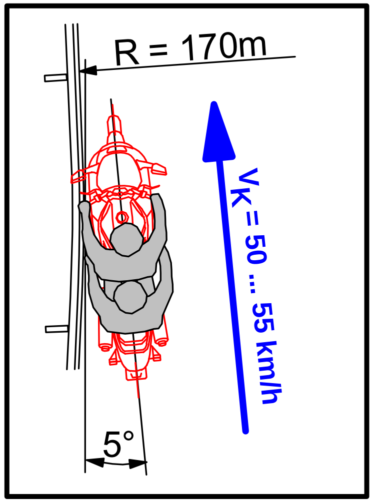
MC rider

- v = 85 - 95 km/h
- neck impact
- AIS 5
- neck fracture below C4
- internal injuries

Motorcycle Impacts on Roadside Barriers
Real-World Crash Example 2

Accident

- MC leaves the road due to a tyre defect
- single vehicle accident
- MC impacts upright
- einfache Schutzplanke (ESP)
- sigma post (no jacket)
- v_{MC} = 50 - 55 km/h

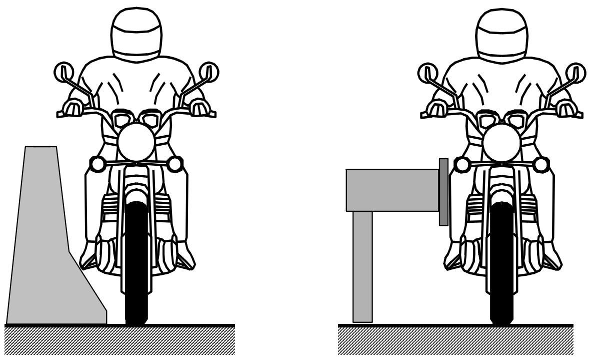


MC rider & passenger

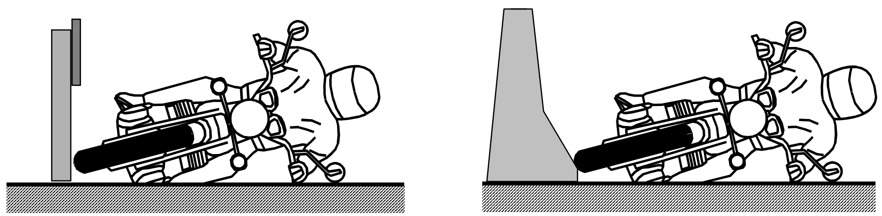
- v = 50 - 55 km/h
- impact with left leg
- rider: AIS 3 leg and left arm fractured
- passenger: AIS 3 leg and left arm fractured

Motorcycle Impacts on Roadside Barriers
Crash Tests

velocity ≈ 60 km/h



MC impacts upright



MC impacts sliding

Kawasaki ER-5 Twister `98

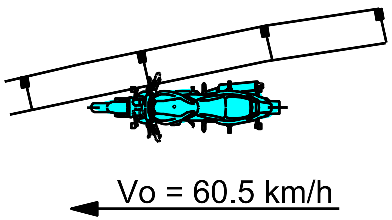
Hybrid III, 50th percentile male

Motorcycle Impacts on Roadside Barriers

Crash Tests Using Conventional Barriers

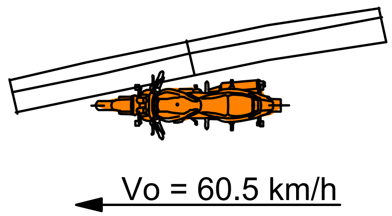
MC impacts upright into „Einfache Distanzschutzplanke (EDSP)"

Impact angle 12°, velocity = 60.5 km/h



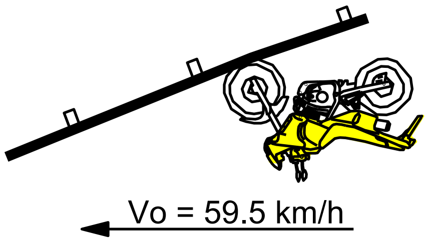
MC impacts upright into concrete barrier (H = 0.81 m)

Impact angle 12°, velocity 60.5 km/h



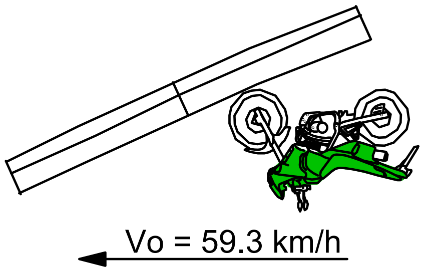
MC impacts sliding into „Einfache Schutzplanke (ESP)"

Impact angle 25°, velocity 59.5 km/h



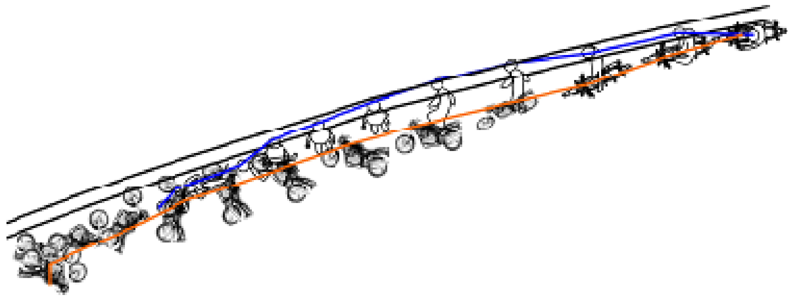
MC impacts sliding into concrete barrier (H = 0.81 m)

Impact angle 25°, velocity 59.3 km/h



Motorcycle Impacts on Roadside Barriers
Crash Tests Using Conventional Barriers

MC impacts upright into
„Einfache Distanzschutzplanke EDSP“



Movements shown until t = 2.30 s after first impact

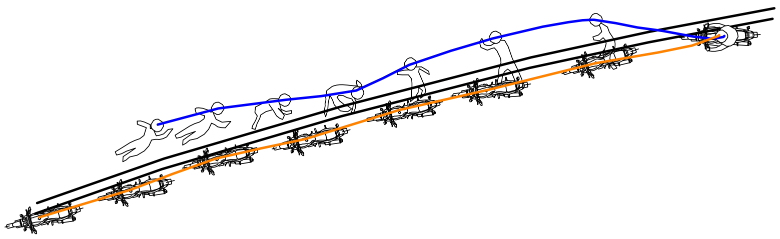
Distance 1st impact to final rest position

MC:	**28.0 m**
Dummy:	**20.5 m**

Motorcycle Impacts on Roadside Barriers

Crash Tests Using Conventional Barriers

MC impacts upright into concrete barrier



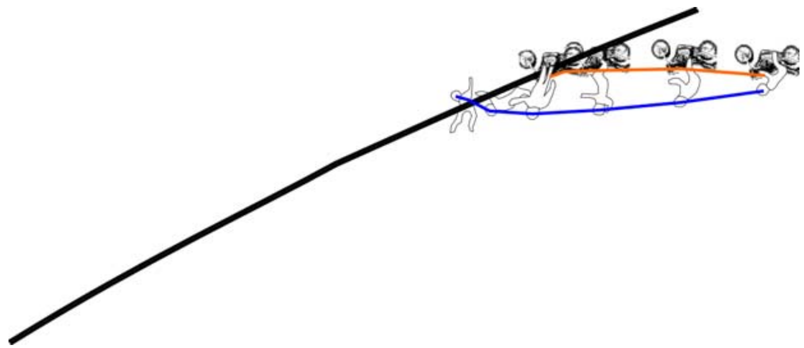
Movements shown until t = 1.75 s afer first impact

Distance 1st impact to final rest position

MC:	**38.0 m**
Dummy:	**25.5 m**

Motorcycle Impacts on Roadside Barriers
Crash Tests Using Conventional Barriers

MC impacts sliding
into „Einfache Distanzschutzplanke ESP“



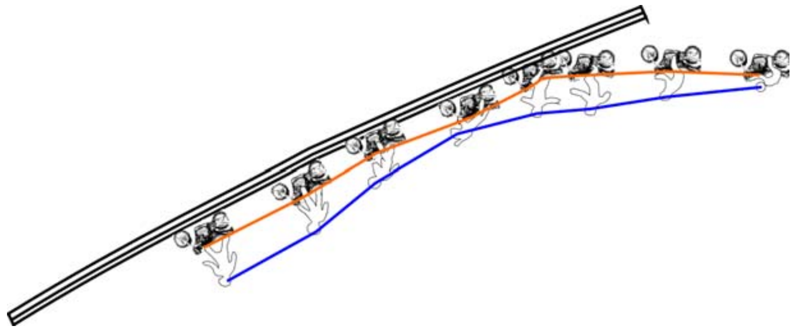
Distance 1st impact to final rest position

MC: 1.9 m

Dummy: 4.8 m

Motorcycle Impacts on Roadside Barriers
Crash Tests Using Conventional Barriers

MC impacts sliding
into a concrete barrier

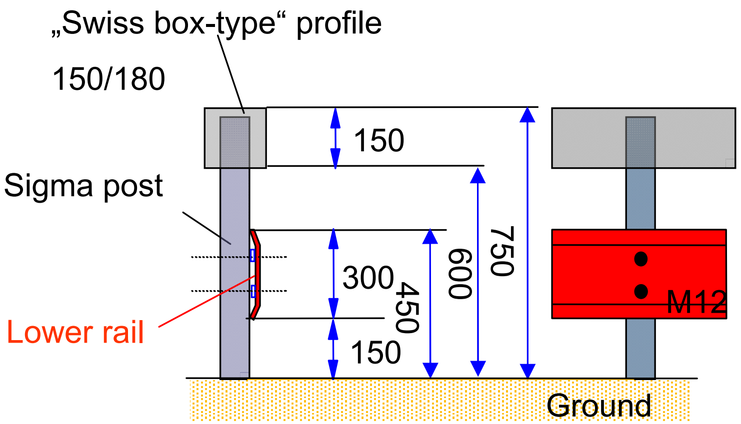


Distance 1st impact to final rest position

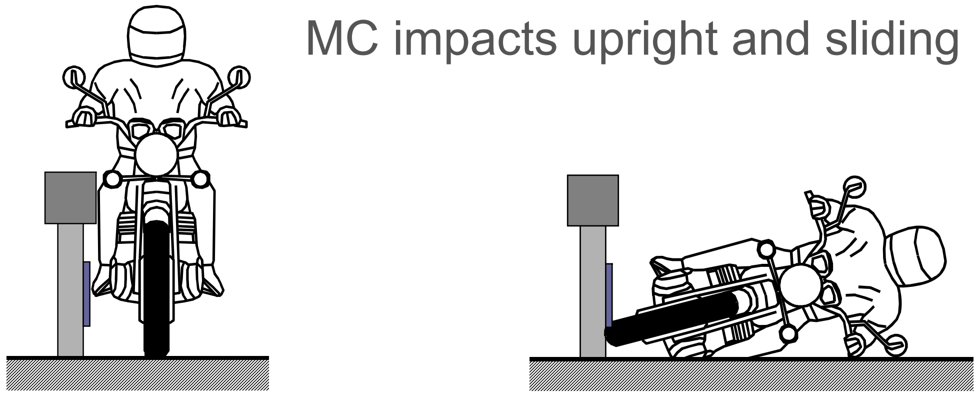
MC:	**13.6 m**
Dummy:	**13.6 m**

Motorcycle Impacts on Roadside Barriers

Crash Tests Using Improved First Prototype Barrier

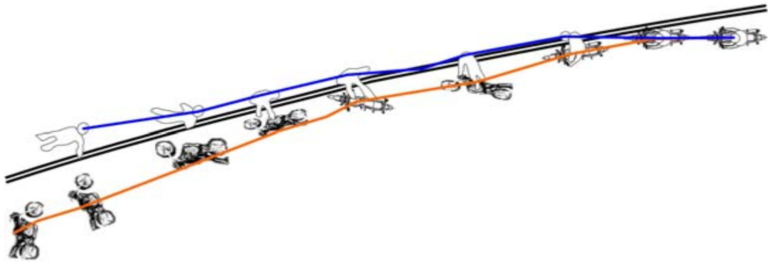


MC impacts upright and sliding



Motorcycle Impacts on Roadside Barriers
Crash Tests Using Improved First Prototype Barrier

MC impacts upright



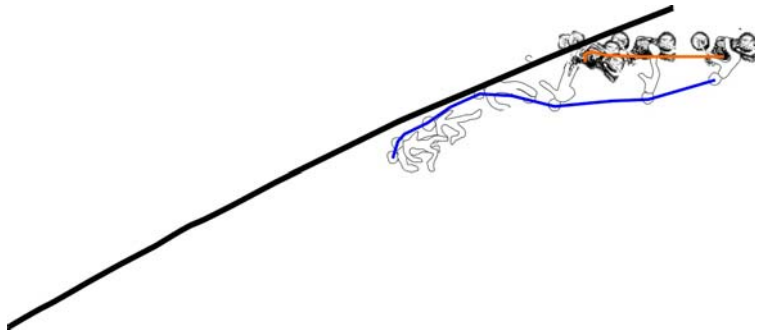
Movements shown until t = 2,30 s after first impact

Distance 1st impact to final rest position

MC:	**23.0 m**
Dummy:	**21.7 m**

Motorcycle Impacts on Roadside Barriers
Crash Tests Using Improved First Prototype Barrier

MC impacts sliding



Distance 1st impact to final rest position

MC: 1.0 m

Dummy: 7.1 m

Motorcycle Impacts on Roadside Barriers

Assessment Results for the Improved First Prototype Barrier

MC impacts upright

Advantages:

- Sliding along the barrier after first impact (may also be a disadvantage) smaller delta-v of dummy
- No snagging of the dummy
- Separation of dummy and MC
- No rebound of MC
- Absorption of energy resulting from deformation

Disadvantages:

- Possible movement of dummy over protection system into other traffic

MC sliding

Advantages:

- Separation of dummy and MC
- No snagging of the dummy
- Short distances from first impact to final rest position of MC and dummy
- Impact damping effect by lower rail
- absorption of energy resulting from deformation

Disadvantages:

- The fastening of the lower rail failed (should be reinforced)

Motorcycle Impacts on Roadside Barriers

Assessment Results for the Improved First Prototype Barrier

MC upright

Advantages:

- Sliding along the barrier after first impact (may also be a disadvantage) slow delta-v of dummy
- No snagging of the dummy
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MC sliding

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Disadvantages:

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Motorcycle Impacts on Roadside Barriers
Follow-up-improvements on Barriers and Current Status

Problem of Propagation:

The Installation of a new barrier is much more expensive then the retro fitment of an already installed conventional barrier (ESP or EDSP).

Problem of Compatibility:

Improvements on barriers regarding increased safety for motorcycle riders could lead to reduced safety for car occupants (test according to DIN EN 1317)

Therefore:

- **System “Euskirchen” was assembled for retro fitment of an ESP using the lower rail only for sliding impact protection (not the “Swiss box type profile” on the top for upright impact protection) – but crash tests (DIN EN 1317) have shown degradations of the safety for occupants in impacting cars**
- **Improved system “EuskirchenPlus” was developed using retrofitting components for ESP and EDSP to improve the safety of an impacting motorcycle rider in both upright and sliding impact situation**
- **Advanced systems “ESP Motorrad” and “EDSP Motorrad” are now available to replace conventional steel barriers ESP and EDSP on all roads that are relevant with high regard to motorcycle accidents**

Motorcycle Impacts on Roadside Barriers
Follow-up-improvements on Barriers and Current Status

BASt application release for roadside barriers in Germany

Einsatzfreigabeliste

für Fahrzeug-Rückhaltesysteme

in Deutschland

Stand: 26.07.2012

WEBSITE:
http://www.bast.de/nn_39148/DE/Qualitaetsbewertung/Listen/Strassenausstattung/pdf/einsatzfreigabeliste260712,templateId=raw,property=publicationFile.pdf/einsatzfreigabeliste260712.pdf

- **Long term: Supplement for DIN EN 1317 to describe additional demands for impacting motorcycles (and riders)**

Motorcycle Airbags – An Option?
Historical Background

- **First proposals to equip motorcycles with airbags go back to the 70's**

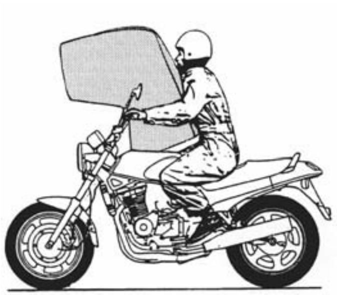
  Bothwell P, Hirsch A E: Airbag Crash Protection for Motorcycle Application
  NHTSA, ASME-Paper, 1973

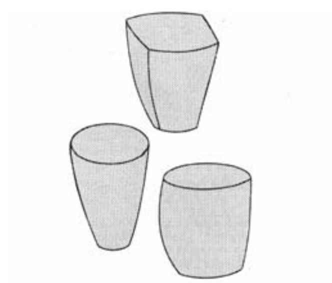
- **Further proposals followed in the 80's**

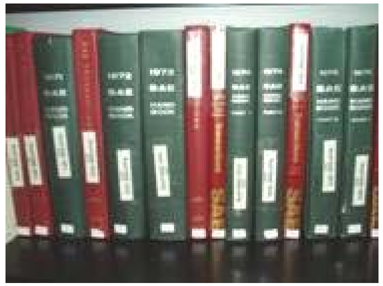
  Chinn B P, Donne G L, Hopes P D: Motorcycle Rider Protection in Frontal Collisions.
  10th ESV-Conference, Oxford, 1985

  Danner M, Langwieder K, Sporner A: Accidents of Motorcyclists Increase of Safety by Technical Measures on the Basis of Knowledge derived from Real-Life Accidents.
  10th ESV-Conference, Oxford, 1985

  Langwieder K, Sporner A, Polauke J: Stand der Passiven Sicherheit für den Motorradfahrer und mögliche Entwicklungstendenzen.
  1. VDI-Tagung Aktive und Passive Sicherheit von Krafträdern, Berlin, 1987

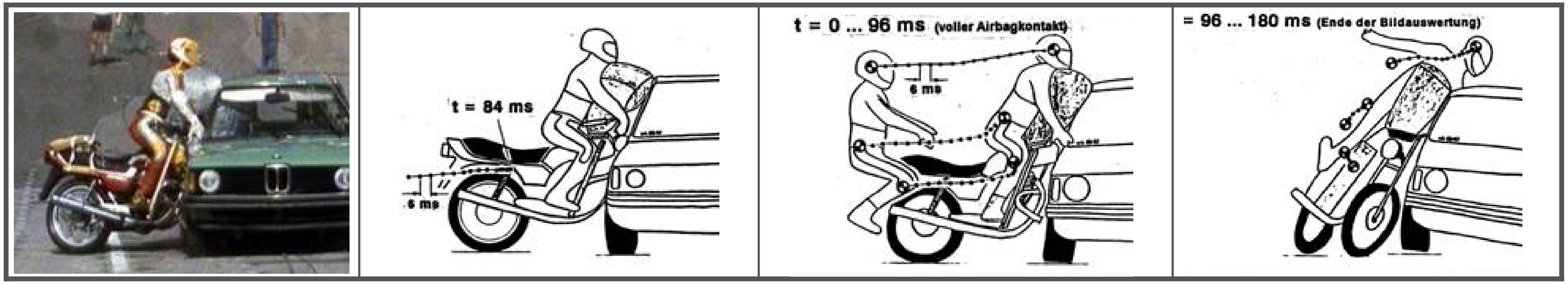




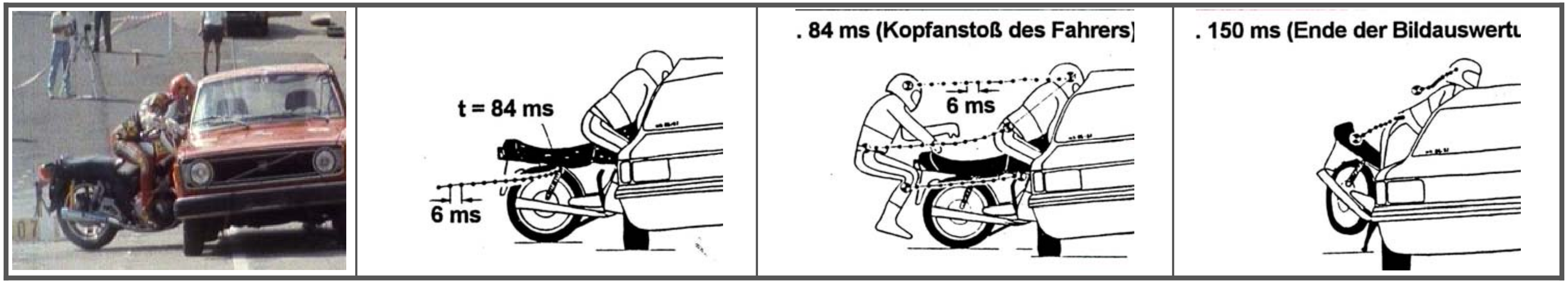


Motorcycle Airbags – An Option?
Historical Background

- 1987: HUK-organisation (now GDV), DEKRA and Winterthur-insurance conducted a joint crash-test project in Wildhaus (Switzerland) – a moving motorcycle (equipped with kneepads and airbag) crashed into the side of a moving passenger car



Motorcycle equipped with knee pads and airbag



Motorcycle baseline

Motorcycle Airbags – An Option?
Historical Background

1994: Motorcycle-airbag feasibility study carried out by the motorcycle industry and various research institutes

Zellner J W, Newman J A, Rogers N M: Preliminary Research into the Feasibility of Motorcycle Airbag Systems.
14th ESV-Conference, Munich, 1994

1996: Motorcycle-airbag study was developed and tested in Great Britain (Triumph/Lotus Engineering/TRL)

Grose G, Patel B, Okello J: The Development of a Motorcycler Rider Airbag Restraint System.
XXVI FISITA-Congress, Prague, 1996
Chinn B P, Okello J A, McDonough P J, Grose G: Development and Testing of a Purpose built Motorcycle Restraint System
15th ESV-Conference, Melbourne, 1996

Motorcycle Airbags – An Option?
Historical Background

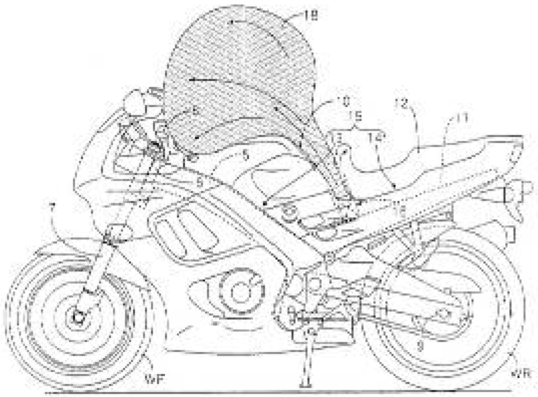
1999: BMW pointed out the airbag as an option for further development to improve the passive safety of the C1

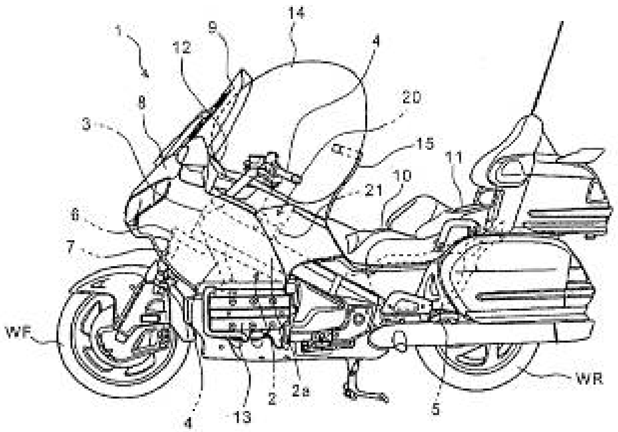
1990 … 2004: Honda developed an airbag for a large touring motorcycle (Gold Wing)

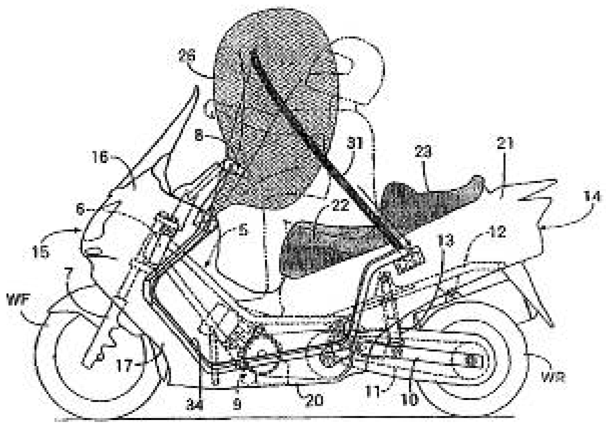
Iijima S, Hosono S, Ota A, Yamamoto T: Exploratory Study of an Airbag Concept for a Large Touring Motorcycle.
16th ESV-Conference, Windsor 1998
Yamazaki T, Iijima S, Yamamoto T: Exploration Study of an Airbag Concept for a Large Touring Motorcycle: Further Research.
17th ESV-Conference, Amsterdam, 2001

Source: Honda

Motorcycle Airbags – An Option?
Recent and Future Projects







Motorcycle Airbags – An Option?

Prototype of an Airbag for a Mid-Sized Touring Motorcycle

Volume and geometry

Definition of requirements:
DEKRA Accident Research

Design and production:
hs-Technik + Design

1. Volume determination (60 litre)
2. Design of bag geometry when undeployed
3. Assessment of Bag-Geometry when deployed

Motorcycle Airbags – An Option?

Prototype of an Airbag for a Mid-Sized Touring Motorcycle

Side view to airbag in 1st inflation test

Time to deploy: 40 ms

Motorcycle Airbags – An Option?

Prototype of an Airbag for a Mid-Sized Touring Motorcycle

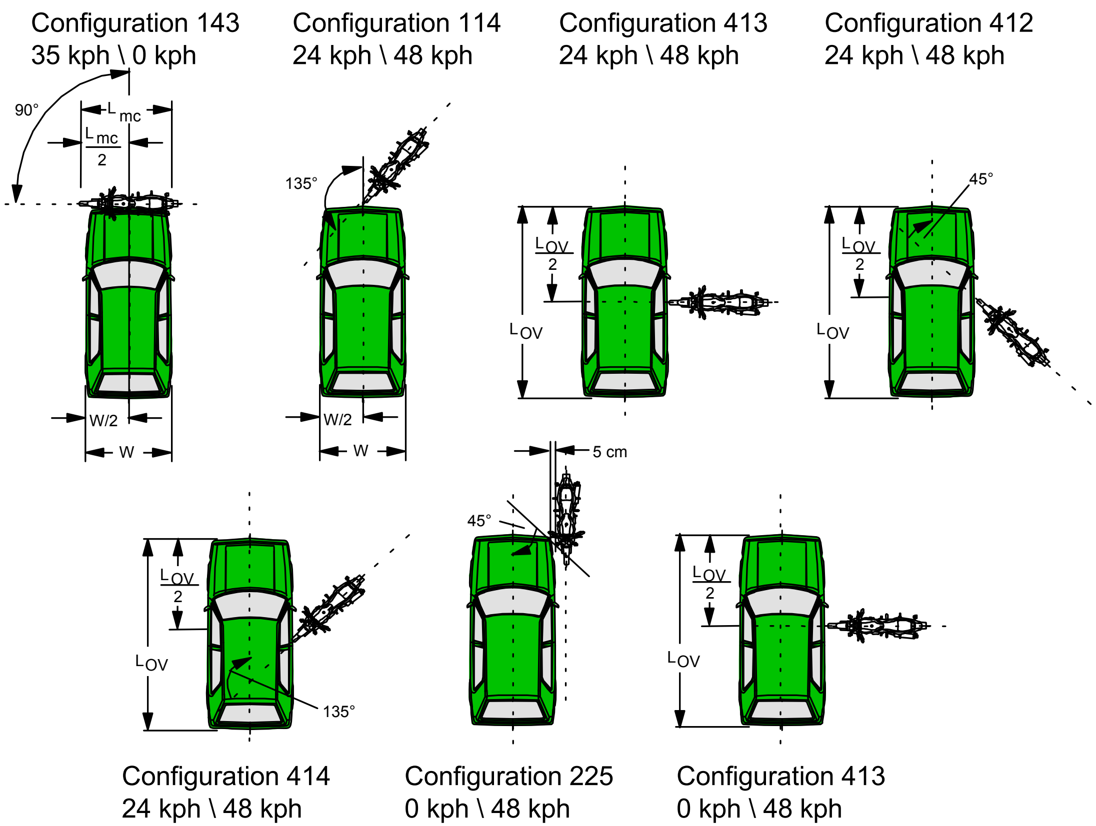
Stationary Test

To check geometry and inflation
on the motorcycle relative to the rider

Motorcycle Airbags – An Option?
Crash Tests

Since 1996 : ISO 13232 is the worldwide standard for motorcycle crash tests
Purpose: Investigate the effects of passive safety elements fitted to motorcycles

$v_{\text{Motorcycle}}$	=	**0 kph**
	=	**48 kph**
v_{Car}	=	**0 kph**
	=	**24 kph**
	=	**35 kph**



Motorcycle Airbags – An Option?

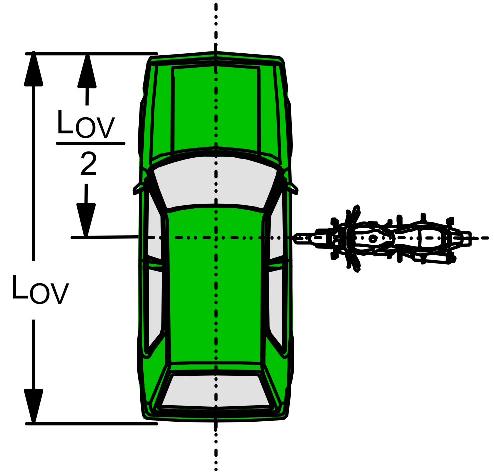
Crash Tests

Test configuration:

- Impact configuration 413 (ISO 13232)
- 1st step: „moving/stationary“
- 2nd step: “moving moving

Protective effects:

- Cushioning of the rider's impact in the early phase of the collision and reduction of the rider's velocity
- Avoidance of severe contact with the roof rail of the car
- Influence of the rider's cinematic in a later phase of the collision (movement of rider into upward direction) due to a “airbag ramp”
- Sliding onto the roof of a car
- No negative influence to the free movement of the rider
- No negative influence to the rider's injury risk



Motorcycle Airbags – An Option?
Crash Tests

Test configuration:

- $v_{Motorcycle}$ = 48 kph
- v_{Car} = 0 kph
- Dummy: Hybrid III
- No airbag

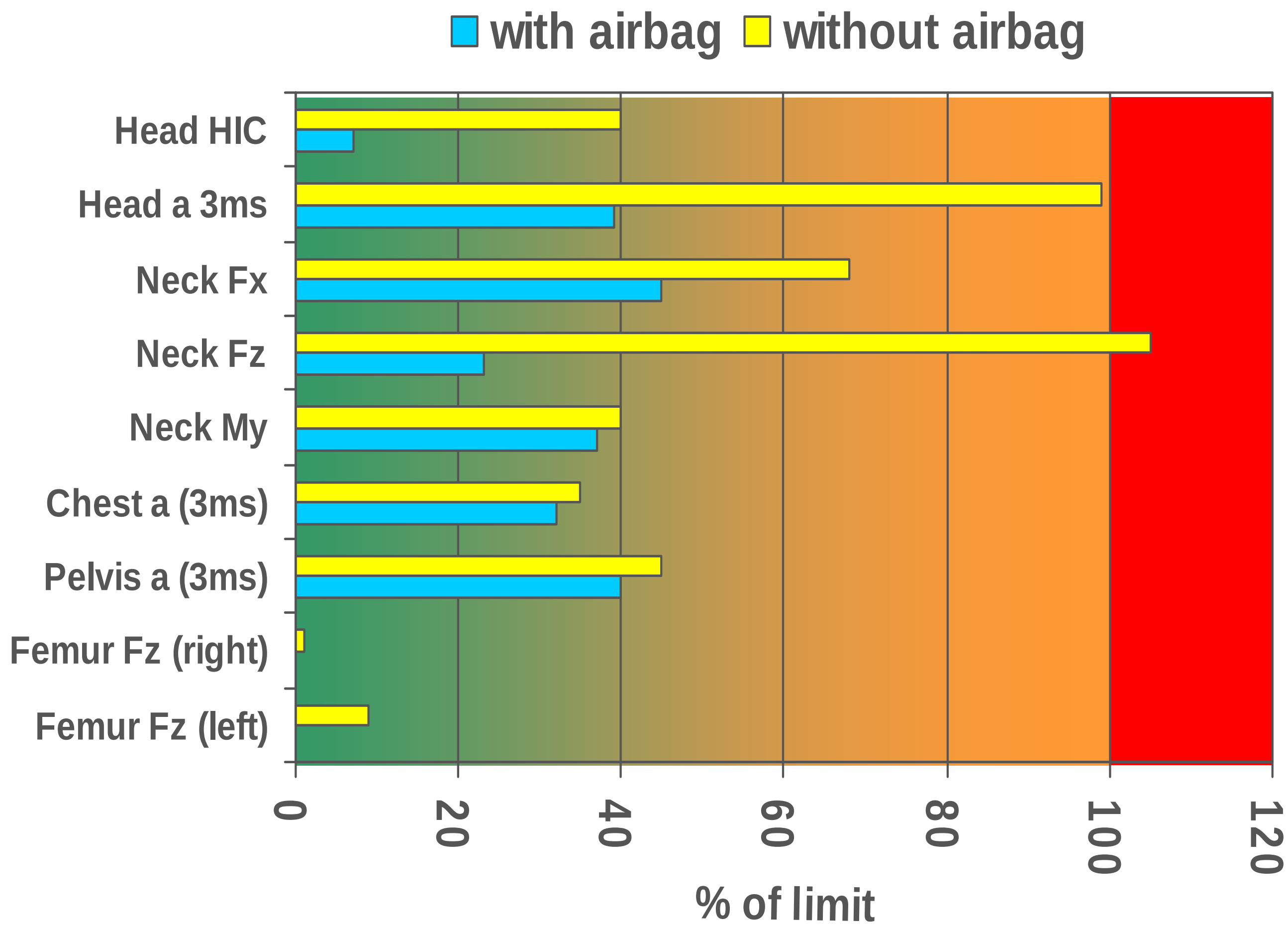
Motorcycle Airbags – An Option?

Crash Tests

Test configuration:

- $v_{Motorcycle}$ = 48 kph
- v_{Car} = 24 kph
- Dummy: Hybrid III
- Airbag

Motorcycle Airbags – An Option?
Crash Tests



Body region	Limit	Value [100 %]
Head	HIC	1000
Head	a_{3ms}	80 g
Neck	$F_{x,\ max}$	3.1 kN
Neck	$F_{z,\ max}$	4.0 kN
Neck	$M_{y,\ min}$	-57 Nm
Chest	a_{3ms}	60 g
Pelvis	a_{3ms}	60 g
$\text{Femur}_{\text{left}}$	F_z	10 kN
$\text{Femur}_{\text{right}}$	F_z	10 kN

Motorcycle Airbags – An Option?
Crash Tests

Test configuration:

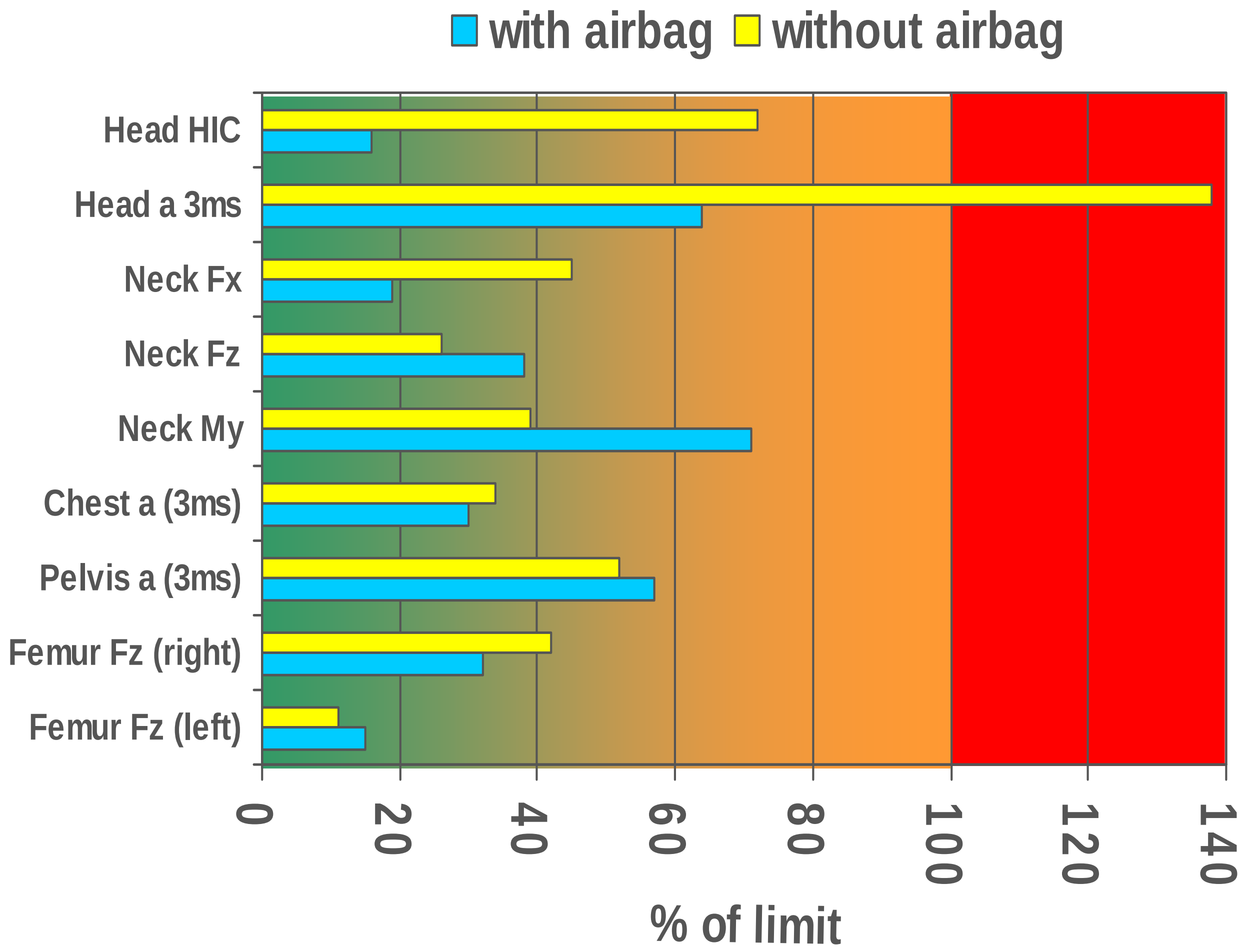
- $v_{Motorcycle}$ = 48 kph
- v_{Car} = 0 kph
- Dummy: MATD
- No airbag

Motorcycle Airbags – An Option?
Crash Tests

Test configuration:

- $v_{Motorcycle}$ = 48 kph
- v_{Car} = 24 kph
- Dummy: MATD
- No airbag

Motorcycle Airbags – An Option?
Crash Tests



Body region	Limit	Value [100 %]
Head	HIC	1000
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Neck	$F_{x, max}$	3.1 kN
Neck	$F_{z, max}$	4.0 kN
Neck	$M_{y, min}$	-57 Nm
Chest	a_{3ms}	60 g
Pelvis	a_{3ms}	60 g
$\text{Femur}_{\text{left}}$	F_z	10 kN
$\text{Femur}_{\text{right}}$	F_z	10 kN

Motorcycle Airbags – An Option?
Crash Tests

broken femur (test without airbag)

Motorcycle Airbags – An Option?
ADAC Crash Test with Honda Gold Wing

Honda Gold Wing Config. 413 ISO 13232, “moving stationary”, v = 72 km/h Dummy: MATD

	with airbag	without airbag
head	0	6
neck	0	6
chest	0	0
abdomen	0	0
femur	0	2
knee	0	0
lower leg	2	2

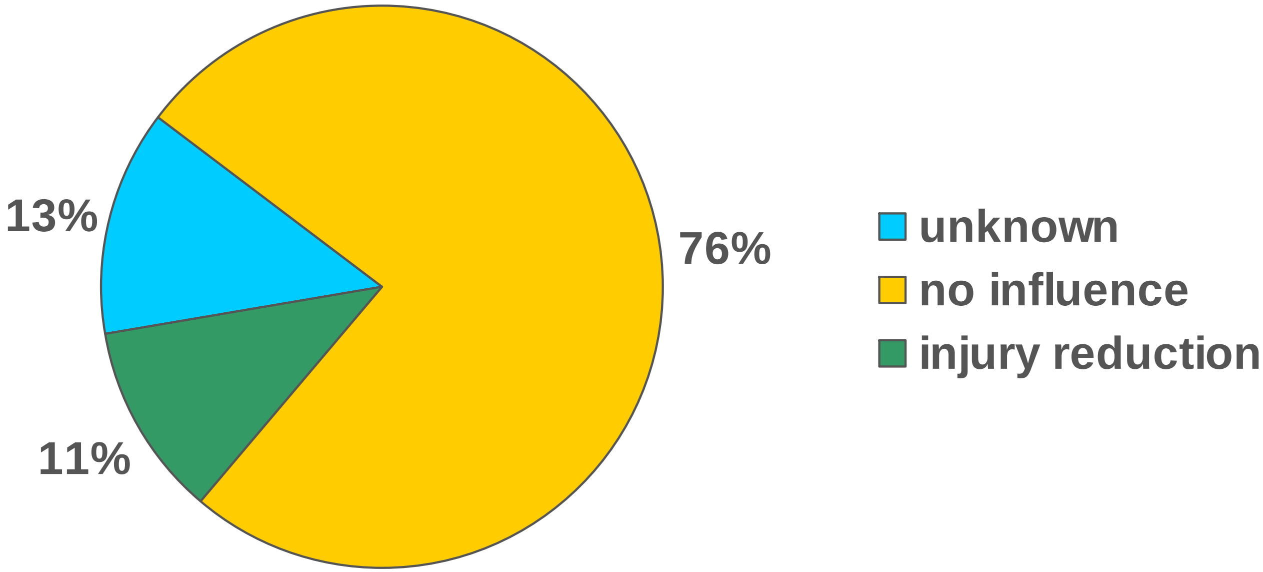
injury risk	
very low	0
low	2
medium to high	4
very high	6

source: www.adac.de

Motorcycle Airbags – An Option?
Findings from Real-World Accidents

DEKRA

DEKRA study on 97 real-world motorcycle crashes

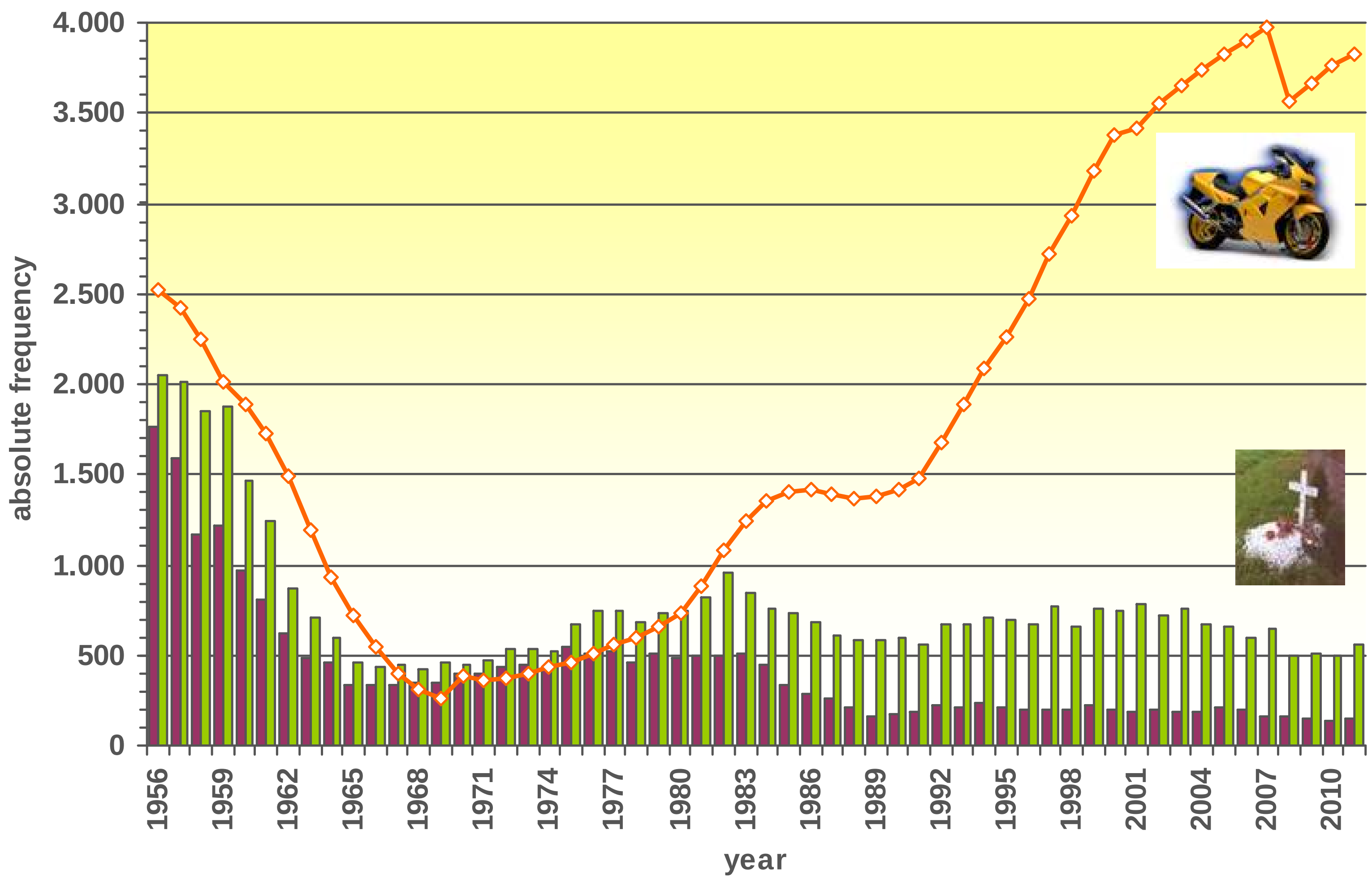


Result:
In 11 % of the real-world crashes analysed an MC airbag may reduce rider´s injury severity

Motorcycle Airbags – An Option?
Conclusions

- A motorcycle airbag is a real option - especially for the passive safety of touring bikes
- The development of an airbag by DEKRA Accident Research is an additional contribution to corresponding research
- The damping of the impact by the airbag plays an important role especially for large-sized touring motorcycles
- A combination of damping the impact (by reducing the rider's velocity) and influencing the passenger's movement is more target-oriented for smaller-sized touring motorcycles
- Additional crash tests (all 7 full scale test as per ISO 13232) and numerical simulations (200 impact scenarios) are necessary
- Protection clothing may contribute to solve remaining problems, also during secondary impacts on the road (system-approach)
- Accident research can deliver more knowledge on the performance of motorcycle airbags in real-world crashes

Safety of Motorcycles



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Thank you for your attention

Thank you   Takk   Cám ón   Ngiyabonga

Mahalo   Shukran   Jag tackar

Kiitoksia   Efcharisto

Gracias

Merci

Danke schön

DEKRA

FIM EUROPE

UEM

European Motorcycle Union

Union Européenne de Motocyclisme