FI-09-03

European Commission frontal impact accident analysis study: Provisional results

David Richards on behalf of TRL, BASt, and LAB

Tuesday 27th April 2010

Objectives

- To perform an analysis of European accident data to ascertain the taxonomy of frontal impacts and quantify casualty target populations for potential changes to frontal impact legislation
- To perform detailed case analysis:
  - To review the reasons for fatal injury in Regulation 94 compliant cars
  - To analyse the performance of vehicles involved in impacts similar to Regulation 94 test to help understand how well this test represents real world accidents
- To perform an analysis of car to other vehicle impacts to help understand the nature of the compatibility problem, in particular the distribution of the mass ratio of different weight cars involved in vehicle-to-vehicle crashes

Tasks

1	Task 1: Determination of frontal impact taxonomy using European and national databases
2	Task 2: Determination of detailed frontal impact taxonomy using detailed accident databases
3	Task 3: Detailed case analysis to review fatals and determine performance of current regulation 94 test
4	Task 4: Compatibility

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Data sources – European / national / in-depth

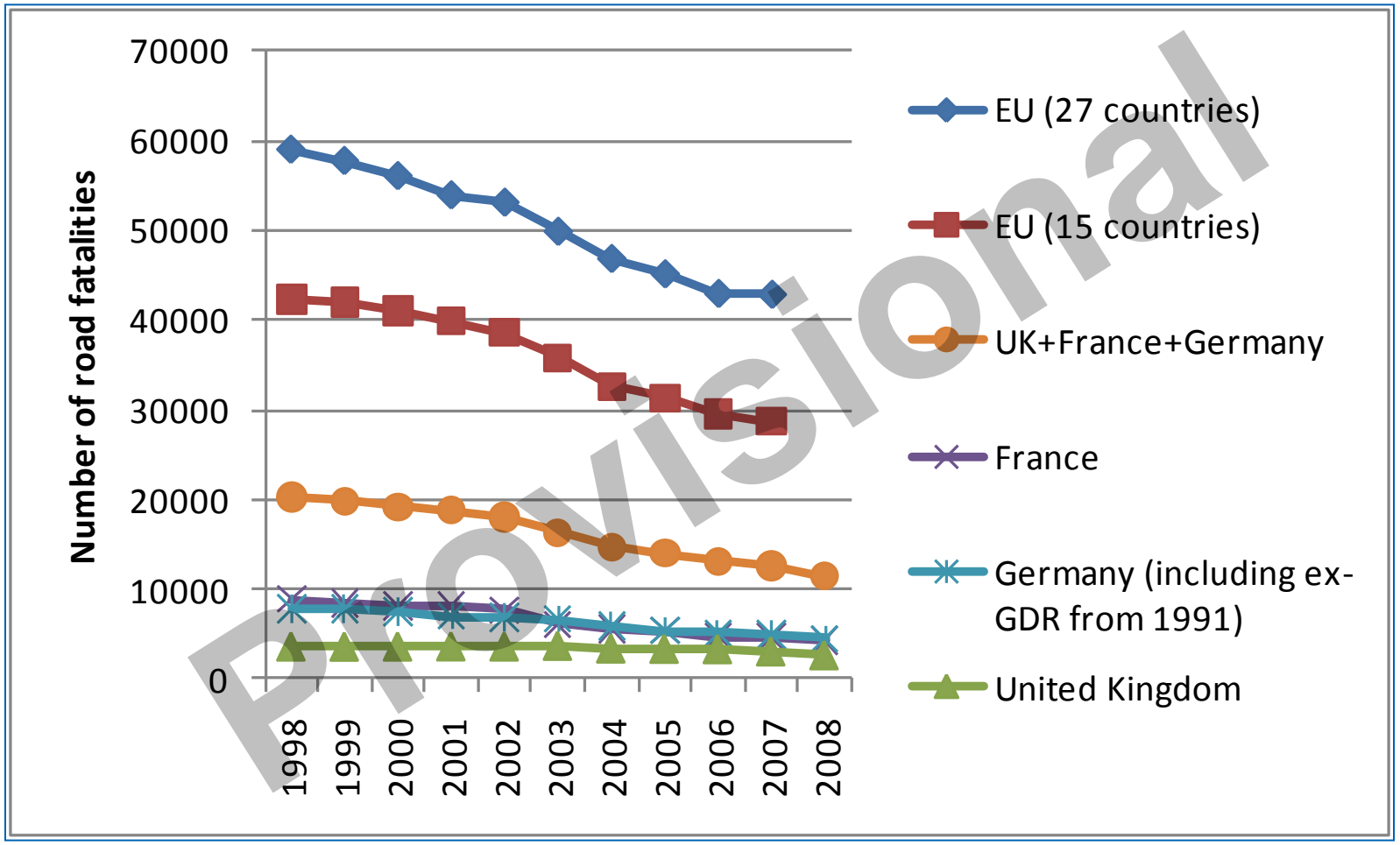
- Eurostat
- CARE
- GB national data (STATS19)
- German national data
- French national data (ONISR)

- Co-operative Crash Injury Study (CCIS)
- German In-Depth Accident Study (GIDAS)
- LAB in-depth database
- Heavy Vehicle Crash Injury Study (HVCIS)

Task 1 - Determination of frontal impact taxonomy using European and national databases

- Task 1 identified:
  - Changes over time in the number of road casualties in Europe
  - Changes over time in the number of car and LGV occupant casualties in frontal impacts in France, Germany, and Great Britain
  - The size of high-level target populations (including cars and LGVs, by object hit, urban/rural/motorway, age and gender, seating position
  - Adjusted target populations, based on a Regulation 94 compliant fleet

Road casualties in EU



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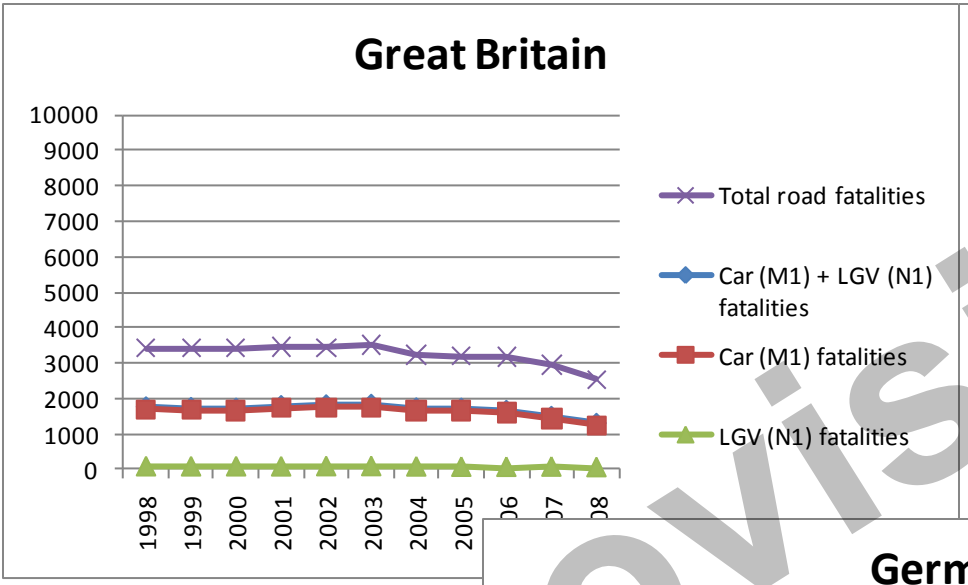
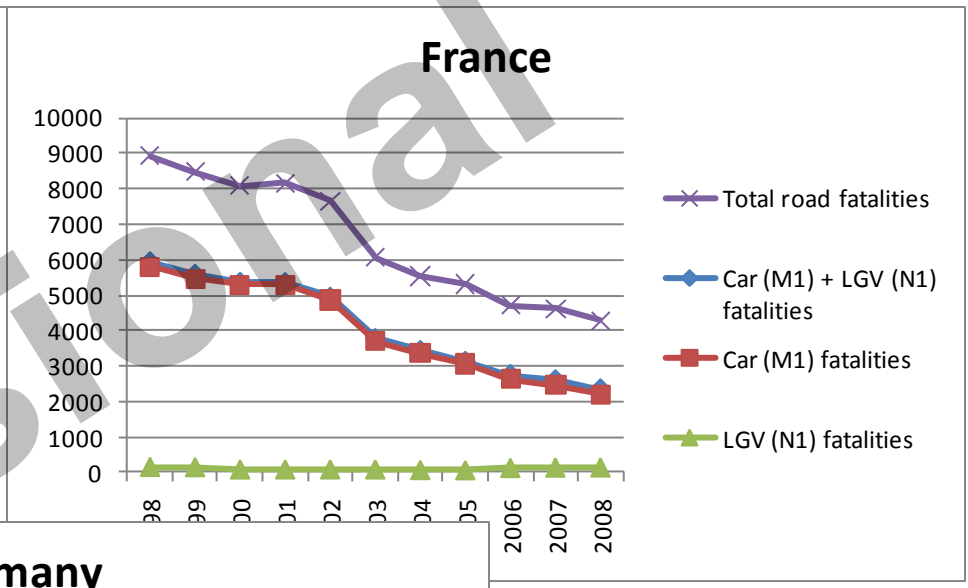
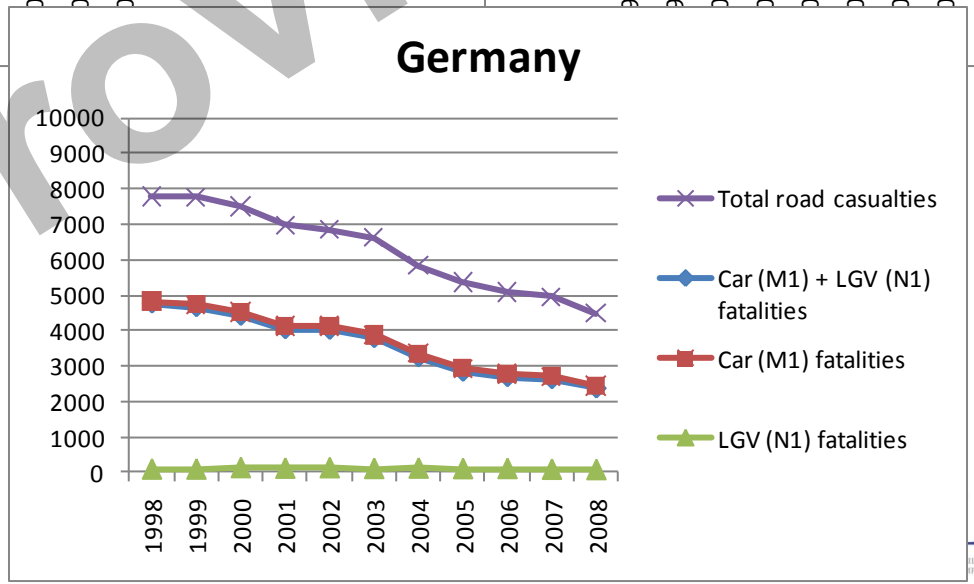
Road casualties in GB, France and Germany

Car (M1) and LGV (N1) occupant fatalities 1998-2008 (CARE and national data)







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Identification of target populations

Great Britain, 2008, cars

Rollover	
Fatal	Serious
297 (23.7%)	1706 (16.0%)

All cars	
Fatal	Serious
1250	10643

Front	
Fatal	Serious
731 (58.5%)	6995 (65.7%)

Side	
Fatal	Serious
438 (35.0%)	2738 (25.7%)

Rear	
Fatal	Serious
57 (4.6%)	700 (6.6%)

Other/unknown	
Fatal	Serious
24 (1.9%)	210 (2.0%)

Impact side: first point of impact, regardless of rollover

Rollover: regardless of first point of impact

France, 2008, cars

Rollover	
Fatal	Serious
132 (6.0%)	741 (5.2%)

All cars	
Fatal	Serious
2205	14127

Front	
Fatal	Serious
1398 (63.4%)	9968 (70.6%)

Side	
Fatal	Serious
491 (22.3%)	1763 (12.5%)

Rear	
Fatal	Serious
130 (5.9%)	1239 (8.8%)

Other/unknown	
Fatal	Serious
186 (8.4%)	1157 (8.2%)

Impact side: first point of impact, regardless of rollover

Rollover: regardless of first point of impact

Identification of target populations

GB

	Target population	
	Adjusted	2008
Fatal	718	731
Serious	6328	6995

France

	Target population	
	Adjusted	2008
Fatal	1119	1398
Serious	8885	9968

- Limitations
  - No adjustment made for non R94 compliant partner vehicle
    - There is evidence that R94 vs R94 impacts may lead to greater injury in the R94 vehicle than an R94 vs older car impact
    - Therefore, the adjusted population may underestimate the number of fatal and serious casualties in an R94 compliant fleet
    - However, there are other factors which this adjustment cannot take into account which may decrease the number of accidents

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Tasks

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Task 2 – Determination of detailed frontal impact taxonomy using detailed accident databases

Approach

- Continue development of frontal impact taxonomy and identification of target populations
  - Belt use, impact configuration (e.g. overlap) and severity, vehicle intrusion
- Determine injuries and injury mechanisms of casualties and relationship to impact type, e.g. Are injuries different for different impact partners?

Note: Analysis uses Regulation 94 compliant vehicles only

Issues

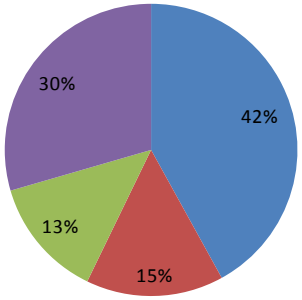
- GB
  - Representativeness of CCIS
    - Higher proportion of car-HGV/bus impacts
    - Lower proportion of car-narrow object impacts
    - Larger proportion of elderly occupants
    - Smaller proportion of occupants aged 12-25
- Germany
  - GIDAS data sample size
- France
  - LAB data sample size

Representativeness of CCIS

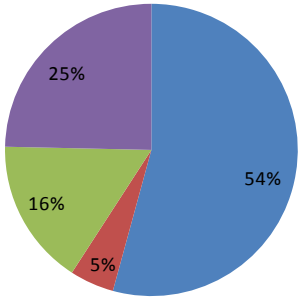
Object hit

STATS19

Fatal

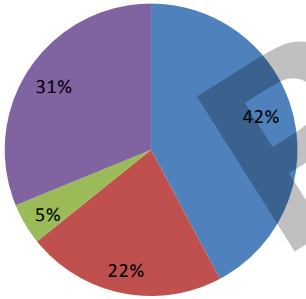


Serious

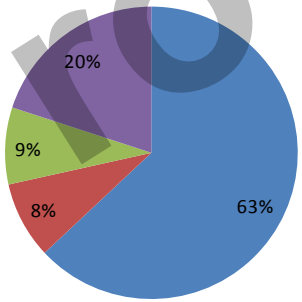


CCIS

Fatal



Serious

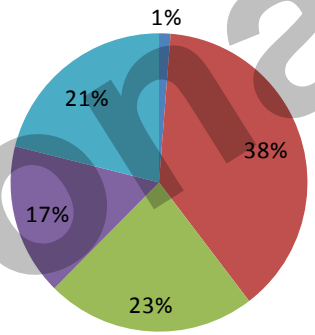


Car or LGV
Bus or HGV
Narrow object
Wide object

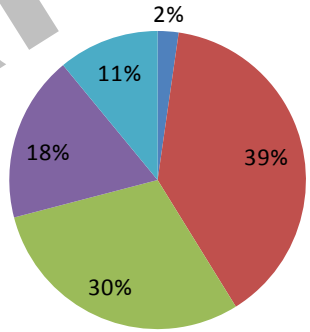
Occupant casualties

STATS19

Fatal

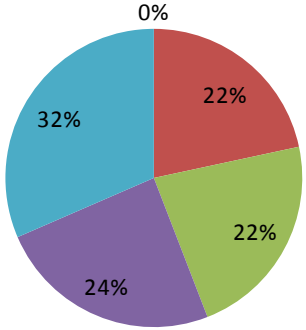


Serious

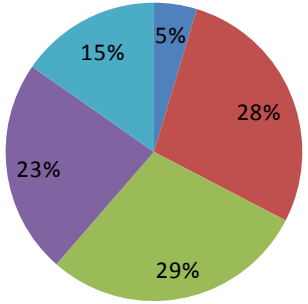


CCIS

Fatal



Serious



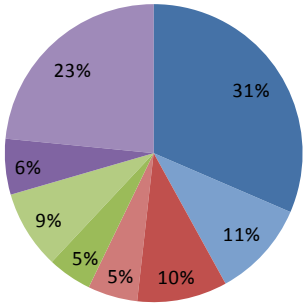
0-11
12-25
26-45
46-65
66+

Impact partner, rollover, belt use

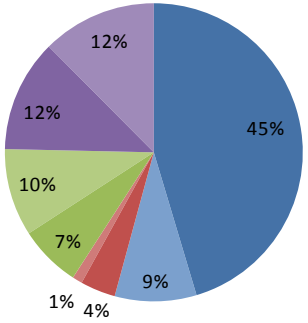
Frontal impacts
Regulation 94 compliant vehicles
All car occupants

Great Britain – CCIS scaled to STATS19 2008

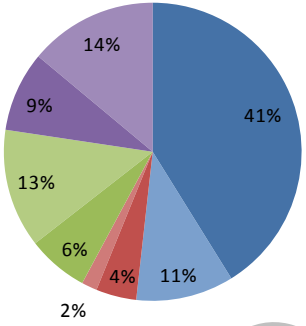
Fatal
n = 704



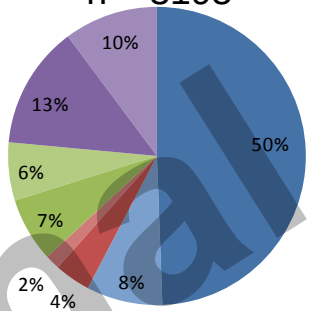
Serious
n = 6230



MAIS 3+
n = 1801



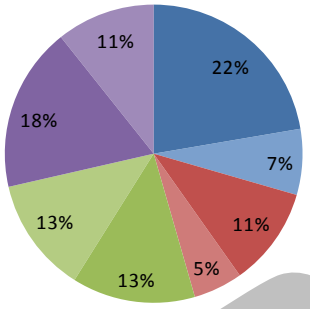
MAIS 2
n = 3195



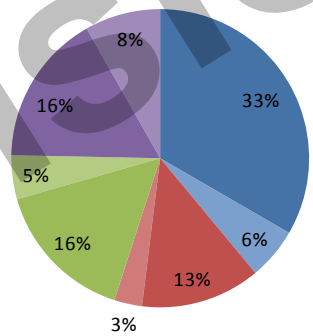
- Car/LGV belted + no roll
- Car/LGV unbelted / roll
- Bus/HGV belted + no roll
- Bus/HGV unbelted / roll
- Narrow belted + no roll
- Narrow unbelted / roll
- Wide belted + no roll
- Wide unbelted / roll

Germany – 2008 national casualties represented by GIDAS

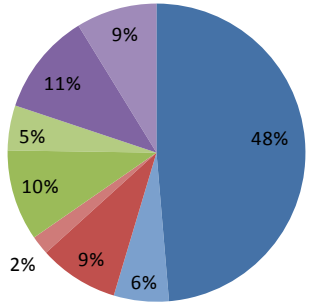
Fatal n=1096



MAIS 3+ n=3017



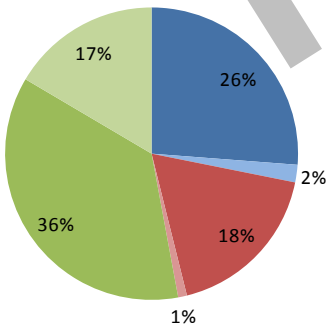
MAIS 2 n=12892



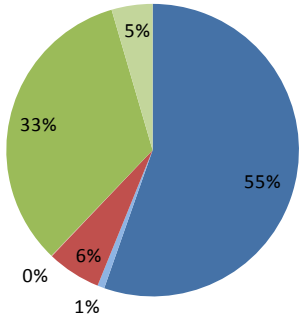
- Car/LGV belted + no roll
- Car/LGV unbelted / roll
- Bus/HGV belted + no roll
- Bus/HGV unbelted / roll
- Narrow belted + no roll
- Narrow unbelted / roll
- Wide belted + no roll
- Wide unbelted / roll

France – 2008 national casualties R94

Fatal n=213



Serious n=1694



- Car/LGV Belted
- Car/LGV Unbelted
- Bus/HGV Belted
- Bus/HGV Unbelted
- Object Belted
- Object Unbelted

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Identification of target populations – in depth data scaled to adjusted national data - GB

Front impact			
Fatal	Serious	MAIS 3+	MAIS 2
100%	100%	100%	100%

Belted, no rollover			
Fatal	Serious	MAIS 3+	MAIS 2
52%	68%	61%	74%

Front seat occupants			
Fatal	Serious	MAIS 3+	MAIS 2
51%	61%	55%	67%

Rear seat passengers			
Fatal	Serious	MAIS 3+	MAIS 2
1%	7%	6%	7%

HGV/BUS			
Fatal	Serious	MAIS 3+	MAIS 2
10%	3%	4%	4%

Car/LGV			
Fatal	Serious	MAIS 3+	MAIS 2
30%	41%	37%	45%

Wide objects			
Fatal	Serious	MAIS 3+	MAIS 2
6%	11%	7%	12%

Narrow objects			
Fatal	Serious	MAIS 3+	MAIS 2
5%	6%	6%	6%

Drivers			
Fatal	Serious	MAIS 3+	MAIS 2
23%	31%	28%	34%

Front seat passengers			
Fatal	Serious	MAIS 3+	MAIS 2
7%	10%	9%	11%

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Identification of target populations – in depth data scaled to adjusted national data - Germany

Front impact		
Fatal	MAIS 3+	MAIS 2
100%	100%	100%

Belted, no rollover		
Fatal	MAIS 3+	MAIS 2
64%	78%	78%

Car/LGV		
Fatal	MAIS 3+	MAIS 2
22%	33%	49%

HGV/bus		
Fatal	MAIS 3+	MAIS 2
11%	13%	9%

Wide objects		
Fatal	MAIS 3+	MAIS 2
18%	16%	11%

Narrow objects		
Fatal	MAIS 3+	MAIS 2
13%	16%	10%

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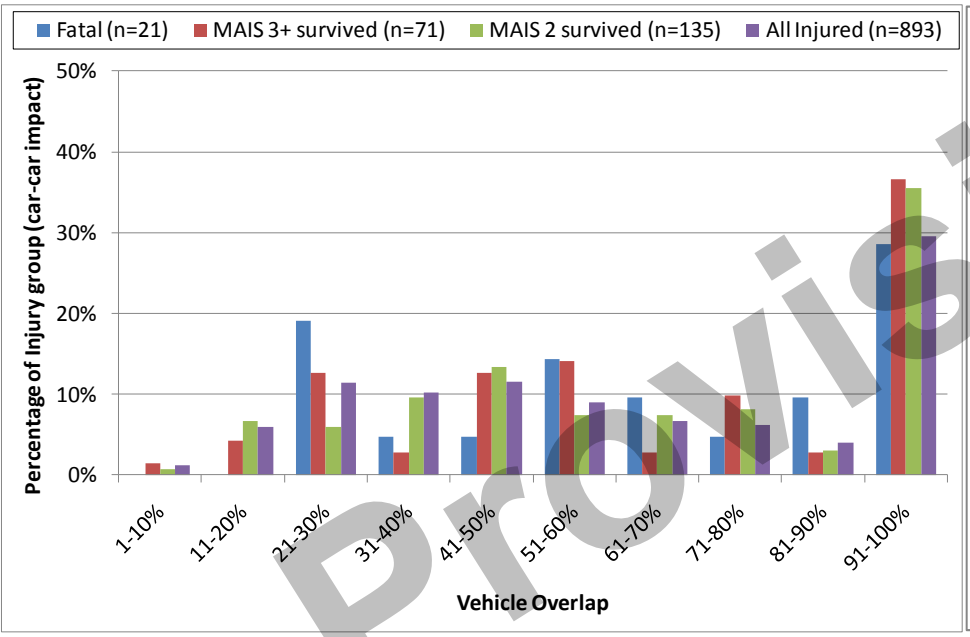
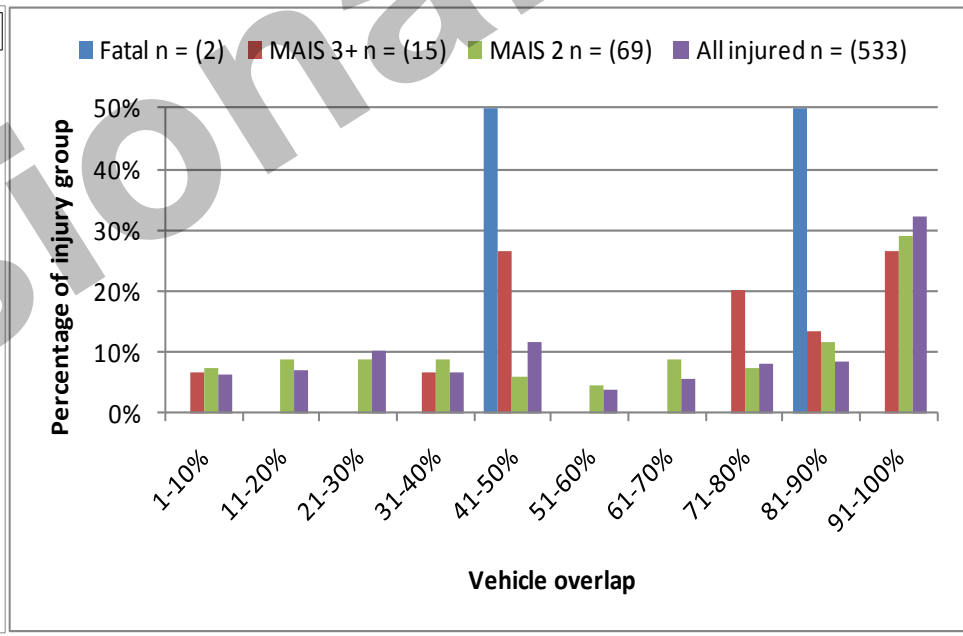
Overlap

Frontal impacts
Regulation 94 compliant vehicles
No rollover, belted, no unbelted occupant behind
Car-car/LGV impacts

GB – CCIS - drivers



Germany – GIDAS – front row occupants



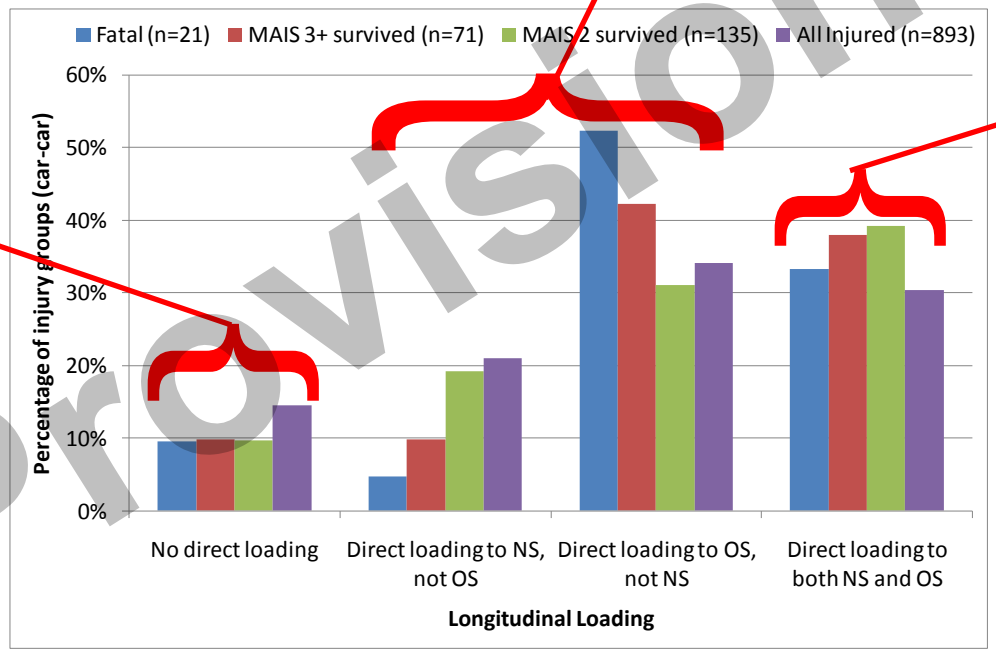
Longitudinal loading

Frontal impacts
Regulation 94 compliant vehicles
No rollover, belted, no unbelted occupant behind
Car-car/LGV impacts

Offset impacts

Full width

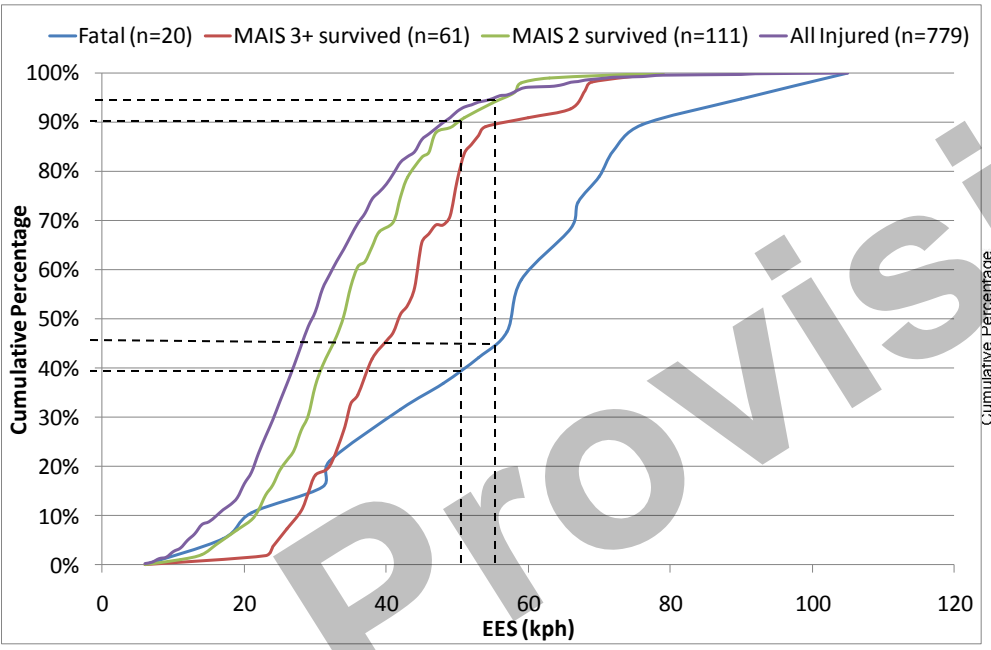
Low overlap



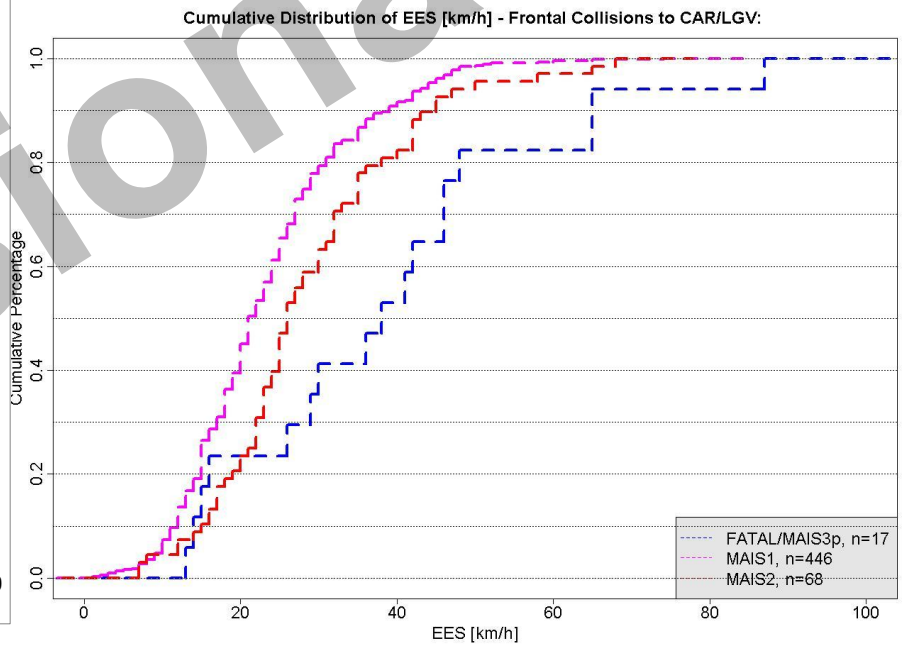
Speed

Frontal impacts
Regulation 94 compliant vehicles
No rollover, belted, no unbelted occupant behind
Car-car/LGV impacts

GB – CCIS - drivers



Germany – GIDAS – front row occupants



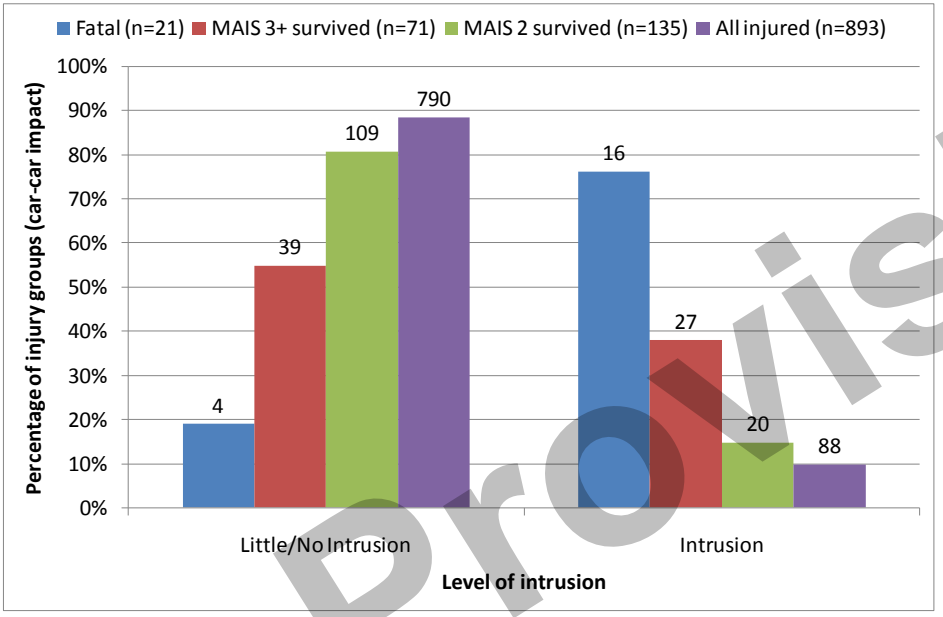
Impact configuration – car-car/LGV impacts

Population	GB: Fatal (drivers)	GB: MAIS 3+ (drivers)	GB: MAIS 2 (drivers)	Germany: MAIS 2 (Drivers + FSP)
Principle direction of force: 12 o'clock	67% (21%)	69% (28%)	66% (33%)	51% (24%)
Low overlap (0 rails)	10% (3.2%)	10% (4%)	10% (5%)	
Medium overlap (1 rail)	57% (18%)	52% (21%)	50% (25%)	
High overlap (2 rails)	34% (11%)	38% (16%)	39% (20%)	
High overlap (>90%)	28% (12%)	36% (15%)	35% (18%)	29% (14%)
Severity: EES <= 50 kph	39% (12%)	83% (34%)	90% (45%)	95% (46%)
Severity: EES <= 56 kph	46% (15%)	90% (37%)	95% (58%)	96% (46%)
Similar to current test	20% (6%)	34% (14%)	33% (17%)	27% (13%)

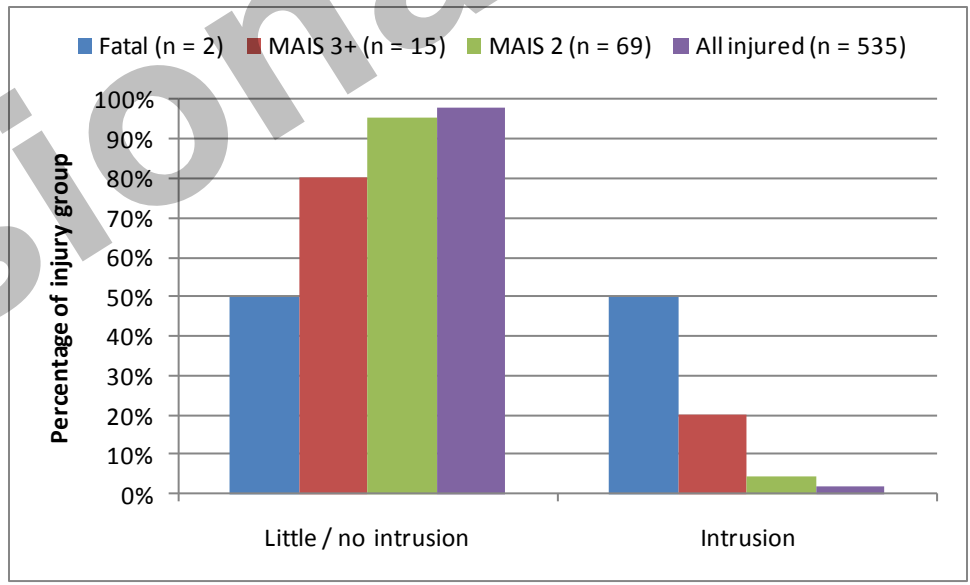
Intrusion

Frontal impacts
Regulation 94 compliant vehicles
No rollover, belted, no unbelted occupant behind
Car-car/LGV impacts

GB – CCIS - drivers



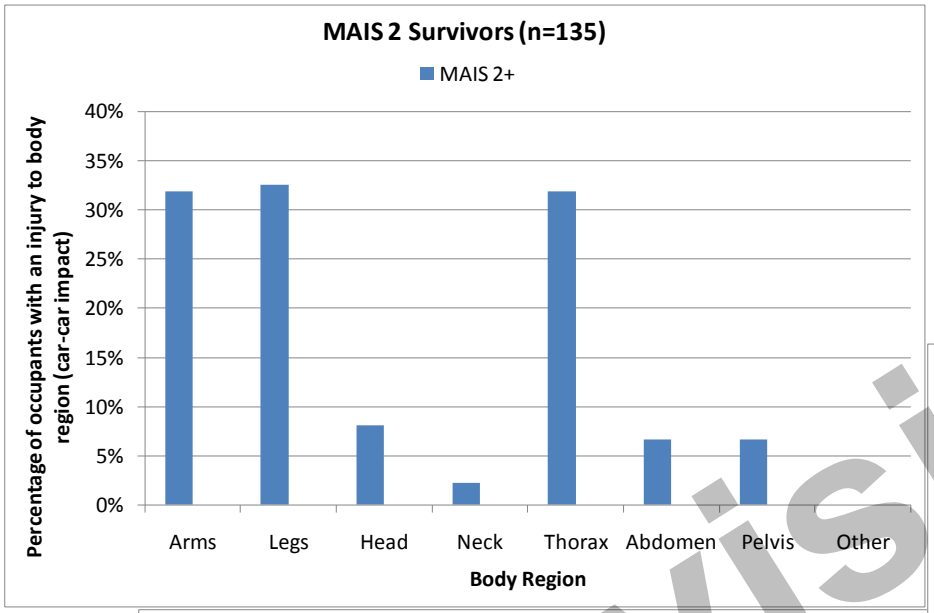
Germany – GIDAS – front row occupants

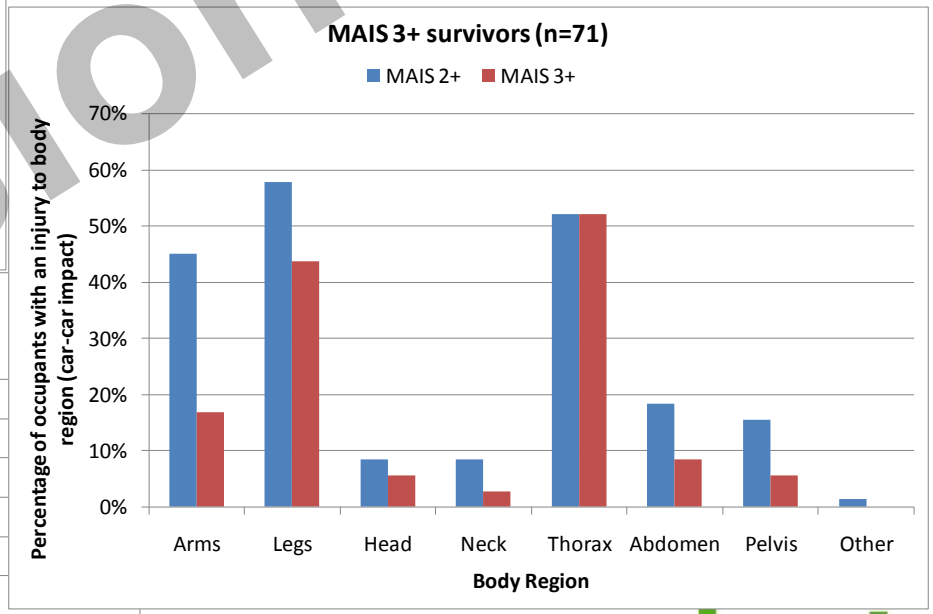


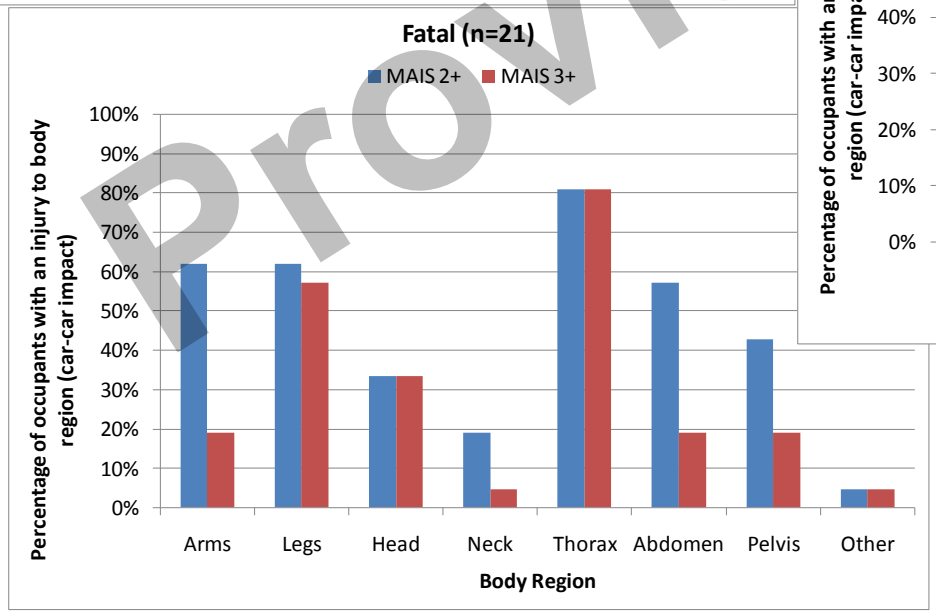
Injury distribution

Frontal impacts
Regulation 94 compliant vehicles
No rollover, belted, no unbelted occupant behind
Car-car/LGV impacts

GB – CCIS - drivers





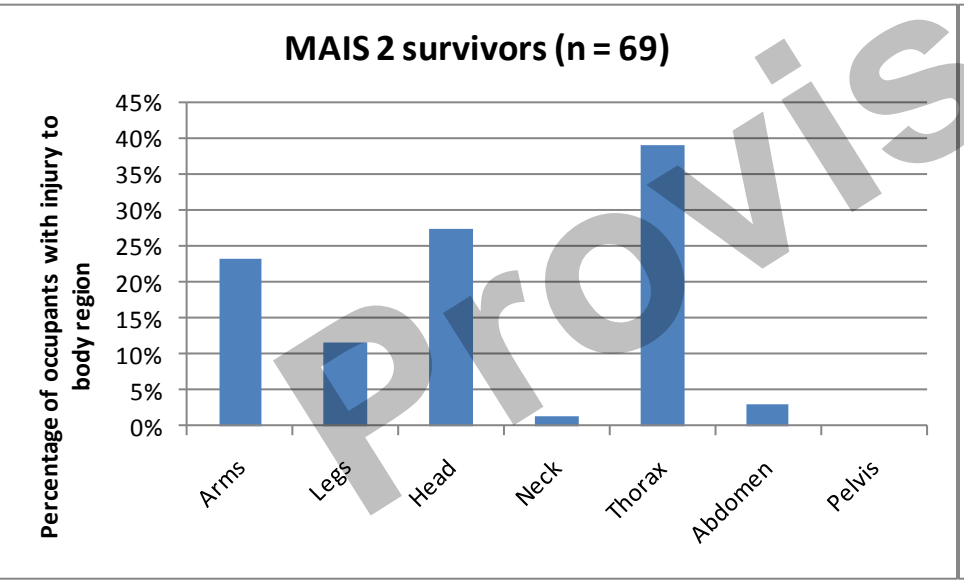


Injury distribution

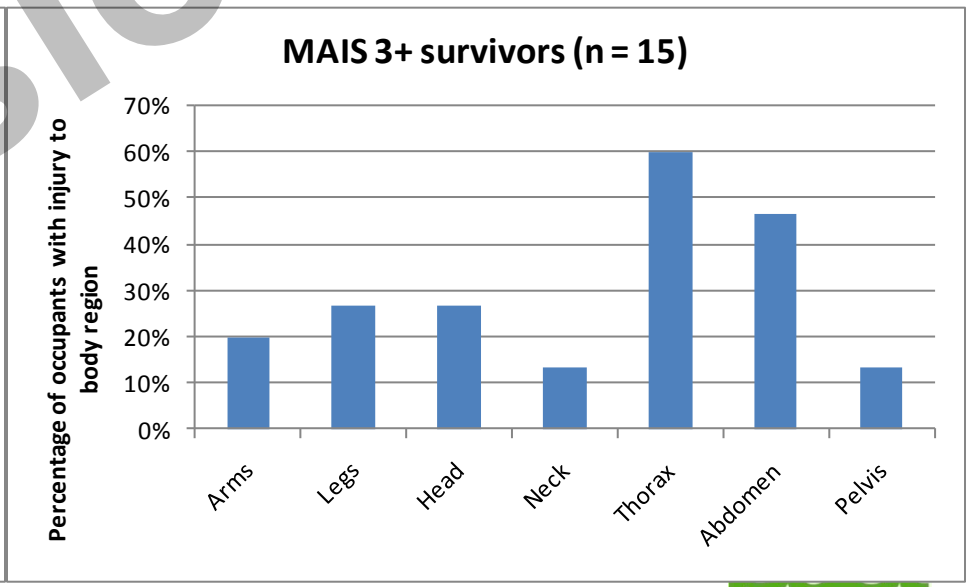
Frontal impacts
Regulation 94 compliant vehicles
No rollover, belted, no unbelted occupant behind
Car-car/LGV impacts

Germany – GIDAS – front row occupants

MAIS 2 occupants – AIS 2 injuries



MAIS 3+ occupants – AIS 2+ injuries



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Injury distribution and mechanisms

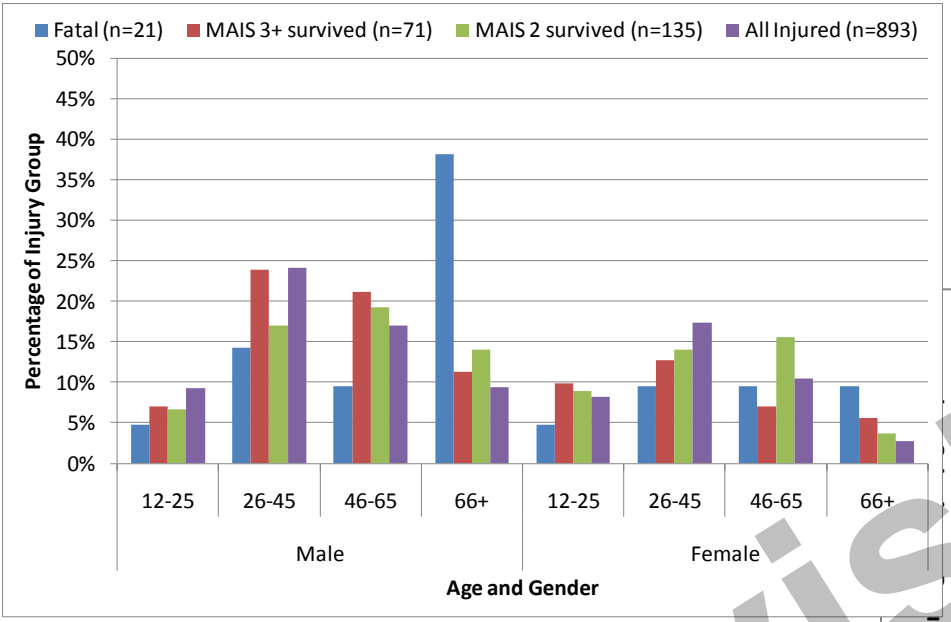
- In GB, the most frequent injuries are to the thorax, legs, and arms, for all injury severities
- In Germany, for MAIS 2 occupants, the most frequent injuries are to the thorax, followed by the head and arms

- For MAIS 2 drivers in GB, injuries are most frequently related to the restraint system, or contact with non-intruding structures
- For fatal drivers in GB, injuries are most frequently related to contact with intruding structures

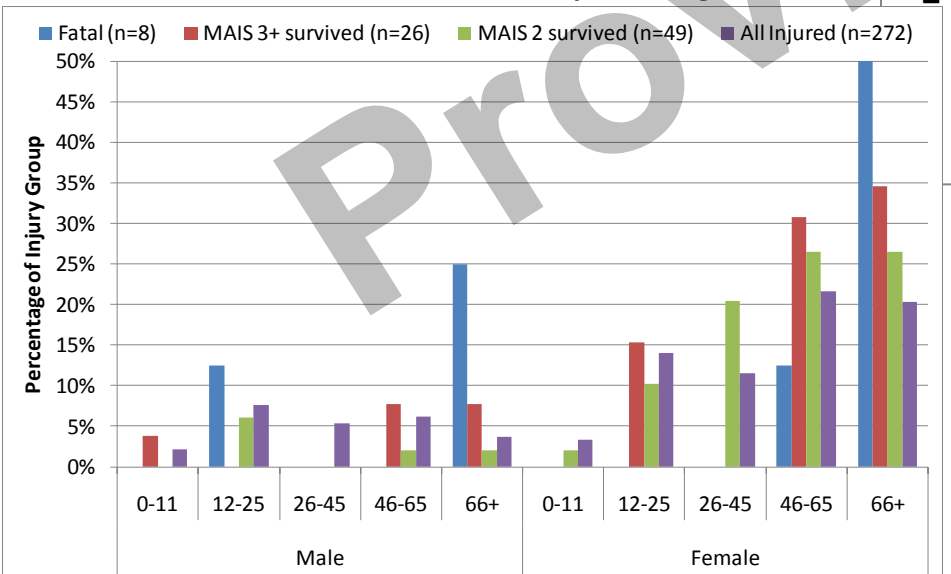
Age and gender

Frontal impacts
Regulation 94 compliant vehicles
No rollover, belted, no unbelted occupant behind
Car-car/LGV impacts

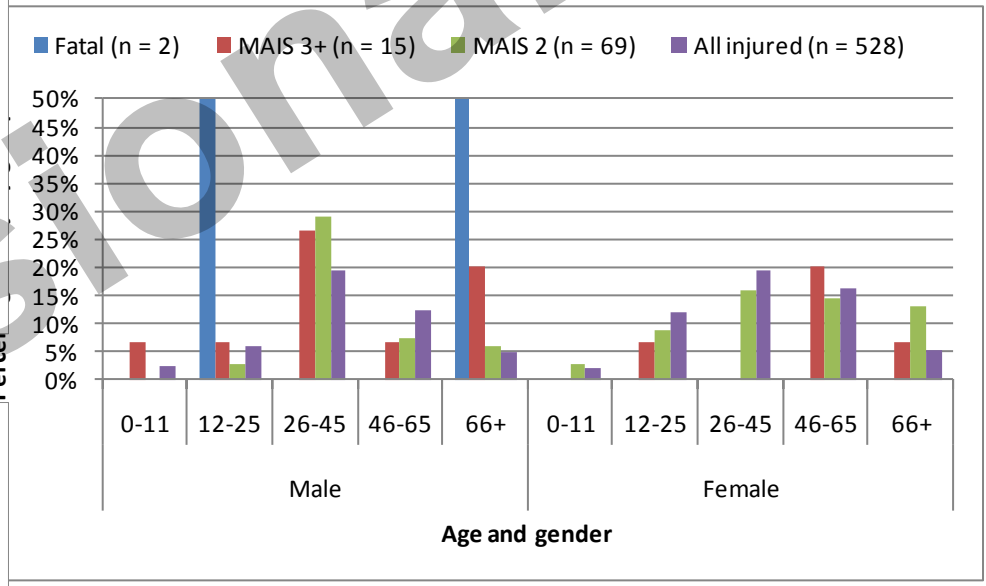
GB – CCIS - drivers



GB – CCIS – front seat passengers



Germany – GIDAS – front row occupants



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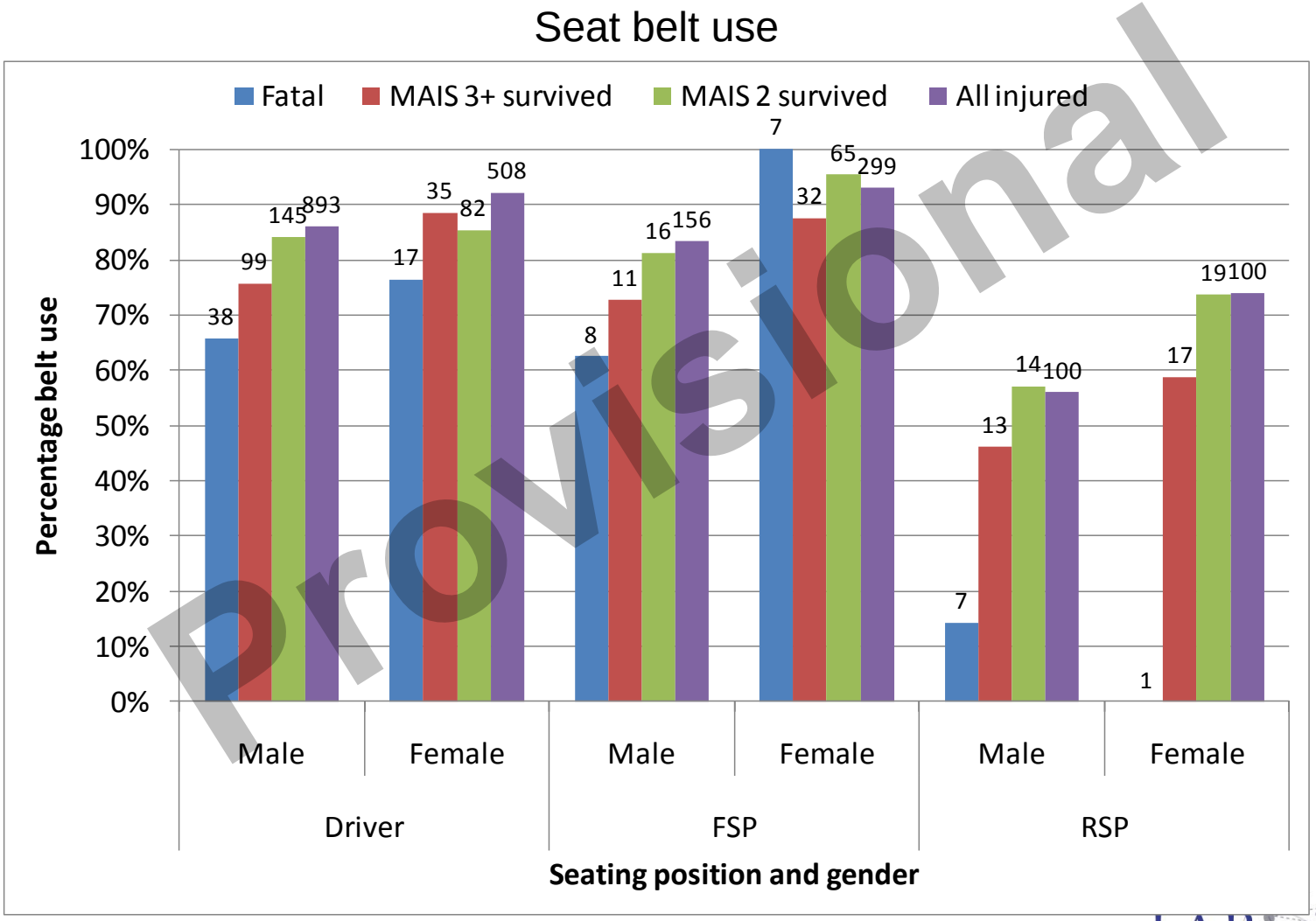
Occupant injuries – car-car/LGV impacts

Population	GB: Fatal drivers	GB: MAIS 3+ drivers	GB: MAIS 2 drivers	Germany: MAIS 2 Drivers + FSP
Gender: Female	33% (11%)	34% (14%)	41% (21%)	55% (26%)
Age: elderly (66+)	48% (15%)	16% (7%)	17% (9%)	19% (9%)
Head AIS 2+	33% (11%)	8% (3%)	8% (4%)	27% (13%)
Thorax AIS 2+	80% (26%)	52% (21%)	32% (16%)	39% (19%)
Leg AIS 2+	61% (20%)	58% (24%)	33% (17%)	11% (5%)
Arm AIS 2+	61% (20%)	45% (18%)	32% (16%)	23% (11%)
Abdomen AIS 2+	58% (19%)	19% (8%)	7% (4%)	3% (1%)
Intrusion	76% (24%)	38% (16%)	15% (8%)	4% (2%)

Rear Seat Passengers

Frontal impacts
Regulation 94 compliant vehicles
No rollover, belted, no unbelted occupant behind
Car-all



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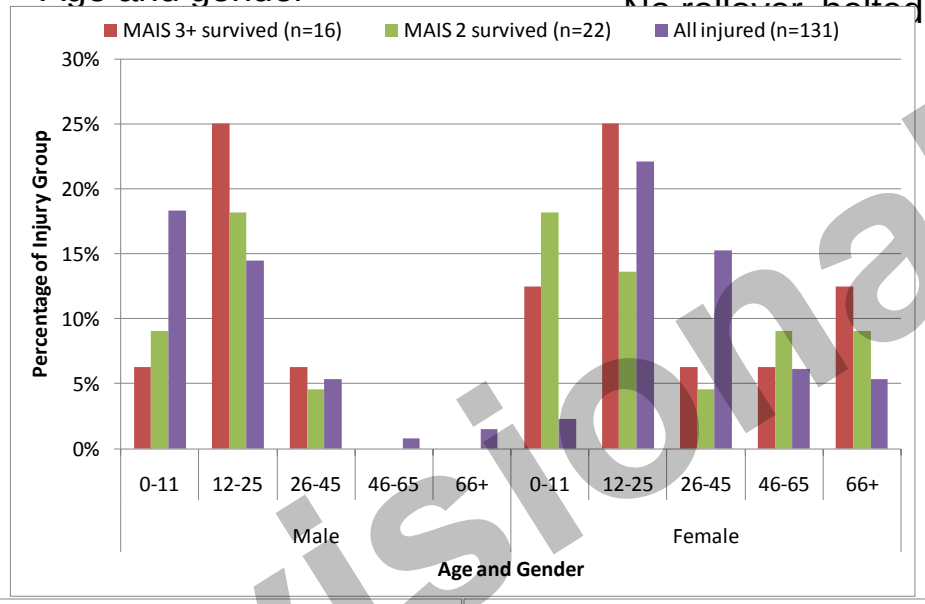
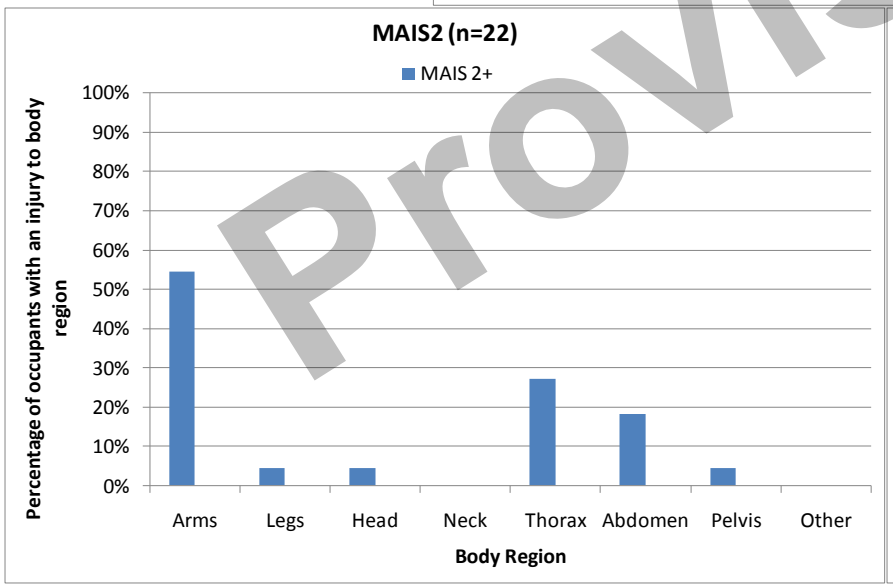
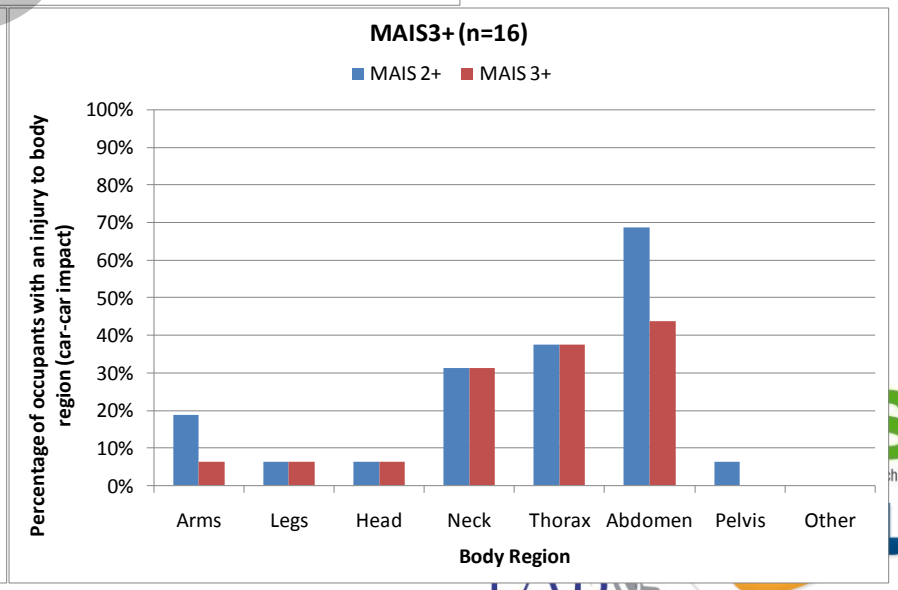
Rear Seat Passengers

Frontal impacts
Regulation 94 compliant vehicles
No rollover, belted, no unbelted occupant behind
Car-all

Age and gender



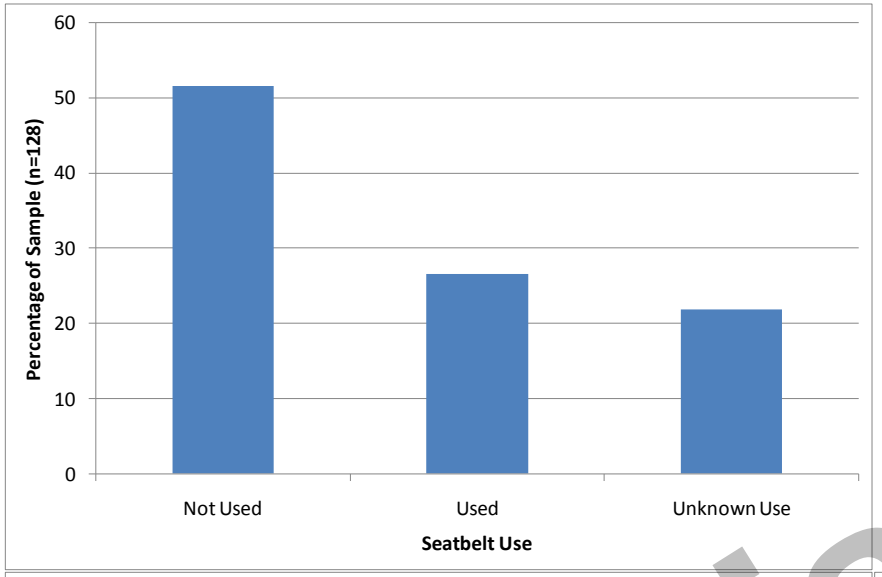


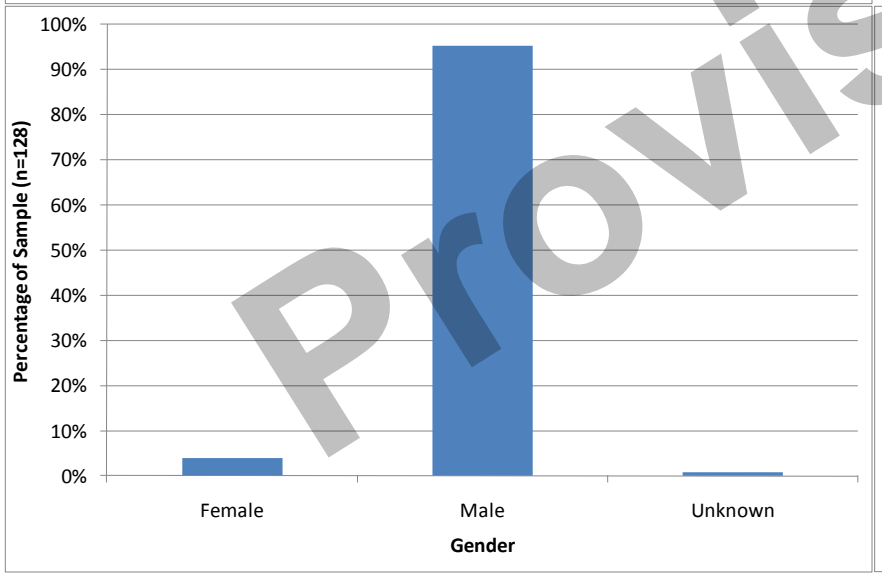


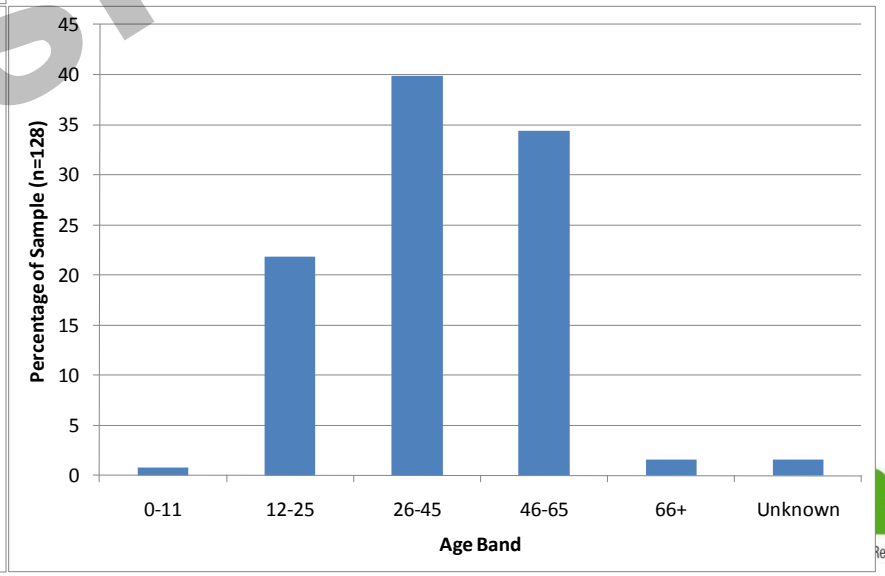
Injury distribution

N1 vehicle fatalities

Frontal impact
No rollover
N1-all







Tasks

1	Task 1: Determination of frontal impact taxonomy using European and national databases
2	Task 2: Determination of detailed frontal impact taxonomy using detailed accident databases
3	Task 3: Detailed case analysis to review fatals and determine performance of current regulation 94 test
4	Task 4: Compatibility

Task 3 – Detailed case analysis to review fatalities and determine performance of current regulation 94 test

Approach

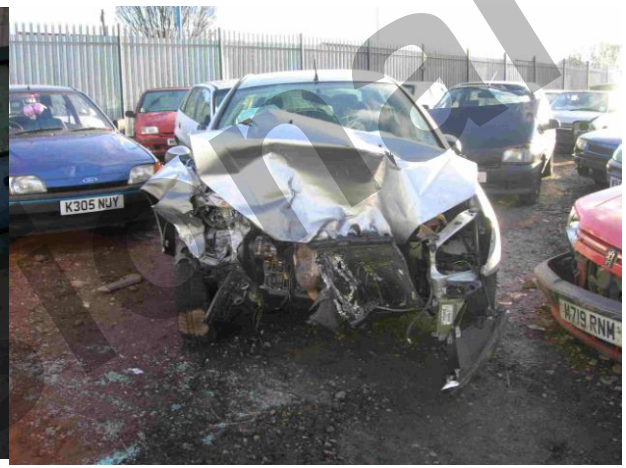
- Detailed case analysis (GB data only):
  - Fatal injuries
    - Determine factors which caused fatal injuries
      - Accident, vehicle or occupant characteristics
  - Impacts with configuration similar to Regulation 94 test
    - Determine how well R94 test represents real-world accidents by review of the structural performance of the vehicle and injuries received by the occupants against that expected from test experience
      - Vehicle test performance (Euro NCAP)
      - Accident characteristics
      - Occupant characteristics

Fatal Occupants – Example

A Fiat Punto overtook a Suzuki and collided with a Peugeot 206 travelling in the opposite direction in a head-on collision

2002 Fiat Punto
PDoF: 12 o'clock
Overlap: 73%
EES: 32 kph
Mass ratio: 1.08

O/S long direct
N/S long indirect



2003 Peugeot 206
PDoF: 12 o'clock
Overlap: 85%
EES: 33 kph
Mass ratio: 0.92

O/S long direct

FSP compartment intrusion: none

Front seat passenger, Female Age: 76 Height: 1.55m Mass: 56kg

Injuries (AIS 2+): head(3), multiple thorax injuries (highest:5)

Primary factor: elevated occupant age
Secondary factor: None
Note: seat belt related injury

Case Findings – Fatal occupants

There were 48 fatal occupants. The primary factors which caused the fatal injuries have been put into bins as follows:

•**Severe crash / anomaly**	**17**
•EES > 65 kph	11
•56 kph < EES <= 65 kph	5
•Anomaly	1
•**Vulnerable occupant**	**13**
•Elevated occupant age	13
•**Underride**	**10**
•HGV front	4
•HGV rear	3
•LCV front	1
•SUV front	1
•Car front	1
•**Limited horizontal structural engagement**	**4**
•With underride	2
•Without underride	2
•**Other**	**4**
•Post crash fire	2
•Oblique impact	1
•Unknown	1

Case Findings – Fatal occupants

The primary and secondary factors which caused the fatal injuries were as follows:

- **Severe crash / anomaly** **17**
  - EES > 65 kph 11
    - *Intrusion (steering wheel)* *5*
    - *Compatibility (minibus)* *2*
    - *No secondary factor* *2*
    - *Elevated occupant age* *1*
    - *Underride (LCV front)* *1*
  - 56 kph < EES <= 65 kph 5
    - *Intrusion (steering wheel)* *3*
    - *Compatibility (car)* *1*
    - *Intrusion (upper compartment)* *1*
  - Anomaly 1
    - *Underride (HGV rear)* *1*

- **Vulnerable occupant** **13**
  - Elevated occupant age 13
  - *No secondary factor** *9*
  - *Anomaly* *1*
  - *Obese occupant* *1*
  - *Small stature* *1*
  - *Severe crash (56 kph< EES <= 65 kph)* *1*

- **Underride** **10**
  - HGV front 4
    - *Elevated occupant age* *1*
    - *External object* *1*
    - *Intrusion (facia)* *1*
    - *Intrusion (upper compartment)* *1*
  - HGV rear 3
    - *External object* *2*
    - *Guard did not prevent underride* *1*
  - LCV front 1
    - *Intrusion (facia)* *1*
  - SUV front 1
    - *Sitting too far forward* *1*
  - Car front 1
    - *Intrusion (steering wheel)* *1*

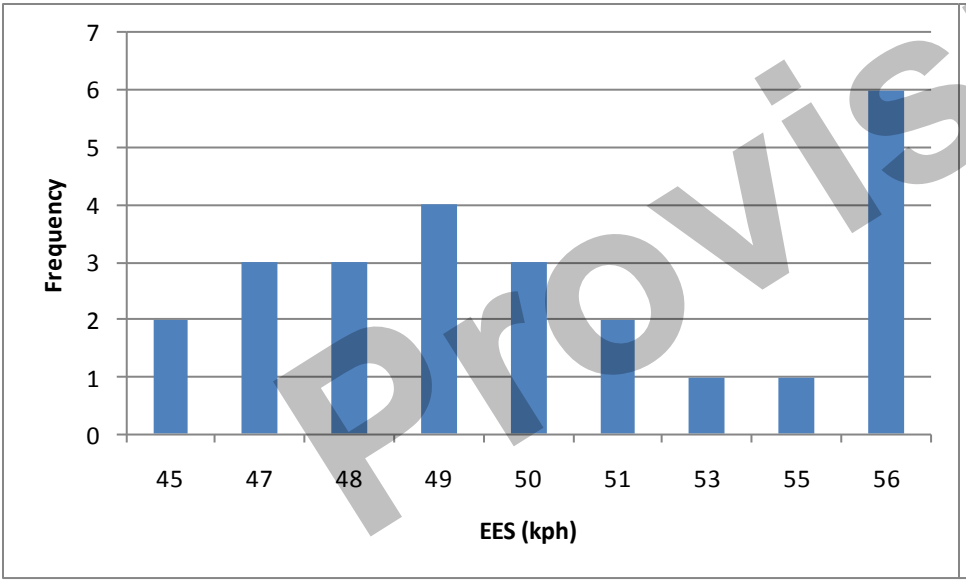
- **Limited horizontal structural engagement** **4**
  - *Intrusion (steering wheel)* *1*
  - *Intrusion (upper compartment)* *1*
  - *Underride (bus front)* *1*
  - *Underride (HGV front)* *1*

- **Other** **4**
  - Post crash fire 2
    - *Severe crash (EES > 65 kph)* *1*
    - *Severe crash (56 kph < EES <= 65 kph)* *1*
  - Oblique impact 1
    - *Elevated occupant age* *1*
  - Unknown 1
    - *No secondary factor* *1*

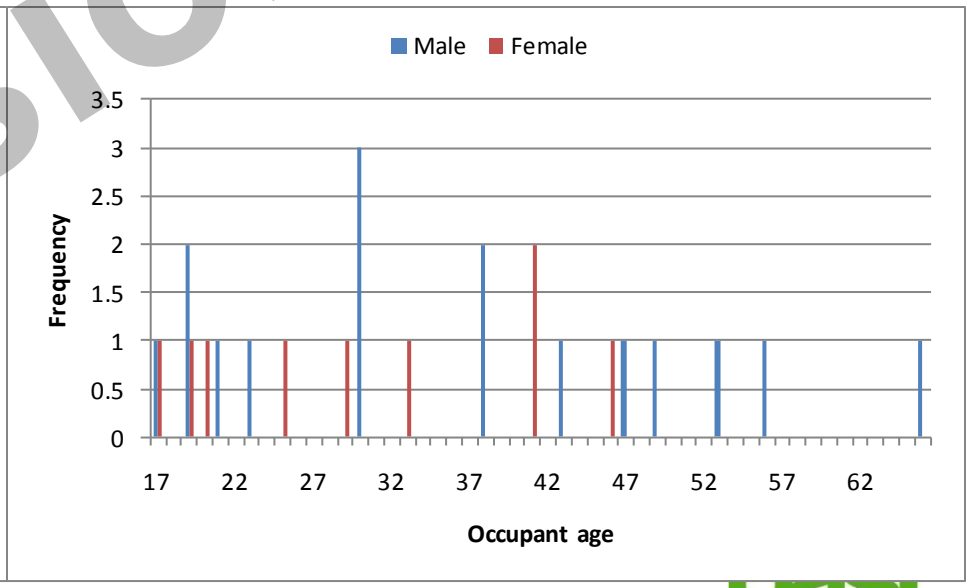
*Note: 6 of this group had seatbelt related injury

Case Findings – Like reg. occupants

Variable	Criteria
Object hit	Car, LGV, or wide object
Longitudinal loading	Only one longitudinal directly loaded
Overlap	>= 20% AND <= 70%
Direction of force	11, 12 or 01 o'clock
Severity (EES)	45-56 kph



EES distribution



Age and gender distribution

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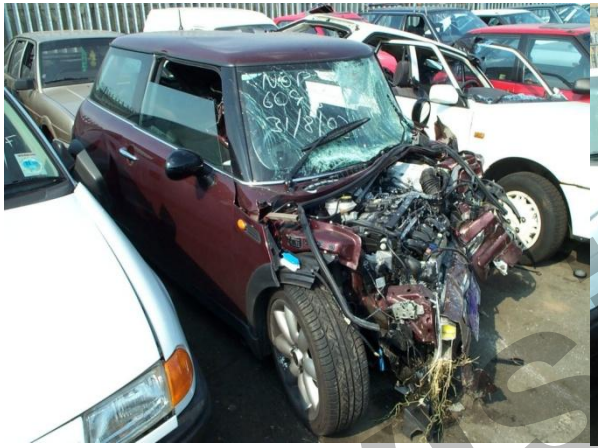
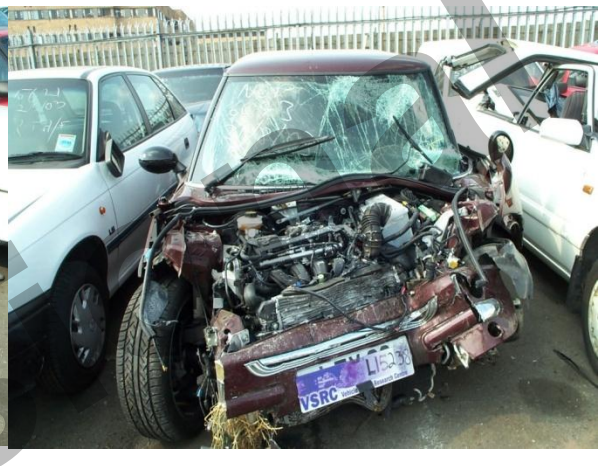
Like Reg. Occupants – Example

The Mini Cooper loses drifts onto the opposite carriageway whilst negotiating a sweeping left hand bend and collides with the Peugeot Expert van traveling in the opposite direction.

2002 BMW Mini
PDoF: 12 o'clock
Overlap: 67%
EES: 47 kph
Mass ratio: N/K

O/S long indirect
N/S long direct

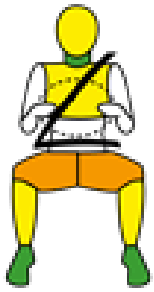




Peugeot Expert Van
Note: Van not examined

Intrusion: none

Driver, Female Age: 19 Height: 1.63m Mass: 51kg



Injuries (AIS 2+): knee laceration (2)

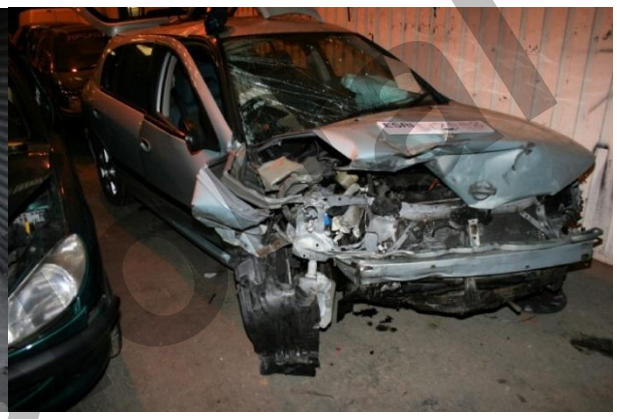
Structural performance: as expected. No intrusion.
Injury outcome: as expected.
Reasons: knee impact area judged to be aggressive in NCAP test

Like Reg. Occupants – Example

A Nissan lost control whilst negotiating a left hand bend and crossed onto the opposite carriageway, colliding with an oncoming Fiat Punto

2001 Fiat Punto
PDoF: 12 o'clock
Overlap: 35%
EES: 51 kph
Mass ratio: 1.35

O/S long direct
N/S long indirect



2001 Nissan Almera
PDoF: 12 o'clock
Overlap: 36%
EES: 36 kph
Mass ratio: 0.74

O/S long direct
N/S long indirect

Intrusion: steering wheel up 3cm, inboard 42cm, backwards 33cm, knee 35cm, footwell, 53cm, o/s facia 37cm

Driver, Female Age: 17 Height: unknown Mass: unknown

Injuries (AIS 2+): multiple thorax injuries (highest:2), multiple limb fractures (highest:2)

Structural performance: worse than expected. Large intrusion (e.g. Footwell 53 cm)
Injury outcome: worse than expected
Reasons: large mass difference. Possible compatibility issue (poor structural interaction)

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Case Findings – Like reg. occupants

- **As expected / better compartment performance** **16**
  - No intrusion 10
    - *As expected / better injury outcome* *6*
    - *Slightly worse than expected injury outcome* *4*
  - Low intrusion 3
    - *As expected / better injury outcome* *2*
    - *Slightly worse than expected injury outcome* *1*
  - Medium intrusion 2
    - *As expected / better injury outcome* *2*
  - Large intrusion 1
    - *As expected / better injury outcome* *1*
- **Slightly worse than expected comptt performance** **1**
  - Medium intrusion 1
    - *Slightly worse than expected injury outcome* *1*
- **Worse than expected compartment performance** **8**
  - Low intrusion 1
    - *As expected / better injury outcome* *1*
  - Medium intrusion 2
    - *Worse than expected injury outcome* *1*
    - *Fatal* *1*
  - Large intrusion 5
    - *As expected* *2*
    - *Worse than expected* *1*
    - *Fatal* *2*

Case Findings – Like reg. occupants

Structural performance:

•Worse than expected	**8**
•Possible compatibility issue (poor structural interaction)	3
•Possible compatibility issue (poor structural interaction / low overlap)	2
•Poor structural interaction (low overlap)	1
•Overridden by SUV, large mass difference	1
•EES possibly an underestimate	1

Occupant injuries:

•Worse than expected	**2**
•Large intrusion – compatibility issue (poor structural interaction / low overlap)	1
•Medium intrusion – poor structural interaction (low overlap)	1
•Fatal	**3**
•Large intrusion – overridden by SUV	1
•Large intrusion – EES possibly an underestimate	1
•Medium intrusion – possible compatibility issue, age of occupant	1

Tasks

1	Task 1: Determination of frontal impact taxonomy using European and national databases
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3	Task 3: Detailed case analysis to review fatals and determine performance of current regulation 94 test
4	Task 4: Compatibility

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Task 4 - Compatibility

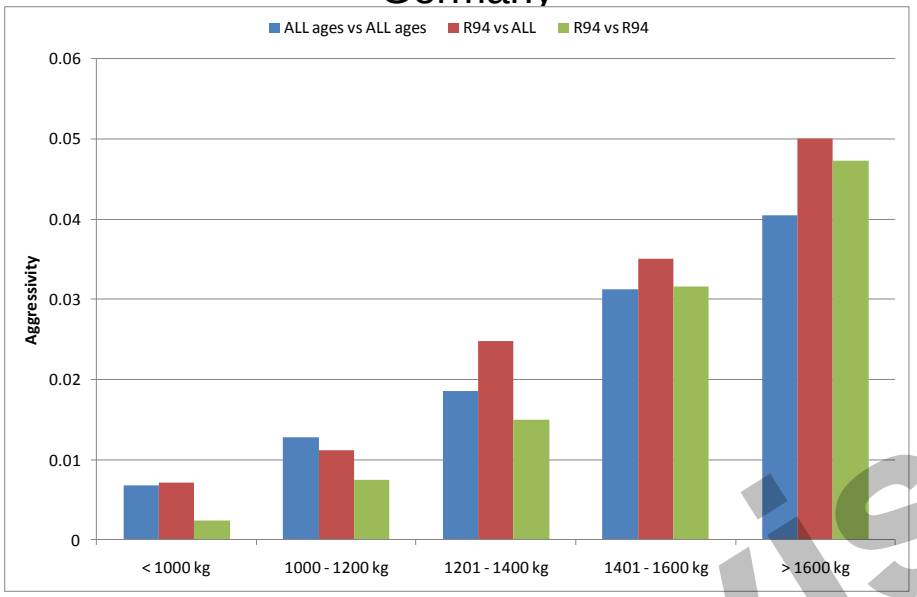
Approach

- Perform analysis to quantify compatibility in frontal impacts
  - Determine partner protection (aggressivity) ratio by vehicle mass and class (e.g. SUVs, small cars, etc)
  - Determine severity proportion by vehicle mass and class for car-to-car and car-to-object impacts
  - Produce cumulative frequency curves of mass ratio of vehicles involved in car-to-car impacts for all vehicles and by mass category (e.g. < 1000 kg, 1000 - 1200 kg, etc.)

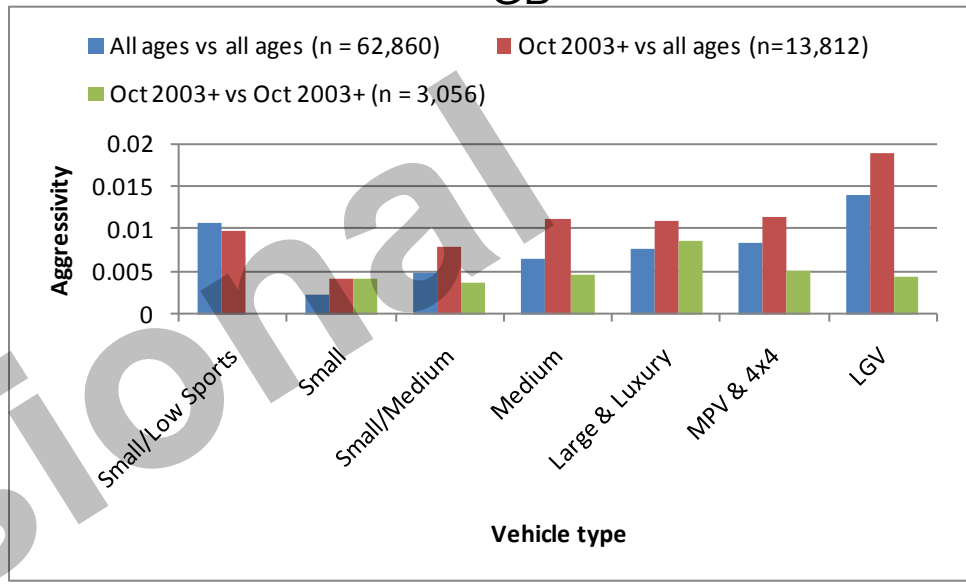
Aggressivity (partner protection)

$$Aggressivity = \frac{Driver\ fatalities in collision\ partner}{Number\ of\ crashes\ of\ subject\ vehicle}$$

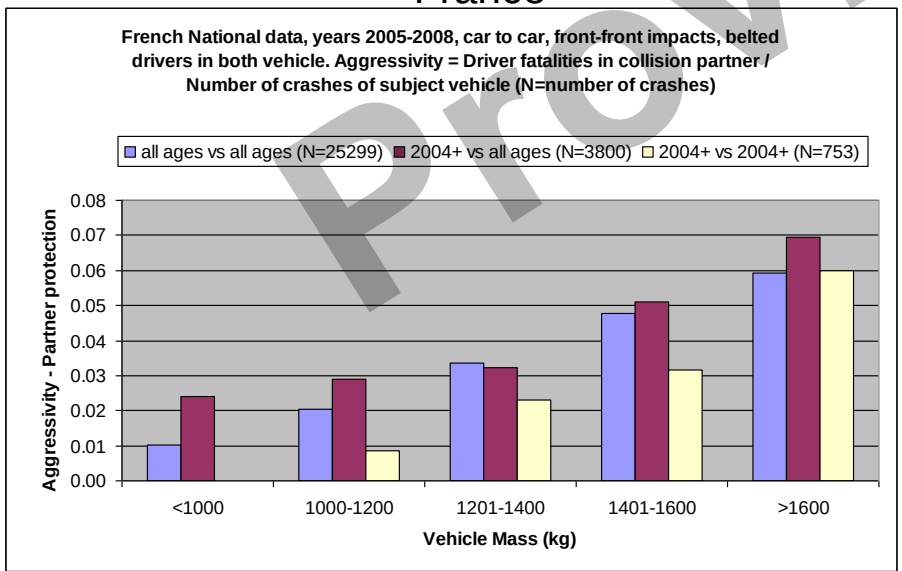
Germany



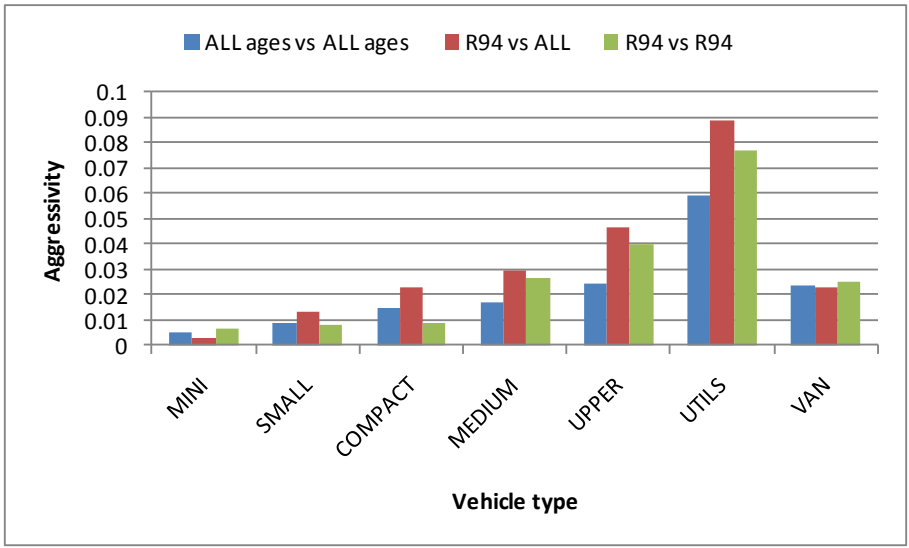
GB



France



Germany



Severity proportion (self protection)

$$Severity\,ratio = \frac{Driver\ fatalities + Seriously\,injured\,drivers}{Fatal + Serious + Slight\,drivers}$$

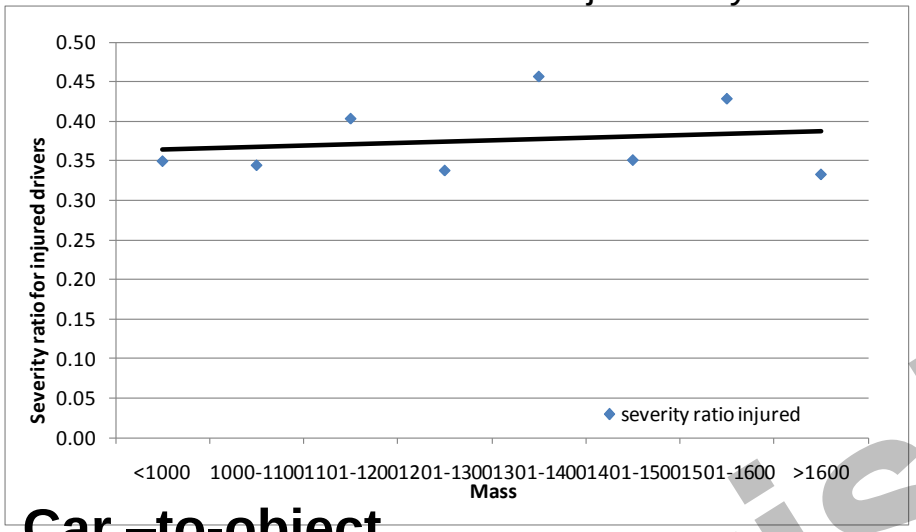
$$Severity\,ratio = \frac{Driver\ fatalities + Seriously\,injured\,drivers}{Fatal + Serious + Slight + uninjured\,drivers}$$

- Severity ratio generally seems to decrease with increasing mass
  - In Germany there is a clear trend for reducing severity ratio as mass increases
  - In France and GB, there is a slight trend towards lower severity ratios at higher masses

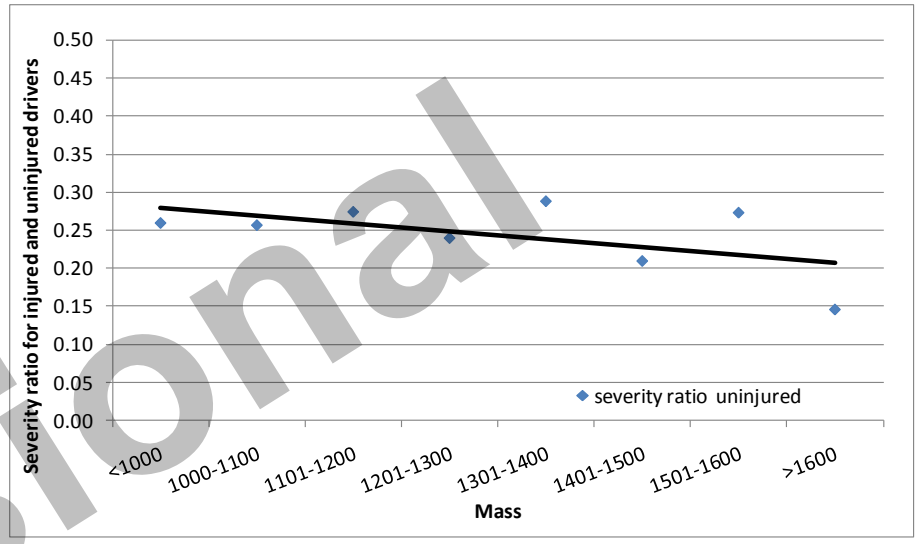
Severity proportion (self protection)

Car –to-car

France – R94 vs R94 – injured only

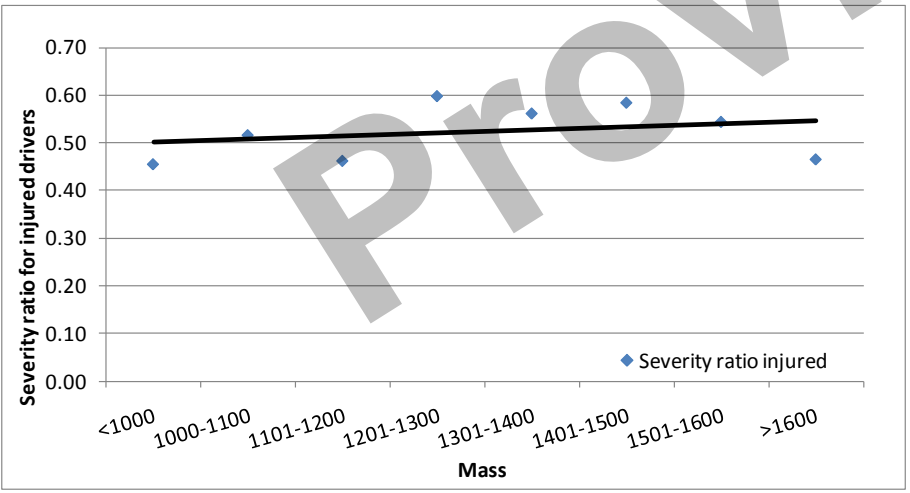


France – R94 vs R94 – injured and non-injured

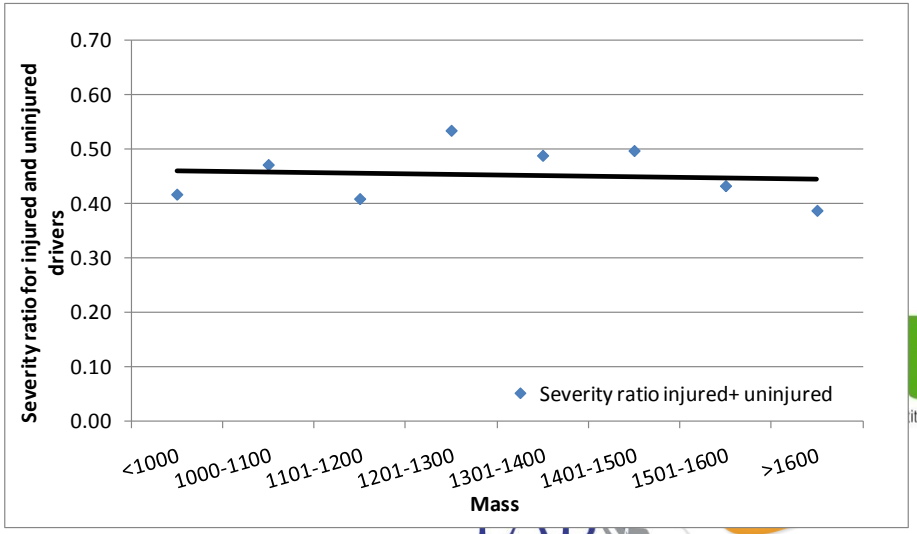


Car –to-object

France – R94 vs object – injured only

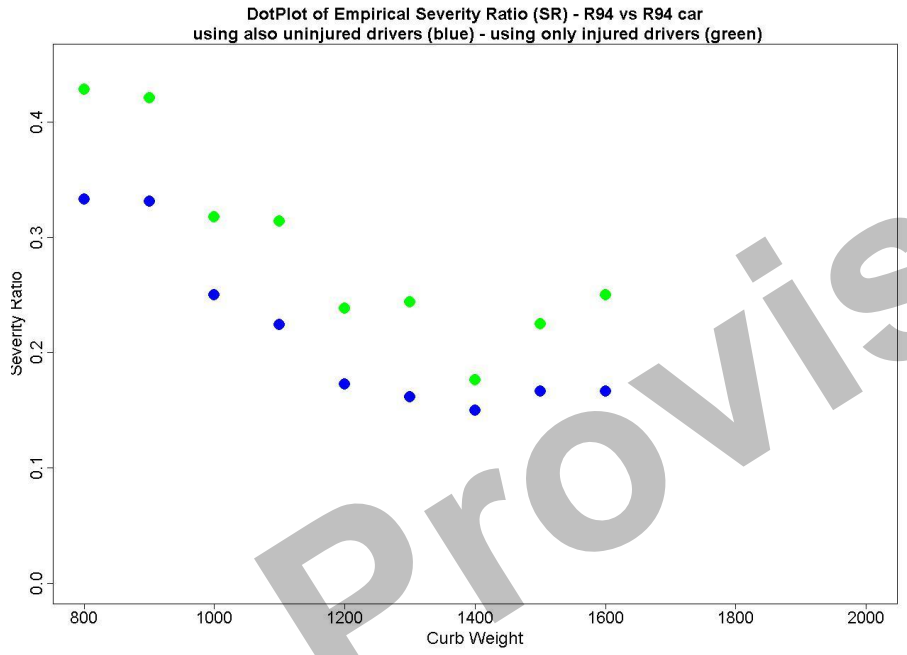


France – R94 vs object – injured and non-injured

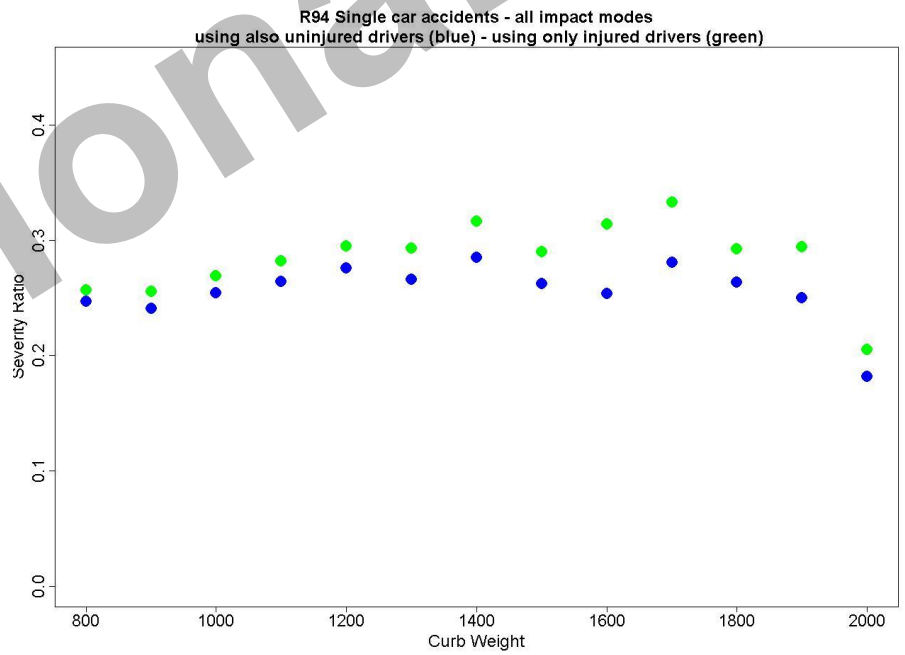


Severity proportion (self protection)

Germany – R94 vs R94



Germany – R94 vs object



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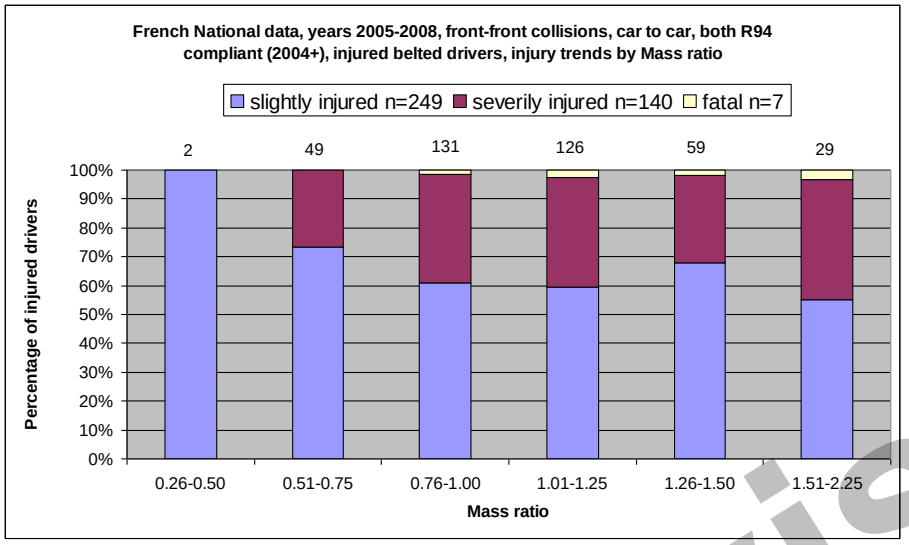
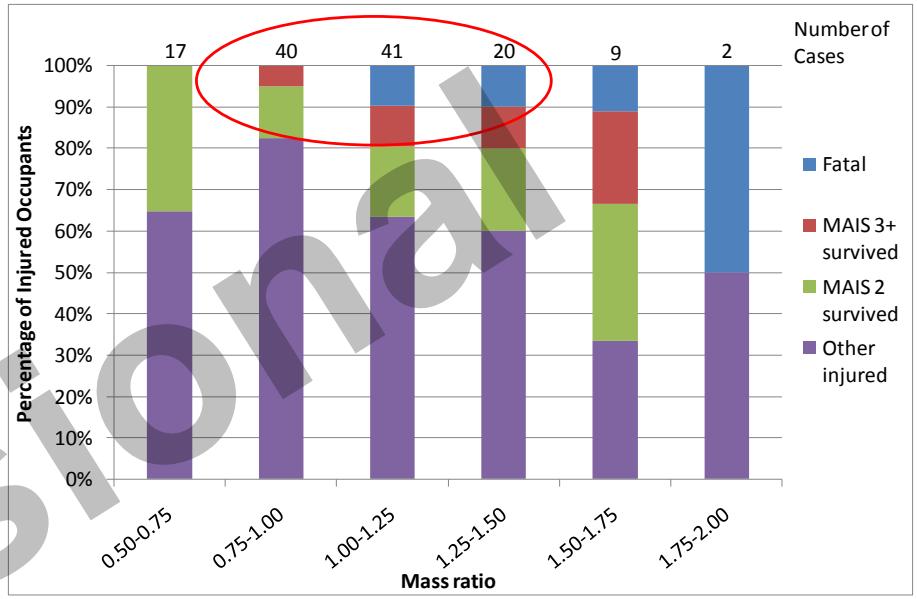
Mass ratio

France – R94 car-car



GB – R94 car-car



$$Mass\ ratio = \frac{Mass\ of\ other\ vehicle}{Mass\ of\ vehicle\ containing\ driver}$$

- Rate of severe or fatal injury increases as the mass ratio increases

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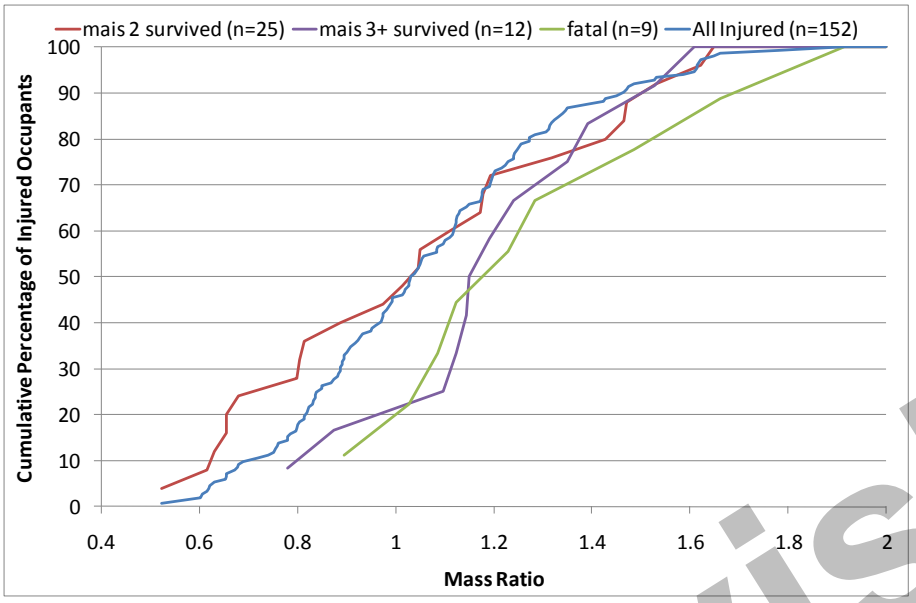
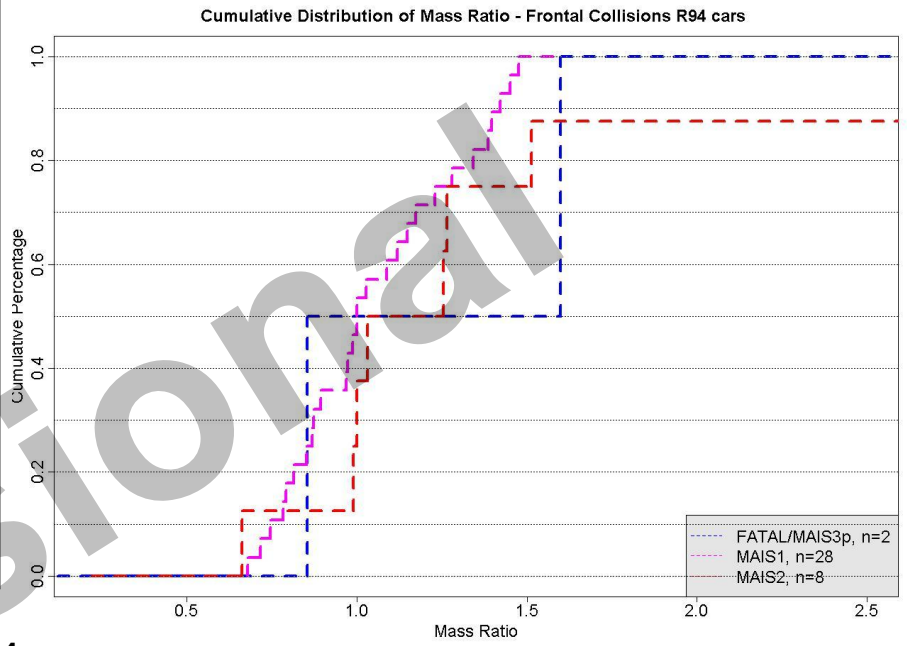
Mass ratio

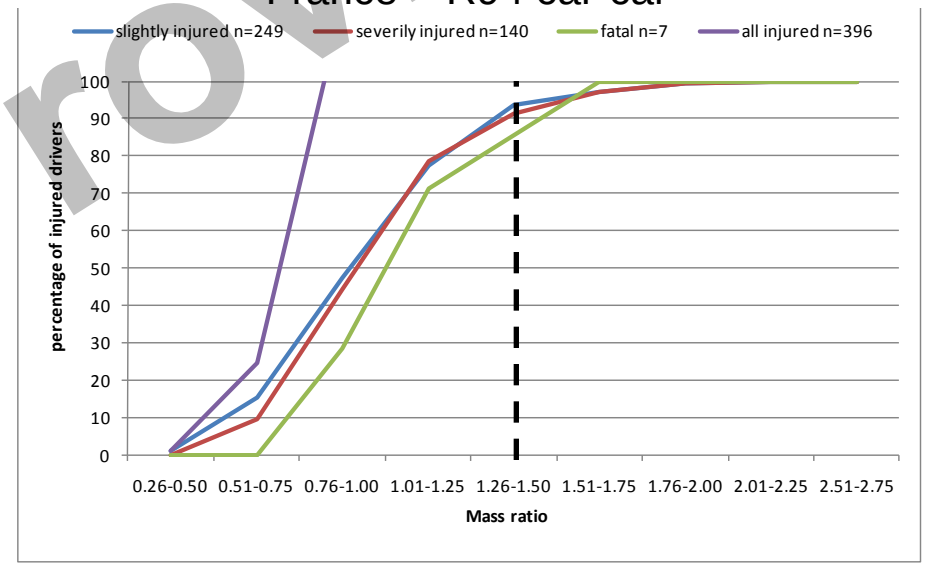
GB – R94 car-car



Germany – R94 car-car



France – R94 car-car



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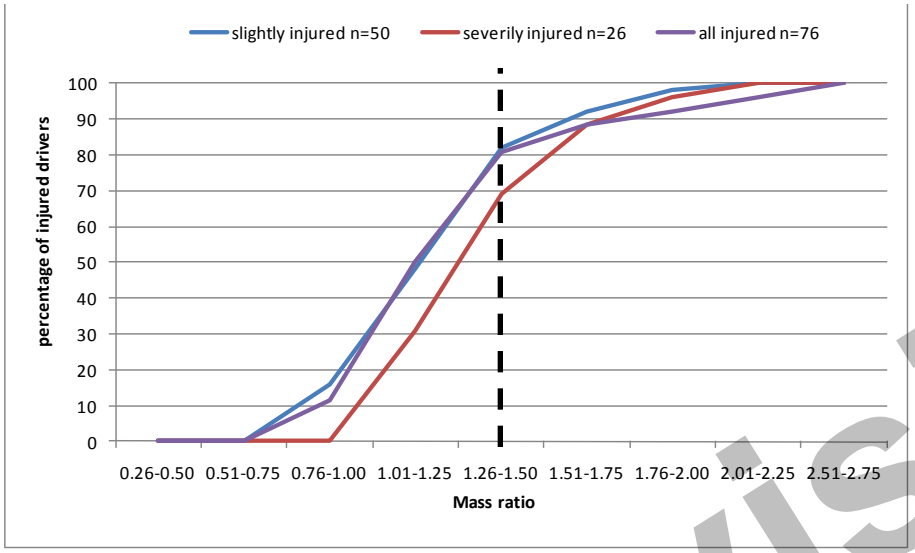
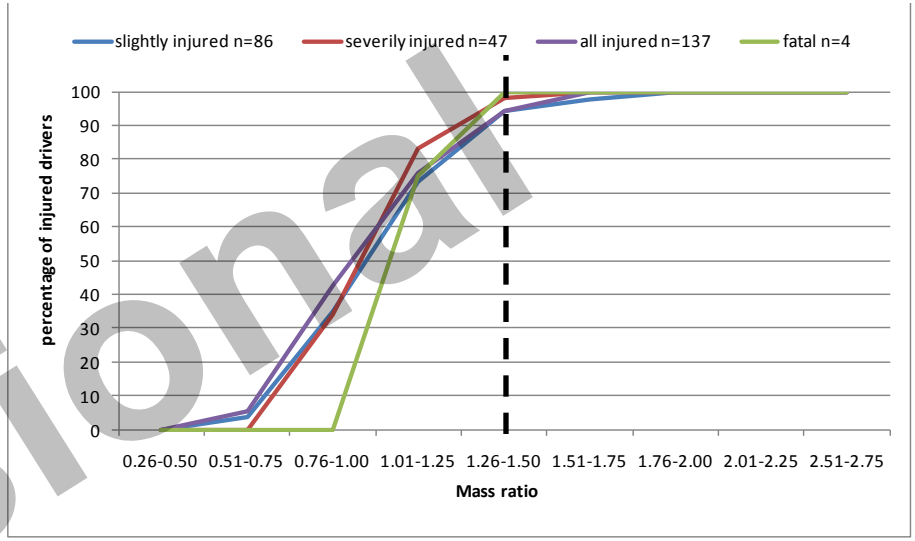
Mass ratio – France national data

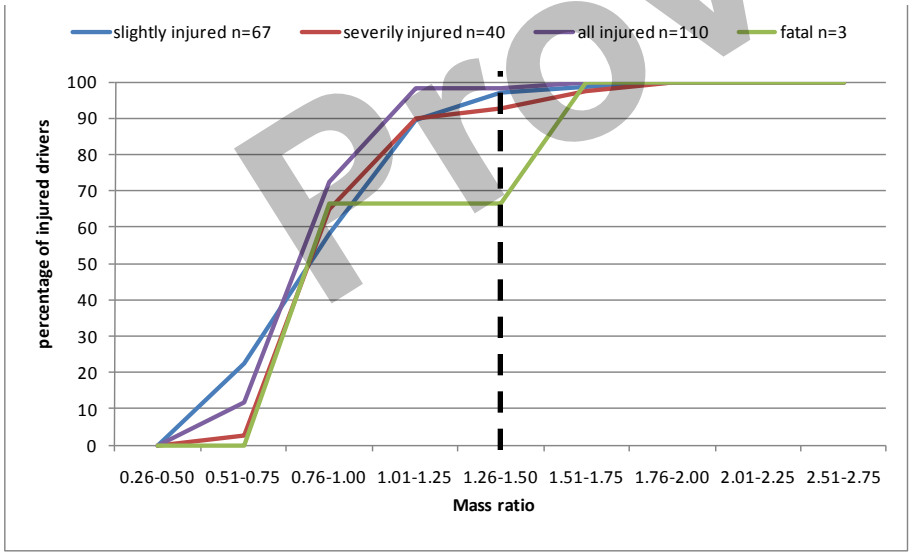
Cars < 1000 kg



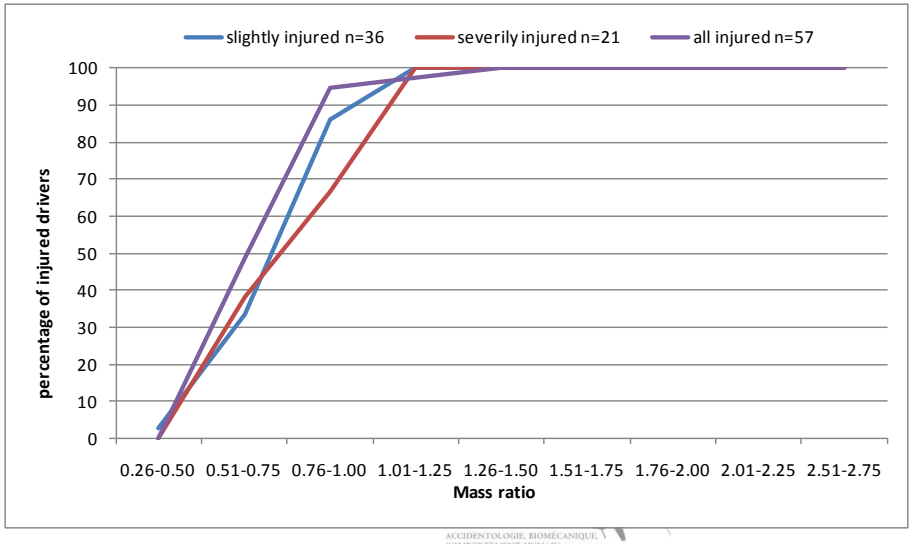
Cars 1000-1200 kg



Cars 1200-1400 kg



Cars 1400-1600 kg



Preliminary Conclusions

Frontal impact taxonomy

- Data sample
  - Only Regulation 94 compliant or equivalent vehicles considered
    - Exception car-to-car impacts where impact partner may be non R94 compliant
- Impact configuration
  - Impact partner
    - Car-to-car/LGV most frequent
      - » GB: 42% fatal, 52% MAIS 3+, 58% MAIS 2; Germany: 29% fatal, 68% MAIS 3+, 54% MAIS 2; France 28% fatal
    - HGV / Bus significant proportion of fatal
      - » GB 15%; Germany 16%; France 19%
  - Unbelted and rollovers
    - Target population reduced substantially with removal of unbelted and rollovers
      - » GB: 52% fatal, 74% MAIS 3+, 61% MAIS 2; Germany: 64% fatal, 78% MAIS 2; France 80%?? fatal
  - Overlap and longitudinal loading
    - Medium overlap most frequent followed by high and low, e.g car-to-car/LGV impacts for GB fatals
      - » Medium (1 rail represented by current ODB test) - 57%
      - » High (2 rails represented by full width test) – 34%
      - » Low (no rails represented by small overlap test) – 10%
  - Collision angle

    Majority of accidents are head-on, i.e. pdf 12 o'clock, although for Germany only 51% for MAIS 2
  - Severity
    - Current test severity addresses large proportion of impacts, e.g for car-to-car/LGV impacts
      - » EES ≤ 50 km/h addresses GB: 39% fatal; 83% MAIS 3+; 90% MAIS 2; Germany: 95% of MAIS 2
      - » EES ≤ 56 km/h addresses GB: 46% fatal ; 90% MAIS 3+; 95% MAIS 2; Germany 96% of MAIS 2

Preliminary Conclusions

Frontal impact taxonomy

- Population injured
  - Majority of drivers male, FSP female
  - Proportion of elderly (aged 66+) drivers and front seat passengers over-represented for fatalities
    - Car-to-car/LGV GB: 48% of fatal drivers ; 75% of fatal FSP but note that elderly over-represented in CCIS sample
- Injuries
  - Body distribution
    - In GB, the most frequent body regions injured at AIS 2+ are the thorax, legs, and arms, for all injury severities with the thorax the most frequent for fatal and the legs for other severities
      - For fatalities there are significantly more head injuries than for other injury severities
    - In Germany, for MAIS 2 occupants, the most frequent body region injured is the thorax, followed by the head and arms
  - Mechanisms
    - For GB fatal drivers, injuries are most frequently related to contact with intruding structures
      - A large proportion of fatalities had intrusion of 10 cm or greater, e.g. for car-to-car/LGV GB: 75% of fatal
    - For GB MAIS 2 drivers, injuries are most frequently related to the restraint system, or contact with non-intruding structures

Preliminary Conclusions

Frontal impact taxonomy

- Rear seat (GB analysis only)
  - Seat-belt use
    - Much lower than drivers and front seat passengers
  - Population injured
    - Majority of casualties are children or young adults of both gender
  - Injuries
    - Abdomen injuries appear to be more common for rear seat passengers in CCIS sample
- N1 vehicle fatalities (GB analysis only)
  - Much lower seat belt use than fatally injured front seat occupants of cars
  - Vast majority of fatalities are male (over 95%)
  - Fewer elderly fatalities (aged 66+) than in cars

Preliminary Conclusions

Detailed case analysis

- Fatals
  - Analysis found that primary factors were:
    - Severe crash / anomaly 17
    - Vulnerable occupant 13
    - Underride (mostly HGV) 10
    - Limited horizontal engagement 4
    - Other 4
  - Note: sample has bias to vulnerable occupants and HGV impacts
- Regulation 94 type impacts
  - In approximately 25% of cases examined the vehicle's compartment integrity was worse than expected
  - In approximately 12% of cases examined the occupant's injury was worse than expected
    - In all these cases the compartment performance was also worse than expected

Preliminary Conclusions

Compatibility

- Aggressivity metric
  - 'Aggressivity' of heavier/larger vehicles generally greater than lighter/smaller vehicles for all countries, although trend much more distinct for France and Germany than GB
    - For GB aggressivity of 'LCVs' and 'MPVs and 4x4s' surprisingly low compared to other classes of vehicles for 'R94 vs R94' age vehicle collisions
  - Agressivity for 'R94 vs R94' collisions lower than for 'R94 vs all vehicles' and 'all vehicles vs all vehicles' for France and GB, but for Germany this is not the case for all masses/sizes of vehicle
- Severity proportion
  - For Germany strong trend of higher severity proportion for lighter cars in 'car-to-car' collisions compared to no trend for 'car-to-object' collisions
  - For France weak trend of higher severity proportion for lighter cars in 'car-to-car' collisions compared to no trend for 'car-to-object' collisions only when severity proportion defined in one manner, i.e. 'uninjured' included in denominator
  - Notes:
    - Severity proportion is a blunt metric which will be subject to confounding factors
    - Significant differences between French and German national data such as the level of reporting of accidents with slight injuries is much less in France

Preliminary Conclusions

Compatibility

- Mass ratio
  - A mass ratio of 1.6 covers approximately 85% of fatalities and over 90% of serious injuries
  - For lighter cars a much higher mass ratio is needed to cover the same percentage of fatalities and serious injuries as for heavier cars. The main contributory factor to this is likely to be exposure (i.e. light cars generally impact heavier cars) although there could be other confounding factors (e.g. more older people drive lighter cars). Hence, provided the other confounding factors have little influence, this indicates that the mass ratio should be higher for lighter cars than for heavier cars is needed if the test is to be representative of the 'real world' situation.

Preliminary conclusions

Regulatory change implications

- Addition of Full Width test
  - Full width (2 rails) most frequent configuration following offset (1 rail), 34% of car-to-car/LGV fatals for GB
- Compatibility
  - Aggressivity metric illustrates degree of compatibility problem with larger/heavier vehicles up to 3 to 4 times more aggressive than smaller/lighter vehicles
  - Severity proportion metric shows compatibility problem clearly for Germany but result is not so clear for France
  - Mass ratio of 1.6 covers about 85% of fatal injuries and over 90% of serious injuries. For lighter cars a much higher mass ratio is needed to cover the same percentage of fatalities and serious injuries as for heavier cars. Assuming that mass ratio is the main contributory factor to the accident outcome, this indicates that a test in which the mass ratio is higher for lighter cars than for heavier cars is needed if the test is to be representative of the 'real world' situation.
- Population injured / injury region / dummy related
  - Majority of drivers male, FSP female
  - Proportion of elderly (aged 66+) drivers and front seat passengers over-represented for fatalities
  - Thorax body region is most frequently injured for fatal and MAIS 2+ injuries
- Extension of scope (N1)
  - For fatals (GB); low belt wearing rate compared to M1; different population (mainly male, less elderly)
  - Aggressivity for 2004+ aged vehicles less than large cars and comparable to small medium cars
- Rear seated occupants
  - Approx 10% of casualties; low belt usage rate compared to front seat occupants; different population (children and young adults); different injuries (more abdomen)– note limited sample size

Do You Have Any Questions?

Thank you

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