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frontal impact and compatibility assessment research

FI-10-07

SEVENTH FRAMEWORK PROGRAMME

FIMCAR Accident Analysis Report to GRSP frontal impact IWG Summary of findings

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October 14th 2010

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Objectives

- Determine if previously identified compatibility issues still a problem in current vehicle fleet
  - Structural interaction
  - Frontal force matching
  - Compartment strength in particular for light cars
- Determine nature of injuries and injury mechanisms
  - Body regions injured
  - Injury mechanism
    - Contact with intrusion
    - Contact
    - Deceleration / restraint induced

Note: Current fleet means cars which have full EU type approval or have safety performance level sufficient to meet UNECE R94 requirements

Accident Databases

- CCIS UK (Cooperative Crash Injury Study)
  - TRL
- GIDAS (German In-Depth Accident Survey)
  - BASt
- PENDANT (Pan European Accident Database)
  - Chalmers

Selection Criteria

Initial selection

- Car involved in ‘significant’ frontal impact
- Car manufactured 2000 onwards
  - Registered October 2003 -> compliant with R94
  - Registered Jan 2000 to September 2003 -> may be compliant with R94
    - Assessment of possible compliance made
- Front seat adult occupants (over 12 years old)

Subsequent analysis

- Belted occupants only
- MAIS2+ injured occupants only

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Sample size*

*Includes unbelted occupants for direct sample size comparison purposes

- CCIS

	Fatal	MAIS2+ Survived	MAIS 1	*Total*
Car - Wide object	28	76	163	267
Car - Narrow object	3	30	82	115
Car - Car	28	269	842	1139
Car - Light Goods Vehicle	3	35	73	111
Car - HGV / PSV	21	53	69	143
Car - Other	0	3	7	10
Total	83	466	1236	1785

- GIDAS

	MAIS2+	MAIS1	Uninjured	Unknown	Total	Fatalities (subset)
CAR_CAR	92	499	724	25	1340	6
CAR_HGV	20	49	21	13	103	3
CAR_OBJ	57	142	276	14	489	7
CAR_OTH	2	11	657	2	672	0
Total	171	701	1678	54	2604	16

Dataset characteristics (Overlap belted occupants)

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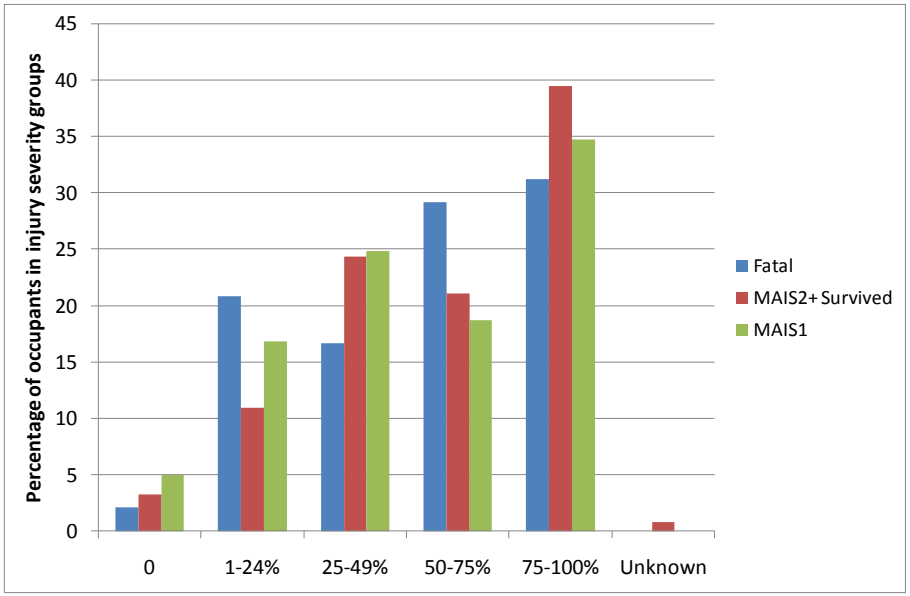
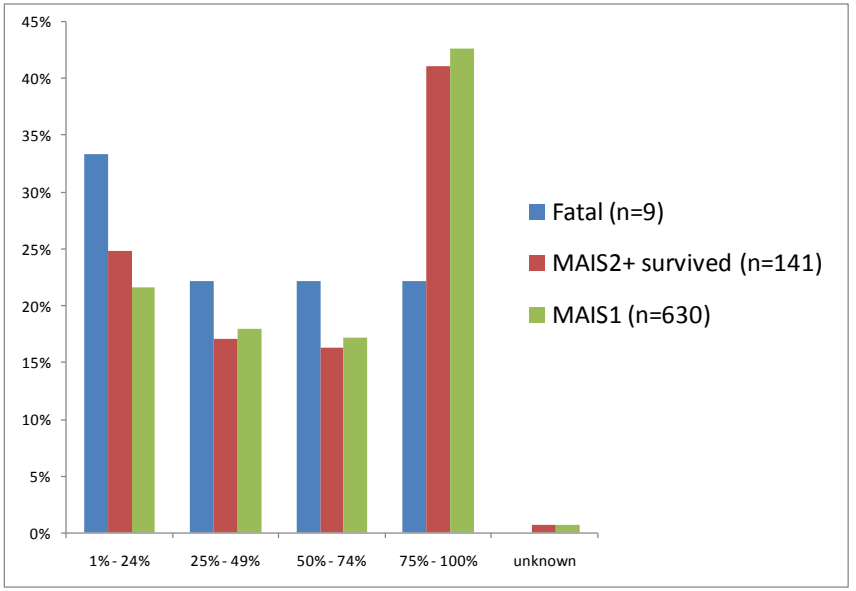
CCIS



GIDAS



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Analysis of compatibility issues

- Compartment strength
- Structural interaction
- Injury distribution / mechanisms

Compartment strength methodology

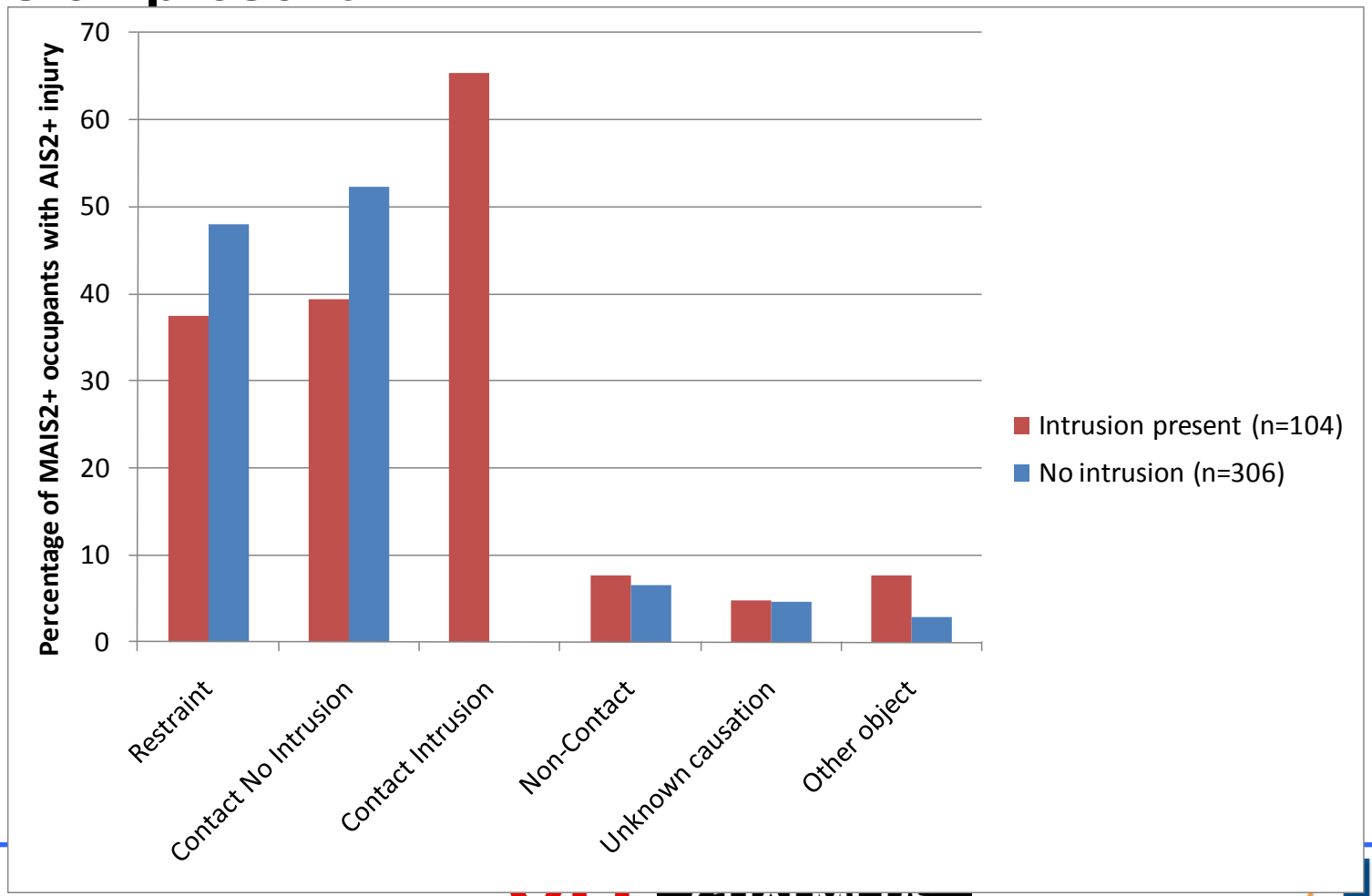
- Select belted adult front seat occupants with MAIS2+ injury
- Investigate what proportion of cases where intrusion into occupant compartment present on same side of vehicle as occupant
  - Intrusion considered to be >10cm at footwell, dashboard or A-pillar
- Assess how this relates to accident characteristics (vehicle mass, speed, overlap)
- Investigate occupant injury causation
  - Did intrusion directly cause AIS2+ injury?

CCIS Proportion of cases with intrusion

- Belted adult front seat occupants in car in frontal impact; Registered 2000 on; Reg 94 compliant cars; MAIS 2+
- Vehicle sustained intrusion ≥ 10cm on occupant side

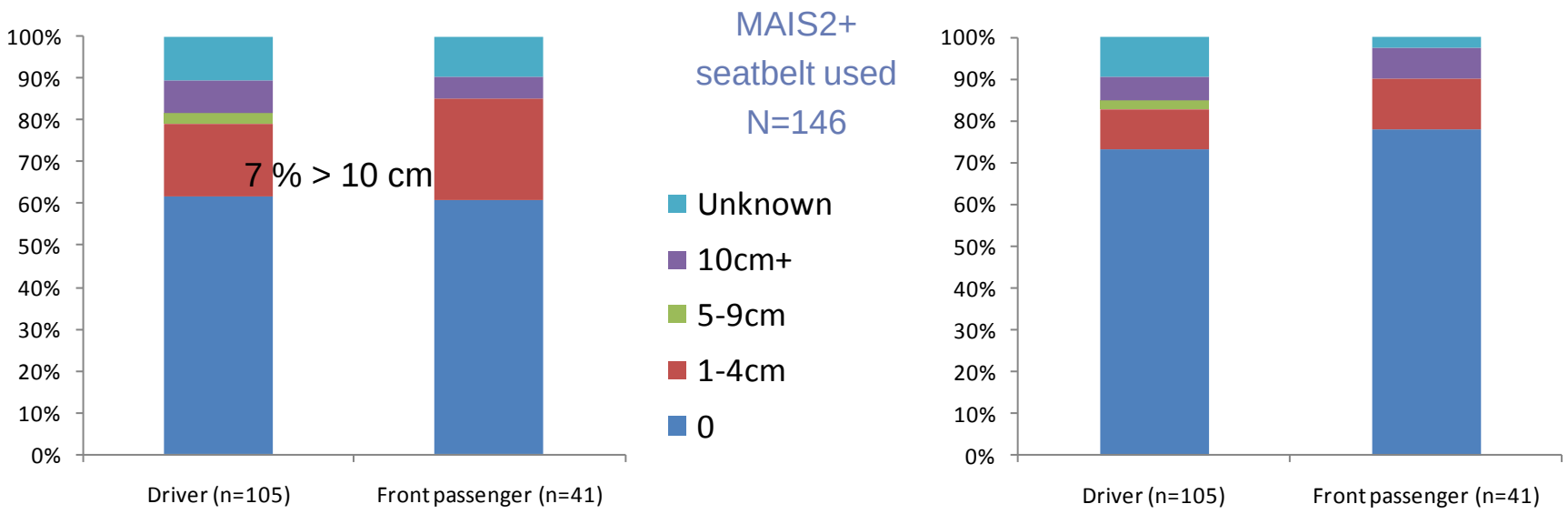
	Fatal		MAIS2+ Survived		Overall	
	No. of occupants	**% of cases with intrusion**	No. of occupants	**% of cases with intrusion**	No. of occupants	**% of cases with intrusion**
Car - Wide object	9	55.6	50	20.0	59	25.4
Car - Narrow object	1	100.0	16	18.8	17	23.5
Car – Car	23	56.5	226	21.2	249	24.5
Car - Light Goods Vehicle	2	50.0	31	22.6	33	24.2
Car - HGV / PSV	13	53.8	39	23.1	52	30.7
Car - Other	0	0	3	0	3	0.0
Total	48	56.3	365	21.1	413	25.2

CCIS injury causation for vehicles with intrusion / no intrusion present

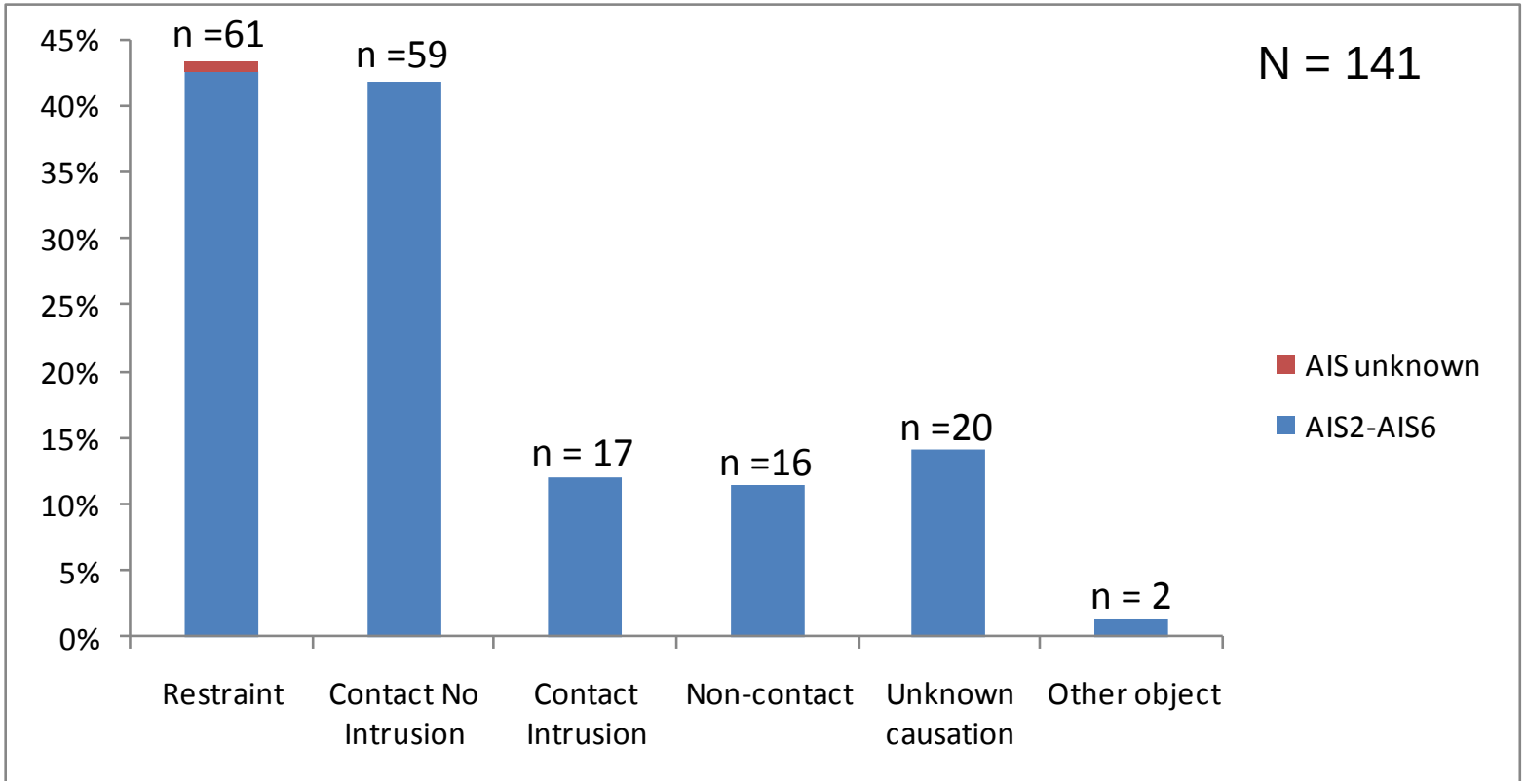


GIDAS intrusion

- Proportion of door opening reduction (DOR) showed 7% of drivers with MAIS 2+ injury in cars with >10cm DOR on occupant side



GIDAS Injury causation



Occupants with injuries caused by contact with intrusion CCIS (16%), GIDAS 12% of MAIS 2+ injured occupants

Structural interaction methodology

- Investigation of structural interaction problems
  - Identify accident subset where it is possible to observe structural interaction problems
    - Cases where intrusion present
      - Only in these cases can definitely identify whether or not structural interaction has been a problem
    - Quantify in how many of these cases a structural interaction problem is seen
- Investigation of frontal force matching issues
  - Identify car to car frontal-frontal impacts where one vehicle sustained significantly more intrusion than partner vehicle
- Can only be achieved with detailed individual case analysis

CCIS Fatal case analysis

- Out of 48 fatal occupants, 28 (56%) had intrusion present on their side of the vehicle
- Structural interaction issues observed in 31% of fatal car to car cases (n=28) where intrusion present
- Frontal force mismatch observed for 1 out of 13 fatally injured occupants in car to car cases where intrusion present

CCIS MAIS2+ Survived case analysis

- 38 occupants in car to car front-front cases (both cars R94 compliant) investigated
  - 31.6% had intrusion
- 66 occupants in car to object cases (R94 compliant cars) also investigated
  - 19.7% had intrusion

- Poor structural interaction is most typical compatibility issue (64%) among car to car accidents
  - Resulting in injuries caused mainly by intrusion (low overlap and overriding)
- Fork effect rarely caused intrusion and most of injuries were result of contact with no intrusion
- Compartment strength issue without poor structural interaction seen in only two of 33 cases
- Force mismatch occurred in 7 of 33 cases (28%)

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Case example – Poor structural interaction between similar cars

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V1 – Ford Mondeo (2002)

1423kg kerb mass
51% overlap
26km/h ETS
19cm Facia intrusion (n/s)
17cm Footwell intrusion (n/s)
Driver (Male, 32)
MAIS2 Shoulder

V2 – Ford Mondeo (2001)

1384kg kerb mass
50% overlap
46km/h ETS
90cm Facia intrusion (n/s)
118cm Footwell intrusion (n/s)
Driver (Male, 53)
MAIS5 Chest

V1 Mondeo overrode V2 Mondeo, leading to compartment collapse in V2. V2 driver sustained MAIS5 chest injury despite most intrusion on opposite side of compartment

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Case example – Frontal force mismatch

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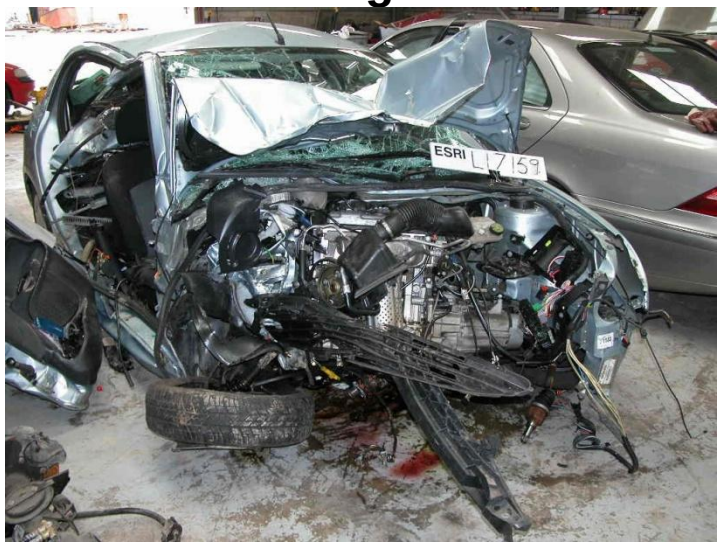
V1 – Peugeot 206



910kg kerb mass
67% overlap
59km/h ETS
29cm Facia intrusion (o/s)
19cm Knee Contact intrusion (o/s)
Driver (Female, 68)
MAIS5 Thorax & AIS4 Head

V2 – Mercedes

1925kg kerb mass
57% overlap
28km/h ETS
No intrusion

Driver (Female, 40)
MAIS1 Thorax

V1 overcrushed by V2 resulting in compartment collapse in V1

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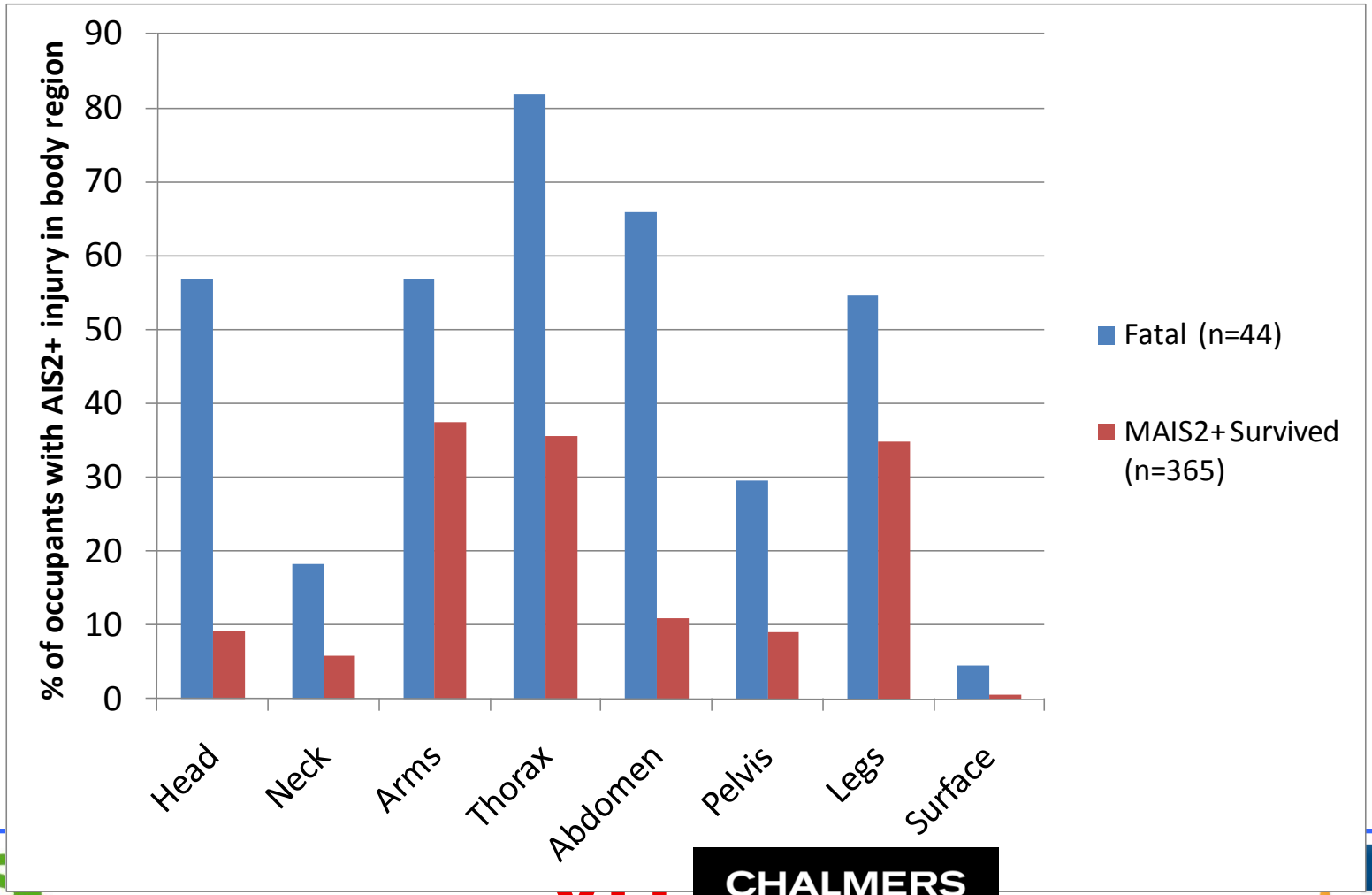
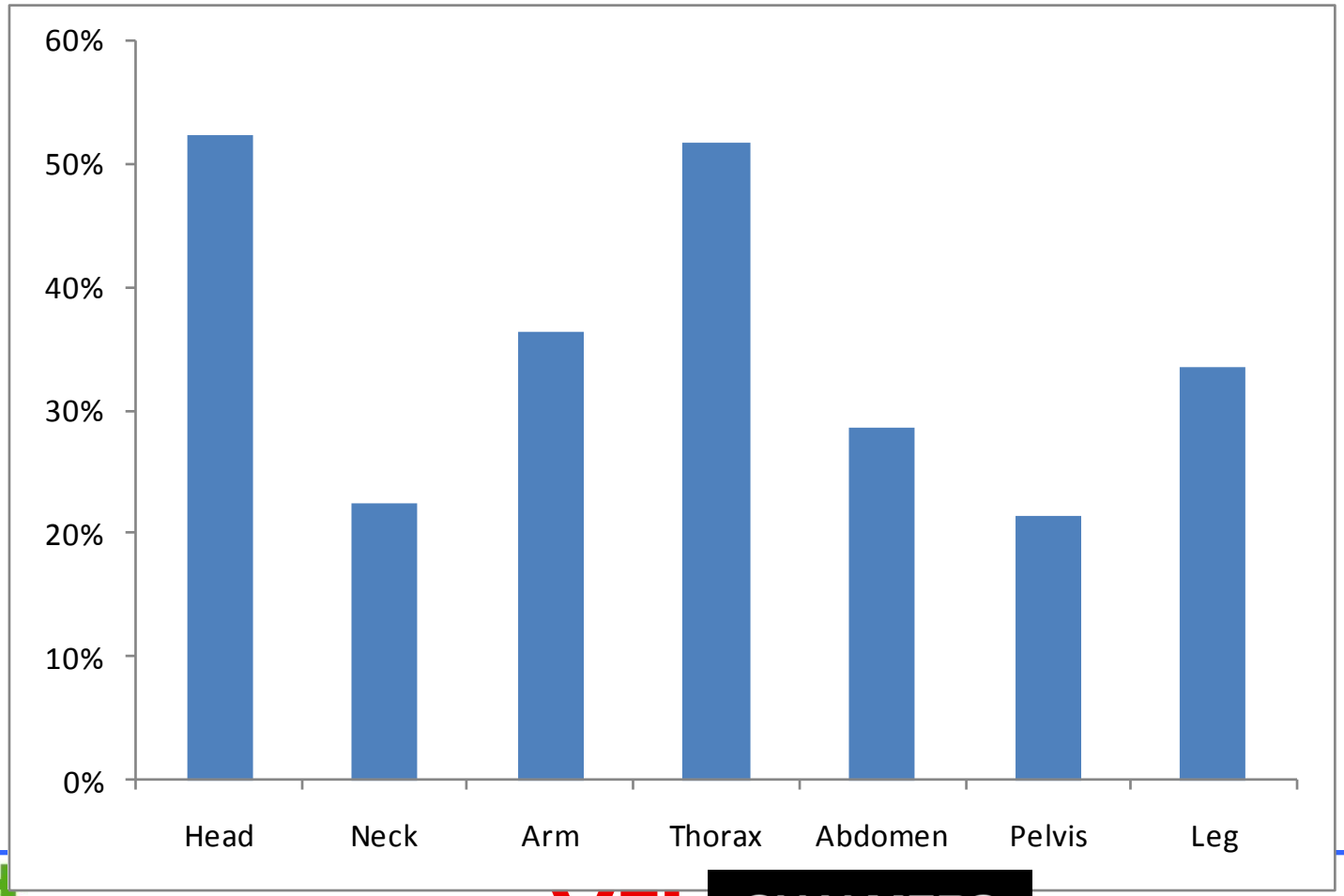
Injury distributions

- Select MAIS2+ injured occupants
- Investigate distribution of AIS2+ injuries by body region
- Investigate factors such as age, gender, accident type and seating position to identify any correlations with injuries to body regions

CCIS AIS2+ Body injury distribution



GIDAS AIS2+ Body injury distribution



Final Conclusions – Compatibility Issues (1)

- Poor structural interaction between vehicles, in particular low overlap and over/underriding of car fronts, has been identified as an issue in the current vehicle fleet.
  - In CCIS, poor structural interaction observed in 64% of MAIS2+ Survived car to car cases and 31% of fatal car to car cases where intrusion was present

- Frontal force mismatch between cars in the current fleet has also been identified, although this appears to be less of an issue than poor structural interaction.
  - Force mismatch identified in 28% of MAIS2+ Survived car to car cases and 8% of fatal car to car cases where intrusion present

Final Conclusions – Compatibility Issues (2)

- Compartment strength of vehicles is still an issue in the current vehicle fleet. However, further work is required to investigate if it is more of a problem for small cars than it is for larger cars.
  - Occupants with injuries caused by contact with intrusion CCIS 16%, GIDAS 12% of MAIS 2+ injured occupants
- Compartment strength is a particular problem in collisions with HGVs and objects, with these collisions having a high proportion of fatal and MAIS2+ injuries
  - In CCIS, 31% of car-HGV cases resulted in intrusion in the car, compared to 25% for car to car cases
  - In GIDAS, 20% of Car-HGV cases had MAIS2+ injury severity for the car occupant, compared with 7% for car to car cases

Final Conclusions – Injury Patterns (1)

- AIS2+ injuries resulting from deceleration loading of the occupant by the restraint system are present in a significant proportion of frontal crashes, regardless of whether intrusion was present or not
  - Over 40% MAIS2+ occupants sustained AIS2+ injury attributed to restraint loading in both CCIS and GIDAS datasets

- AIS2+ injuries to the Thorax are the most prevalent. AIS2+ injuries are also frequently sustained by the Head, Legs and Arms
  - Over 80% fatally injured occupants and 35% MAIS2+ Survived occupants sustained AIS2+ Thorax injuries in CCIS

- AIS2+ injuries resulting from contact with the intrusion occur in a large proportion of cases where compartment intrusion is present
  - 65% of MAIS2+ occupants in cars with intrusion sustained AIS2+ injury attributed to contact with intrusion (CCIS)

Final Conclusions – Injury Patterns (2)

- High proportion of fatal and MAIS2+ injuries in cases with high overlap (>75%)
  - In GIDAS, 41% of MAIS2+ Survived were in high overlap cases
  - In CCIS, 40% of MAIS2+ Survived and 31% of fatal occupants were in crashes with high overlap
  - In GIDAS, 25% of MAIS2+ Survived were in low overlap cases indicating possible low overlap issue. However, much lower percentage seen in CCIS.

- Greater proportion of fatal and MAIS2+ injuries for elderly occupants compared with other age groups
  - Occupants over 60 years old represent18% of injured occupants in CCIS dataset
  - However, over 60s account for 52% of fatalities and 25% of MAIS2+ Survived occupants in CCIS dataset

Way Forward

- Additional restraint injury investigation
  - When do restraint injuries occur?
- ‘Matched pair’ analysis (compartment strength) with detailed and national accident databases
  - Is compartment intrusion a bigger issue for light vehicles compared to heavier vehicles?