



EUROPEAN ENHANCED VEHICLE-SAFETY COMMITTEE

**EEVC Working Group 13 Report.
Head Contacts In Side Impact - An Accident Analysis
February 2001**



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Head Contacts In Side Impact - An Accident Analysis

An EEVC Working Group 13 Report.

1. INTRODUCTION

In 1989, the European Enhanced Vehicle-Safety Committee (EEVC) proposed a full-scale side impact test procedure in which a vehicle, complete with a EuroSID dummy, was impacted by a mobile barrier onto which was attached a deformable element. Accident analyses have demonstrated that occupants in a side impact often suffer serious or fatal head injuries, some of these being from contact with the interior of the vehicle. A full-scale test can only assess one contact point, assuming head contact on the vehicle structure occurs in the test. Consequently, EEVC recommended that a supplementary interior headform test be developed to evaluate the protection afforded by the vehicle interior at a range of locations that can be contacted in side impact accidents.

This study will assist in defining the parameters required for a European test procedure for interior head protection in side impact.

The objective of this study was to determine the range of head impact locations observed in real world crashes to aid the specification for the impact test locations. Four organisations have supplied data for the study:

1. TRL - Data from the Co-operative Crash Injury Study (CCIS) in the UK,
2. BASt - Medical University of Hannover database in Germany,
3. LAB PSA-Renault - A retrospective accident analysis in France.
4. NHTSA - NASS files in the US.

The data have been analysed to determine the most important impact areas in terms of frequency of contact in accidents. The influence of intrusion on the severity of injuries also has been analysed. Different sampling strategies and contact classifications have been used for each database, therefore it is not valid simply to add the data together to make a single large database. However, each sample can be used to give evidence of the head contact sites observed in side impacts according to its own sampling and categorisation methods. Conclusions can be drawn with greater confidence where the distribution of contacts across more than one of the four samples is similar.

2. SIDE IMPACT ACCIDENT DATA

2.1 DEFINITION OF SIDE IMPACT

The data has been gathered in accordance with a pro-forma developed by the Transport Research Laboratory. Each database was analysed for all non-rollover, single-impact, side-impact accidents, and uses a clock method to describe the principal direction of force. Side impact was classified as an impact occurring between 2 and 4 o'clock, and 8 and 10 o'clock at any point on the side of the vehicle. To eliminate frontal and rear impacts, the point of contact was specified as being to the side of the struck vehicle, Figure 1. The search was confined to accidents, in which occupant(s) sustained a head injury. Front and rear seat occupants were analysed separately. Occupants were predominantly adult, but covered the full range of ages.

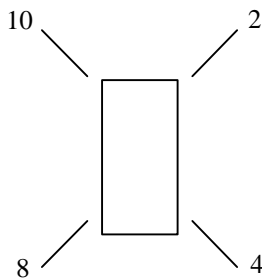


Figure 1 - Clock System used in the CCIS Database

2.2 DATABASE OUTPUTS

The important outputs from the search were:

- Side of Impact (Left/Right)
- Occupant Side (Passenger/Driver)
- Struck Side Occupant (Yes/No)
- Restraint Use (Yes/No/Claimed)
- Collision Deformation Classification (CDC)
- Head Contact (Location)
- Head Severity (In terms of AIS)
- Intrusion (Supported/Unsupported/None)

2.3 DEFINITION OF HEAD IMPACT SITES

The data was analysed for restrained and unrestrained occupants on the struck side, and non-struck side.

The codes used in the databases are explicit, however there are a few exceptions that require further classification:

- **External Object** - The head injury was caused by a contact with an object such as a tree, lamp post, or another vehicle. Three scenarios exist for this code. In the majority of these cases, the occupant would be partially or fully ejected, and the head contact occurred outside of the vehicle. The second scenario is that the external object loads the side of the vehicle, causing the side glass to break. The occupant is not ejected but the head contacts the external object, which has now replaced the position of the side glass. Finally, the head could contact an external object, which has penetrated the vehicle. This code appears in the TRL, BASt and LAB data only (no fully ejected occupants in LAB data).
- **Side Glass** –Head Injury was caused by contact with the side glass. In low severity impacts the glass can remain intact, but during more severe impacts the head contact causes the glass to break. This code was used by the TRL, BASt and LAB databases.
- **Occupant Contact*** – The injury was caused by the occupant’s head striking another occupant in the vehicle, and was used by the TRL and BASt databases.
- **Side Other** – This code suggests a contact anywhere on the side of the vehicle that is not already coded. This code usually suggests the door, but is not limited to contacts in front of the B Pillar. This code was used by the TRL, BASt and LAB databases.
- **Unknown** – Injury was caused by a contact, but the contact region could not be identified. Unknown head contact sites were recorded in the TRL and LAB data only.
- **Non-contact injury** – This is separate from an unknown contact region. The injury sustained was not caused by a contact. Only the TRL databases recorded this type of head injury.
- **B Pillar** - This does not include the upper anchorage point, in the TRL and BASt data, where a separate code exists.
- **Window Frame** - This is a code used solely by the Renault-PSA LAB database.

*This code is additional to those used in the TRL (CCIS) database. It was devised for the purposes of this study and evolved from a case by case analysis.

The following groupings have been used:

VEHICLE STRUCTURE	VEHICLE GLAZING	NON VEHICLE
Airbag	Side Glass	External Object
A Pillar	Flying Glass	Occupant Contact
B Pillar	Windscreen	
Facia Top		
Header		
Head Restraint		
Mirror		
Seat		
Side Roof Rail		
Steering Wheel		
Sunroof		
Roof		
Upper Anchorage Point		
Window Frame		

For each stage of the analysis, the frequency and severity of contacts for each region are presented in the form of tables. The most frequent contacts on the vehicle structure are also presented pictorially to show the specific point of contact, when so recorded. This information was established from individual case reports. Where conclusive forensic

evidence of a head contact on the vehicle structure is found, the contact regions are shown graphically. In cases where this type of evidence could not be found, the investigator used all the other circumstantial evidence such as type of injury, and direction of force to establish the most likely contact region. In this instance, the contact region is coded but is not graphically illustrated. Illustrations in the sections that follow show the number of contacts to a specific region. This refers only to the number of contacts in which forensic evidence was found and is therefore often less than the total number of contacts for each region as given in the corresponding tables.

2.4 ACCIDENT SAMPLES

2.4.1 FRONT SEAT OCCUPANTS

Front seat occupant data was obtained from the TRL, BAsT, LAB and NHTSA accident databases for occupants that received a head injury in a side impact. In total there are 965 cases for analysis. In 197 of these the occupant sustained a serious head injury. The number of cases, which met the selection criteria, is shown for each database, in Table 1.

DATABASE	TRL		BAsT		LAB		NHTSA	
AIS	3+	1+	3+	1+	3+	1+	3+	1+
Totals	89	408	33	93	30	304	45	160

Table 1 - Number of Cases in which Front Seat Occupants Sustained Head Injuries in Side Impact

2.4.2 REAR SEAT OCCUPANTS

Data for rear seat occupants was collected from TRL, BAsT and LAB. In this study, a total of 113 rear seat occupants received a head injury in side impact. Of this, 95 occupants sustained minor head injury and 18 incurred serious head injury, shown in Table 2.

DATABASE	TRL		BAsT		LAB	
AIS	3+	1+	3+	1+	3+	1+
Totals	10	62	1	6	6	41

Table 2 - Head Injuries to Rear Seat Occupants in Side Impact

3. RESULTS OF ANALYSIS

3.1 GENERAL

This section analyses each individual database, in terms of restraint use and occupant position. This approach was taken as different sampling strategies were used in each database. For example, the TRL and BAST data include injury contacts to a greater range of locations on both the vehicle structure and glazing in addition to non-vehicle contacts. However the LAB data consist of fewer locations on the vehicle structure. It is assumed that those contact sites not covered have been omitted from the recording strategy, for this study. The NHTSA database includes contacts to three locations on the vehicle structure only. All other contact sites were omitted from their investigation.

3.2 FRONT SEAT OCCUPANTS

In Europe, it is a legal requirement that vehicle occupants wear a seat belt at all times with certain limited exceptions. Belt use can only be positively established where conclusive evidence has been found. It should be noted that there are a number of cases in the TRL and BAST data where belt use could not be ascertained. These cases have been excluded from section 3, except where all front seat occupants are considered.

3.2.1 HEAD CONTACT FOR RESTRAINED FRONT SEAT OCCUPANTS

3.2.1.1 Struck Side Occupants

Contacts on the vehicle structure for restrained struck side occupants are listed below, Table 3. The specific points of contact when known, are illustrated on Figures 2-5.

Contact Site	TRL		BAST		LAB		NHTSA	
	AIS 3+ No.	AIS 1+ No.	AIS 3+ No.	AIS 1+ No.	AIS 3+ No.	AIS 1+ No.	AIS 3+ No.	AIS 1+ No.
Non Contact Injury	0	4	1	2				
Airbag	0	1	0	0				
A Pillar	2	6	1	1	0	0	5	22
B Pillar	1	13	7	11	2	19	16	39
External Object	18	30	5	8	8	13		
Facia Top	0	1	0	0				
Flying Glass	0	11	0	3				
Head Restraint	0	1	0	0				
Side Roof Rail	6	8	0	4	0	10	7	24
Side Glass	2	52	2	6	0	52		
Side Other	3	4	1	4	0	0		
Steering Wheel	1	3	0	1				
Sunroof	0	1	0	0				
Roof	0	0	1	2				
Upper Anch' Point	0	1	0	1				
Windscreen	0	2	0	0				
Occupant Contact	1	1	0	0				
Window Frame					0	8		
Unknown	8	37			0	8		
Total	42	176	18	43	10	110	28	85

Table 3 - Head Contact Regions for Restrained Struck Side Occupants

Shaded areas denote contact site not recorded

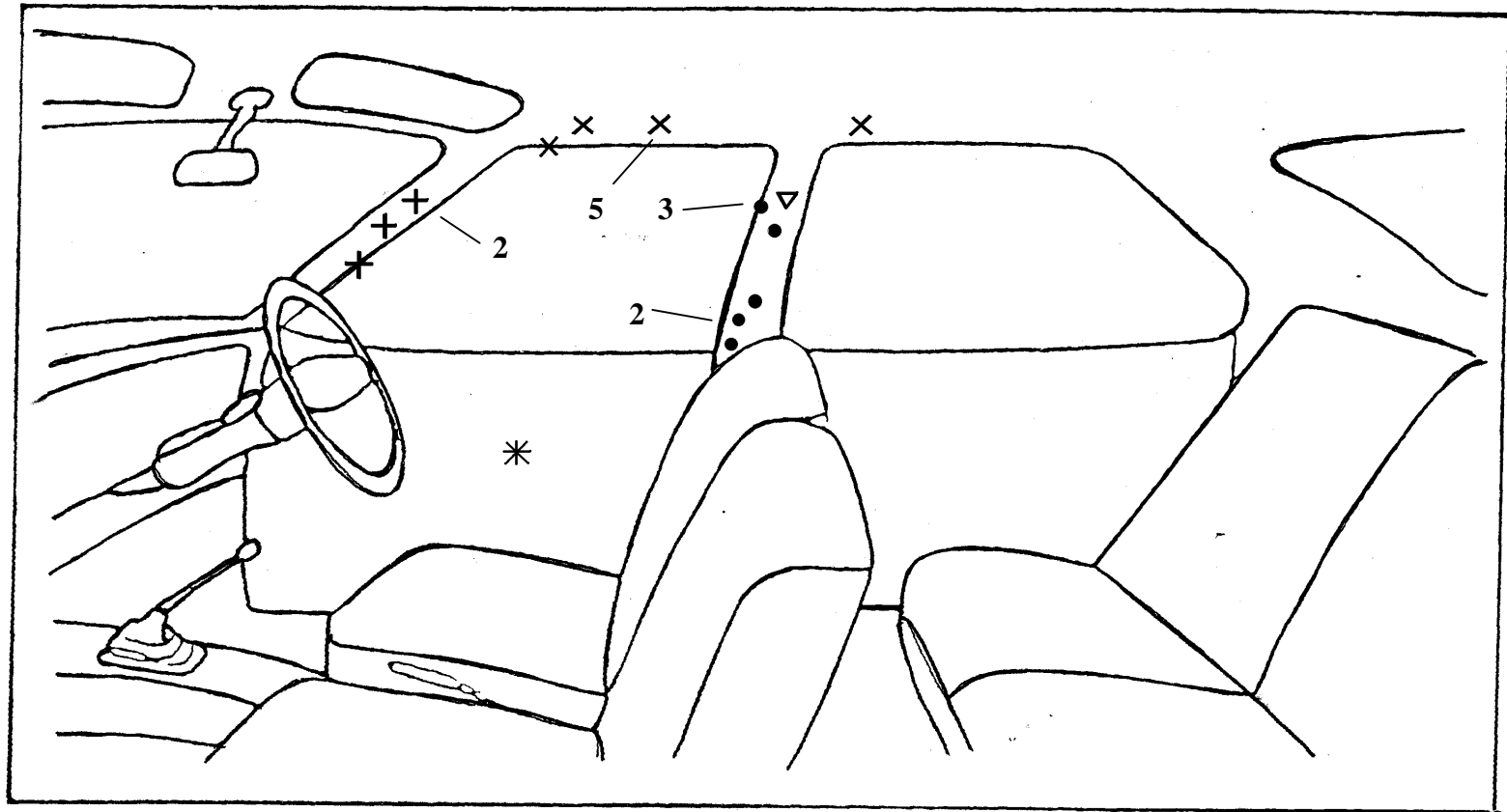


Figure 2 - Graphical Representation of Frequent Head Contact Regions, Front Seat, Restrained Struck Side Occupants - TRL Data

Key	Contact Region	Total in figure	Total no of contacts	Key	Contact Region	Total in figure	Total no of contacts	Key	Contact Region	Total in figure	Total no of contacts
●	B Pillar	8	13	▲	Header	0	0	▽	Upper Anchorage	1	1
+	A Pillar	4	6	#	Facia Top	0	1	■	Steering Wheel	0	3
	Side Other	1	8	O	Roof	0	0	◆	Head Restraint	0	1
	Side Roof Rail	8	8								

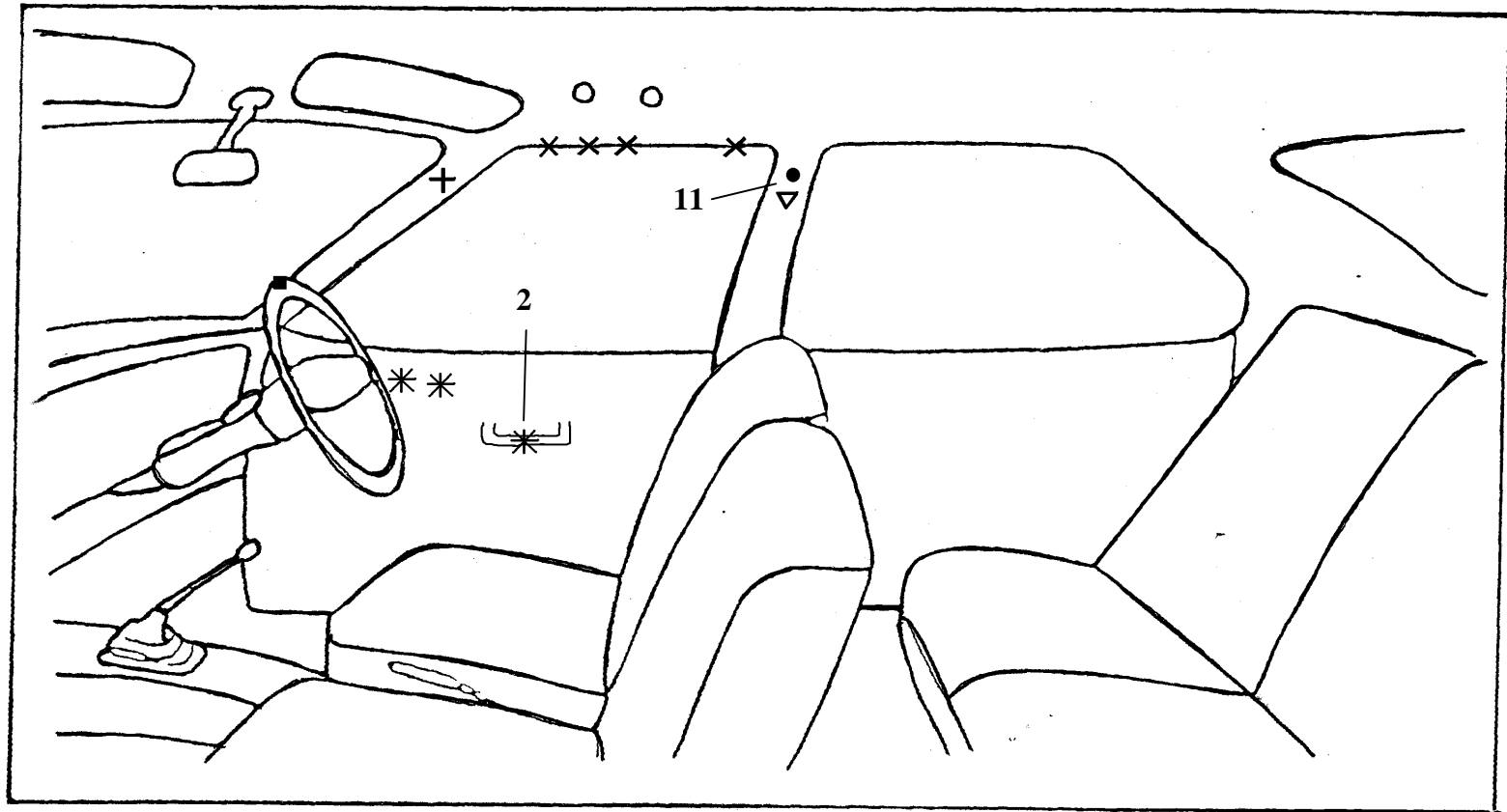


Figure 3 - Graphical Representation of Frequent Head Contact Regions, Front Seat, Restrained Struck Side Occupants - BAST Data

Key	Contact Region	Total in figure	Total no of contacts	Key	Contact Region	Total in figure	Total no of contacts	Key	Contact Region	Total in figure	Total no of contacts
●	B Pillar	11	11	▲	Header	0	0	▽	Upper Anchorage	1	1
+	A Pillar	1	1	#	Facia Top	0	1	■	Steering Wheel	1	1
	Side Other	4	4	O	Roof	2	2	◆	Head Restraint	0	0
	Side Roof Rail	4	4								

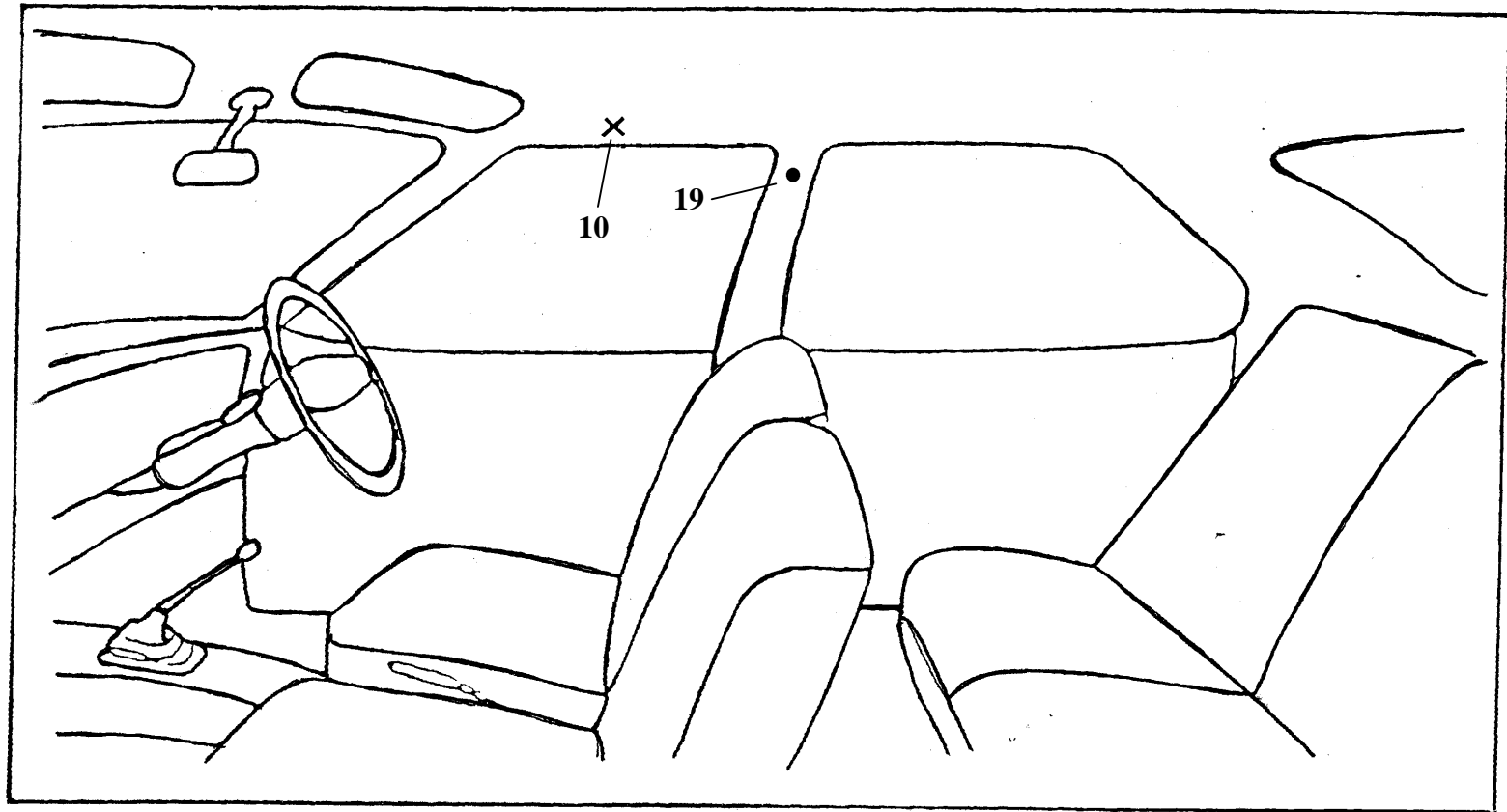


Figure 4 - Graphical Representation of Frequent Head Contact Regions, Front Seat, Restrained Struck Side Occupants - LAB Data

Key	Contact Region	Total in figure	Total no of contacts	Key	Contact Region	Total in figure	Total no of contacts	Key	Contact Region	Total in figure	Total no of contacts
●	B Pillar	19	19	▲	Header			▽	Upper Anchorage		
+	A Pillar	0	0	#	Facia Top			■	Steering Wheel		
	Side Other	0	0	O	Roof			◆	Head Restraint		
	Side Roof Rail	10	10								

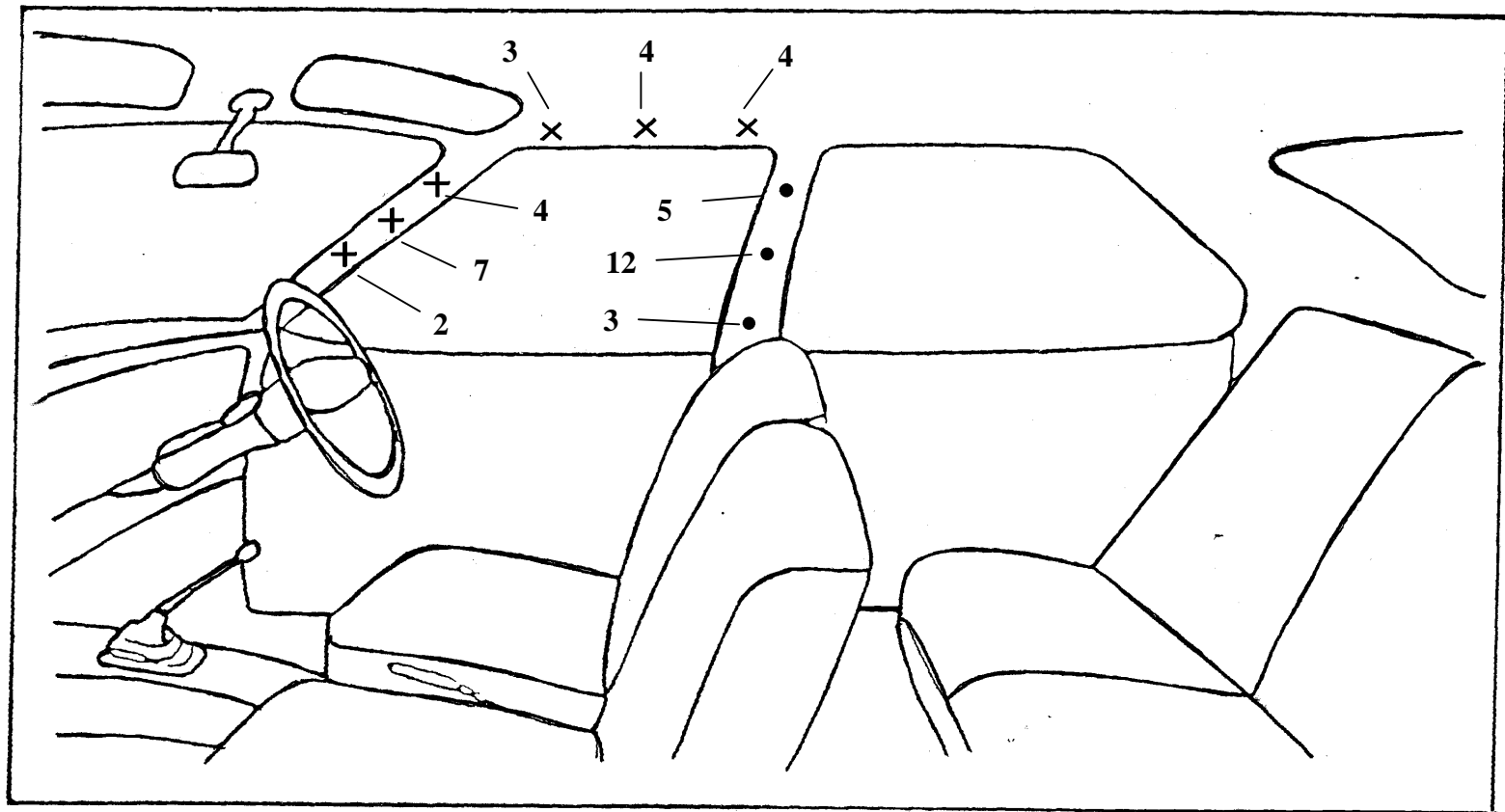


Figure 5 - Graphical Representation of Frequent Head Contact Regions, Front Seat, Restrained Struck Side Occupants - NHTSA Data

Key	Contact Region	Total in figure	Total no of contacts	Key	Contact Region	Total in figure	Total no of contacts	Key	Contact Region	Total in figure	Total no of contacts
●	B Pillar	20	39	▲	Header			▽	Upper Anchorage		
+	A Pillar	13	22	#	Facia Top			■	Steering Wheel		
	Side Other			O	Roof			◆	Head Restraint		
	Side Roof Rail	11	24								

3.2.1.2 Non-Struck Side Occupants

Table 4 shows the results for restrained occupants on the non-struck side.

Contact Site	TRL		BAST		LAB		NHTSA	
	AIS 3+ No.	AIS 1+ No.	AIS 3+ No.	AIS 1+ No.	AIS 3+ No.	AIS 1+ No.	AIS 3+ No.	AIS 1+ No.
Non Contact Injury	1	5	0	0				
A Pillar	0	0	0	2	0	2	1	2
B Pillar	1	4	0	2	2	3	2	4
External Object	4	5	0	1	3	4		
Facia Top	0	1	0	0				
Flying Glass	0	8	0	2				
Header	0	1	0	0				
Head Restraint	1	2	1	2				
Mirror	0	1	0	0				
Seat	0	1	0	0				
Side Roof Rail	1	2	2	4	1	7	2	6
Side Glass	1	10	1	6	0	5		
Side Other	4	9	0	2	0	13		
Steering Wheel	1	5	0	5				
Sunroof	0	0	0	0				
Roof	0	1	0	1				
Windscreen	0	0	0	1				
Occupant Contact	0	6	0	0				
Window Frame					1	1		
Unknown	7	40	0	0	0	23		
Total	21	101	4	28	7	58	5	12

Table 4 –Head Contact regions and injury severity for restrained occupants on the non-struck side

Shaded areas denote contact site not recorded

3.2.1.3 Struck and Non-Struck Side Occupants

Table 5 shows the results for restrained occupants on either side of the vehicle.

Contact Site	TRL		BAST		LAB		NHTSA	
	AIS 3+ No.	AIS 1+ No.	AIS 3+ No.	AIS 1+ No.	AIS 3+ No.	AIS 1+ No.	AIS 3+ No.	AIS 1+ No.
Non Contact Injury	1	9	1	2				
Airbag	0	1						
A Pillar	2	6	1	3	0	2	6	24
B Pillar	2	17	7	13	4	22	18	43
External Object	22	35	5	9	11	17		
Facia Top	0	2	0	0				
Flying Glass	0	19	0	4				
Header	0	1	0	0				
Head Restraint	1	3	0	2				
Mirror	0	1	0	0				
Seat	0	1	0	0				
Side Roof Rail	7	10	2	8	1	17	9	30
Side Glass	3	62	3	13	0	57		
Side Other	7	13	1	6	0	13		
Steering Wheel	2	8	0	6				
Sunroof	0	1	0	0				
Roof	0	1	1	3				
Upper Anch' Point	0	1	0	1				
Windscreen	0	2	0	1				
Occupant Contact	1	7						
Window Frame					1	9		
Unknown	15	77			0	31		
Total	63	277	21	71	17	168	33	97

Table 5 - Contact regions and injury severity for restrained occupants on either side

Shaded areas denote contact site not recorded

3.2.2 HEAD CONTACT FOR UNRESTRAINED FRONT SEAT OCCUPANTS

3.2.2.1 Struck Side Occupants

Table 6 shows the results for unrestrained occupants on the struck side.

Contact Site	TRL		BASt		LAB		NHTSA	
	AIS 3+ No.	AIS 1+ No.	AIS 3+ No.	AIS 1+ No.	AIS 3+ No.	AIS 1+ No.	AIS 3+ No.	AIS 1+ No.
A Pillar	0	3	0	0	0	0	2	18
B Pillar	1	2	2	2	2	8	2	17
External Object	5	13	0	1				
Flying Glass	0	0	0	1				
Header	0	2	0	0				
Side Roof Rail	0	0	0	0	0	5	3	15
Side Glass	0	6	1	1	0	34		
Side Other	0	1	0	0	0	0		
Roof	0	2	0	1				
Windscreen	0	1	0	0				
Window Frame					0	7		
Unknown	0	8			0	5		
Total	6	38	3	6	4	67	7	50

Table 6 - Contact regions and injury severity for unrestrained occupants on the struck side

3.2.2.2 Non-Struck Side Occupants

Table 7 shows the results for unrestrained occupants on the non-struck side.

Contact Site	TRL		BASt		LAB		NHTSA	
	AIS 3+ No.	AIS 1+ No.	AIS 3+ No.	AIS 1+ No.	AIS 3+ No.	AIS 1+ No.	AIS 3+ No.	AIS 1+ No.
Non Contact Injury	0	0	1	1				
A Pillar	0	2	0	0	2	8	3	8
B Pillar	1	1	0	0	1	3	2	4
External Object	3	4	0	0	2	2		
Facia Top	0	0	0	1				
Head Restraint	0	1	0	0				
Mirror	0	1	0	0				
Side Roof Rail	1	1	0	0	1	10	0	1
Side Glass	0	2	0	0	0	2		
Side Other	1	2	0	0	2	13		
Windscreen	0	3						
Occupant Contact	1	2						
Window Frame					0	5		
Unknown	0	8			1	26		
Total	7	27	1	2	9	69	5	13

Table 7 - Contact regions and injury severity for unrestrained occupants on the non-struck side

Shaded areas denote contact site not recorded

3.2.2.3 Struck and Non-Struck Side Occupants

Table 8 shows the results for all unrestrained occupants in a front seat.

Contact Site	TRL		BAST		LAB		NHTSA	
	AIS 3+ No.	AIS 1+ No.	AIS 3+ No.	AIS 1+ No.	AIS 3+ No.	AIS 1+ No.	AIS 3+ No.	AIS 1+ No.
Non Contact Injury	0	0	1	1				
A Pillar	0	5	0	0	2	8	5	26
B Pillar	2	3	2	2	3	11	4	21
External Object	8	17	0	1	4	10		
Facia Top	0	0	0	1				
Flying Glass	0	1	0	1				
Header	0	1	0	0				
Head Restraint	0	1	0	0				
Mirror	0	1	0	0				
Side Roof Rail	1	1	0	0	1	15	3	16
Side Glass	0	8	1	1	0	36		
Side Other	1	3	0	0	2	13		
Roof	0	3	0	1				
Windscreen	0	3	0	0				
Occupant Contact	1	2	0	0				
Window Frame					0	12		
Unknown	0	16			1	31		
Total	13	65	4	8	13	136	12	63

Table 8: Contact regions and injury severity for unrestrained occupants on any side

Shaded areas denote contact site not recorded

3.2.3 HEAD CONTACT BY SEAT POSITION

This section reports the effect of occupant position with respect to side of impact. The tables show the frequency of head contact and severity of injury for each contact region.

3.2.3.1 Struck Side Occupants

Contact Site	TRL		BAST		LAB		NHTSA	
	AIS 3+ No.	AIS 1+ No.	AIS 3+ No.	AIS 1+ No.	AIS 3+ No.	AIS 1+ No.	AIS 3+ No.	AIS 1+ No.
Non Contact Injury	0	5	1	2				
Airbag	0	1	0	0				
A Pillar	2	9	2	3	0	0	7	40
B Pillar	2	18	10	14	4	27	18	56
External Object	24	44	7	12	10	21		
Facia Top	0	1	0	0				
Flying Glass	0	13	0	4				
Header	0	1	0	0				
Head Restraint	0	2	0	0				
Side Roof Rail	8	12	0	4	0	15	10	39
Side Glass	2	69	3	7	0	86		
Side Other	3	5	1	4				
Steering Wheel	1	3	0	1				
Sunroof	0	1	0	0				
Roof	1	3	1	3				
Upper Anch' Point	0	2	0	1				
Windscreen	0	3						
Occupant Contact	1	1						
Window Frame					0	15		
Unknown	10	56			0	13		
Total	54	249	25	55	14	177	35	135

Table 9 - Contact regions and injury severity for all occupants on the struck side

Table 9 shows the results for all struck side occupants (restrained and unrestrained). The specific points of contact on the vehicle structure for struck side occupants, are shown on Figures 6-9

Shaded areas denote contact site not recorded

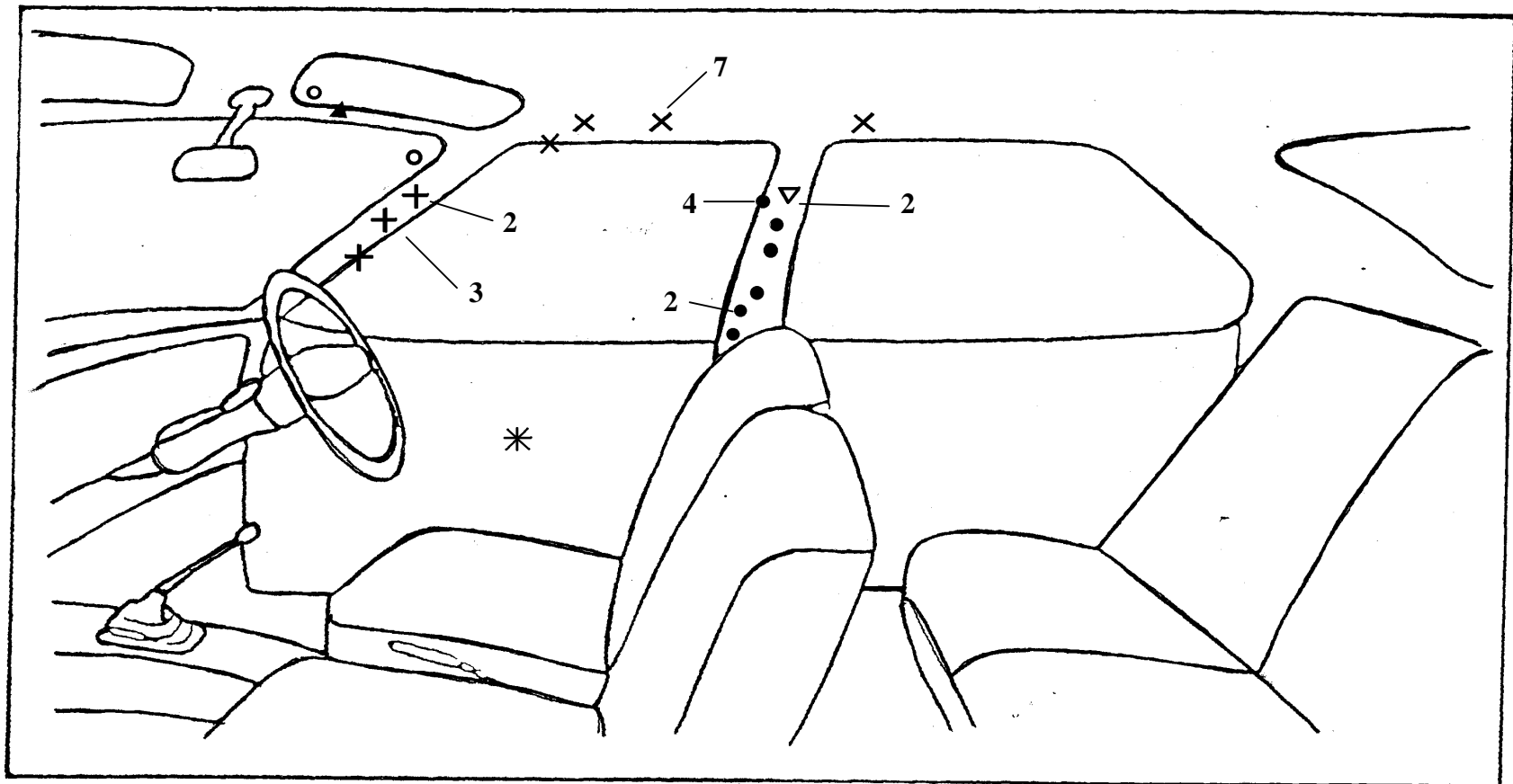


Figure 6 - Graphical Representation of Frequent Head Contact Regions, Front Seat, Struck Side Occupants - TRL Data

Key	Contact Region	Total in figure	Total no of contacts	Key	Contact Region	Total in figure	Total no of contacts	Key	Contact Region	Total in figure	Total no of contacts
●	B Pillar	10	18	▲	Header	1	1	▽	Upper Anchorage	2	2
+	A Pillar	6	9	#	Facia Top	1	0	■	Steering Wheel	0	3
	Side Other	1	5	O	Roof	2	2	◆	Head Restraint	0	2
	Side Roof Rail	10	12								

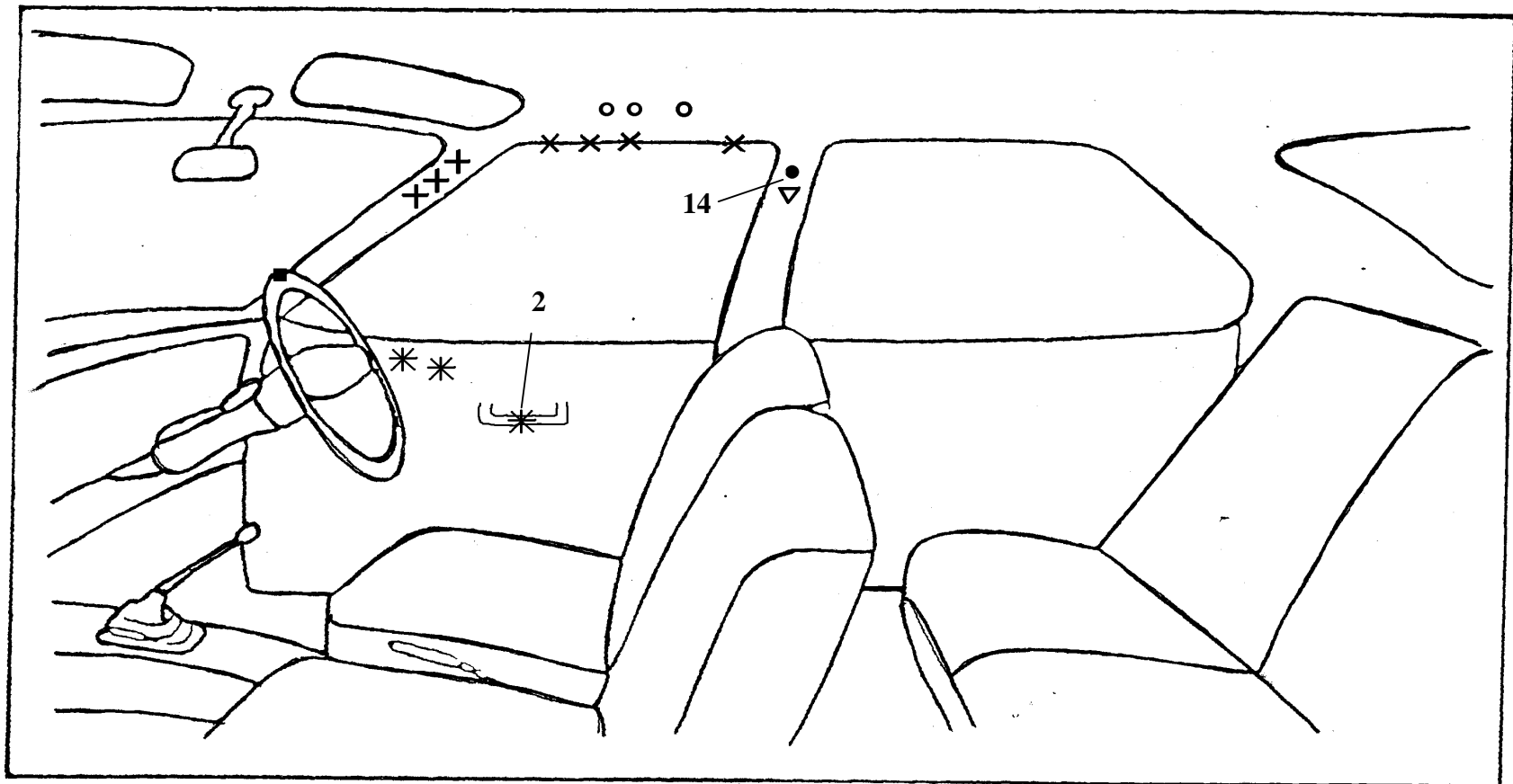


Figure 7 - Graphical Representation of Frequent Head Contact Regions, Front Seat, Struck Side Occupants - BAST Data

Key	Contact Region	Total in figure	Total no of contacts	Key	Contact Region	Total in figure	Total no of contacts	Key	Contact Region	Total in figure	Total no of contacts
●	B Pillar	14	14	▲	Header	0	0	▽	Upper Anchorage	1	1
+	A Pillar	3	3	#	Facia Top	0	0	■	Steering Wheel	1	1
	Side Other	4	4	○	Roof	3	3	◆	Head Restraint	0	0
	Side Roof Rail	4	4								

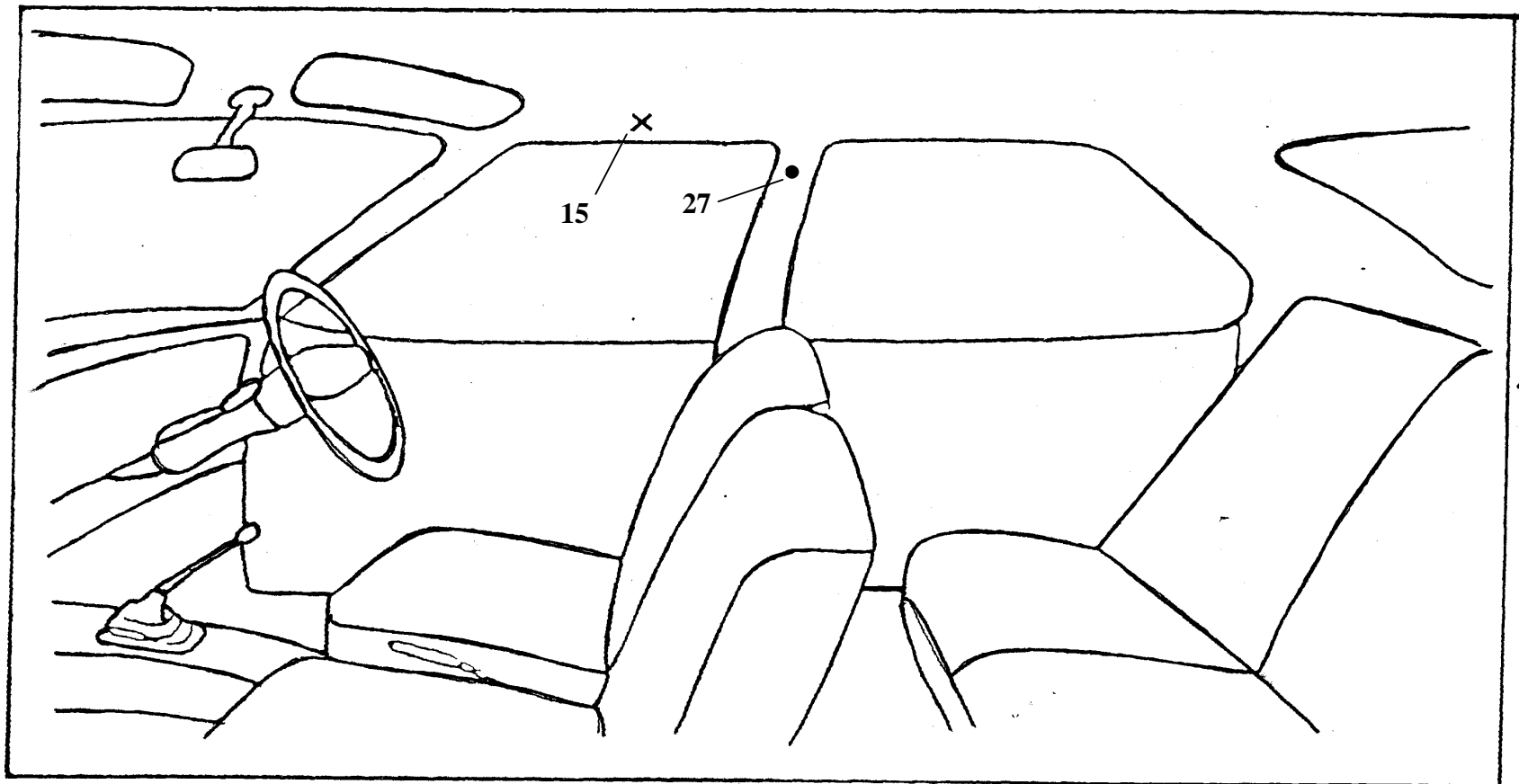


Figure 8 - Graphical Representation of Frequent Head Contact Regions, Front Seat, Struck Side Occupants - LAB Data

Key	Contact Region	Total in figure	Total no of contacts	Key	Contact Region	Total in figure	Total no of contacts	Key	Contact Region	Total in figure	Total no of contacts
●	B Pillar	127	27	▲	Header			∇	Upper Anchorage		
+	A Pillar	0	0	#	Facia Top			■	Steering Wheel		
	Side Other			O	Roof			◆	Head Restraint		
	Side Roof Rail	15	15								

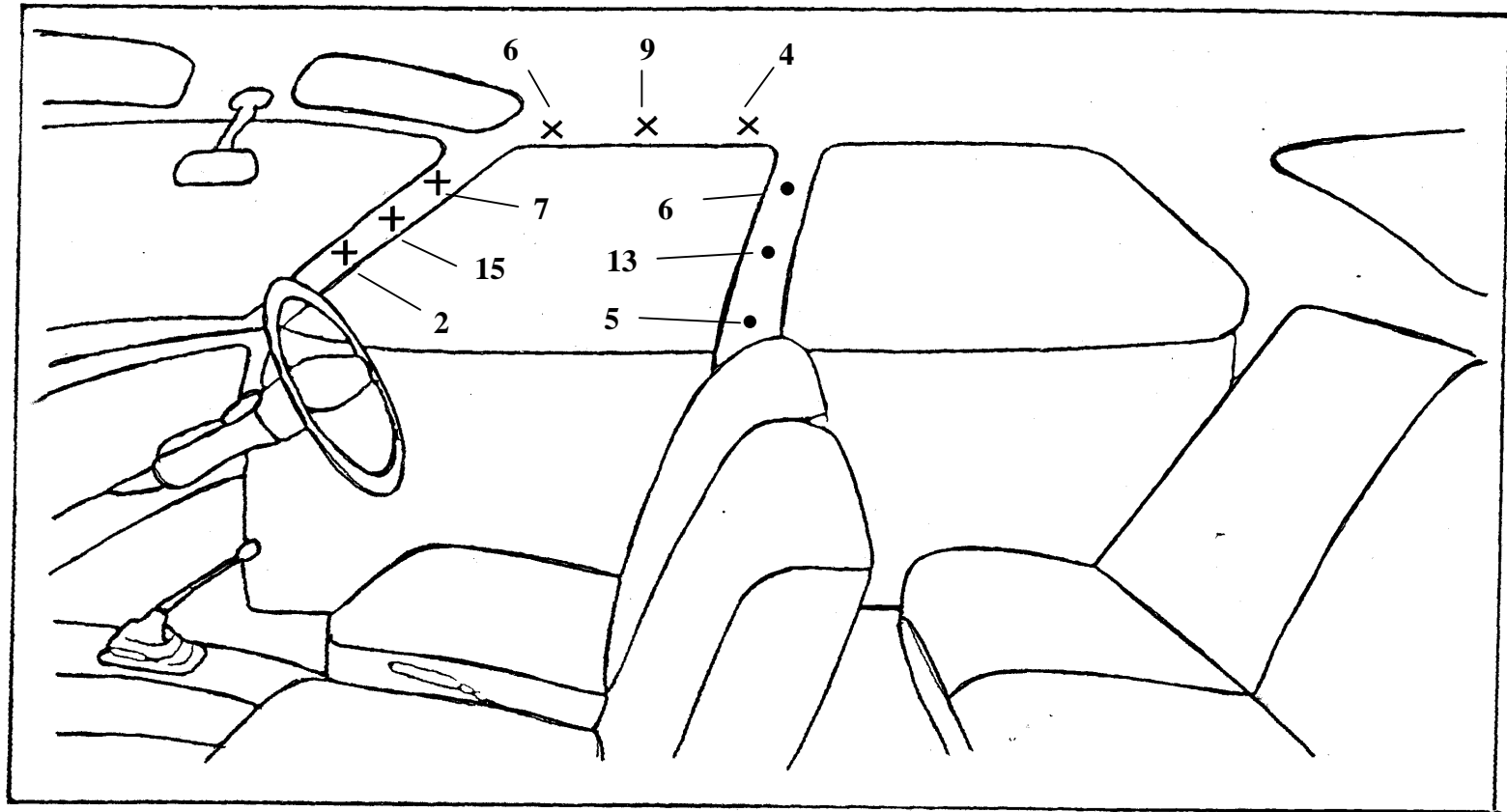


Figure 9 - Graphical Representation of Frequent Head Contact Regions, Front Seat, Struck Side Occupants - NHTSA Data

Key	Contact Region	Total in figure	Total no of contacts	Key	Contact Region	Total in figure	Total no of contacts	Key	Contact Region	Total in figure	Total no of contacts
●	B Pillar	24	56	▲	Header			▽	Upper Anchorage		
+	A Pillar	24	40	#	Facia Top			■	Steering Wheel		
	Side Other			O	Roof			◆	Head Restraint		
	Side Roof Rail	19	39								

3.2.3.2 Non-Struck Side Occupants

Contact Site	TRL		BAST		LAB		NHTSA	
	AIS 3+ No.	AIS 1+ No.	AIS 3+ No.	AIS 1+ No.	AIS 3+ No.	AIS 1+ No.	AIS 3+ No.	AIS 1+ No.
Non Contact Injury	2	6	1	1				
A Pillar	0	2	0	3	2	10	4	10
B Pillar	3	6	1	4	3	6	4	8
External Object	8	10	2	3	5	6		
Facia Top	0	2	0	1				
Flying Glass	0	10	0	2				
Header	0	2	0	0				
Head Restraint	1	3	1	2				
Mirror	0	5	0	0				
Seat	1	2	0	0				
Side Roof Rail	2	3	2	4	2	17	2	7
Side Glass	1	14	1	6	0	7		
Side Other	5	11	0	2	2	26		
Steering Wheel	1	7	0	6				
Roof	1	3	0	1				
Upper Anch' Point	0	0	0	1				
Windscreen	0	5	0	2				
Occupant Contact	3	11						
Window Frame					1	6		
Unknown	8	57			1	49		
Total	36	159	8	38	16	127	10	25

Table 10 - Contact regions and injury severity for restrained and unrestrained occupants on the non-struck side

Table 10 shows the results for all non-struck side occupants, (restrained and unrestrained). The specific points of contact on the vehicle structure for non-struck side occupants are shown on Figures 10-13.

Shaded areas denote contact site not recorded

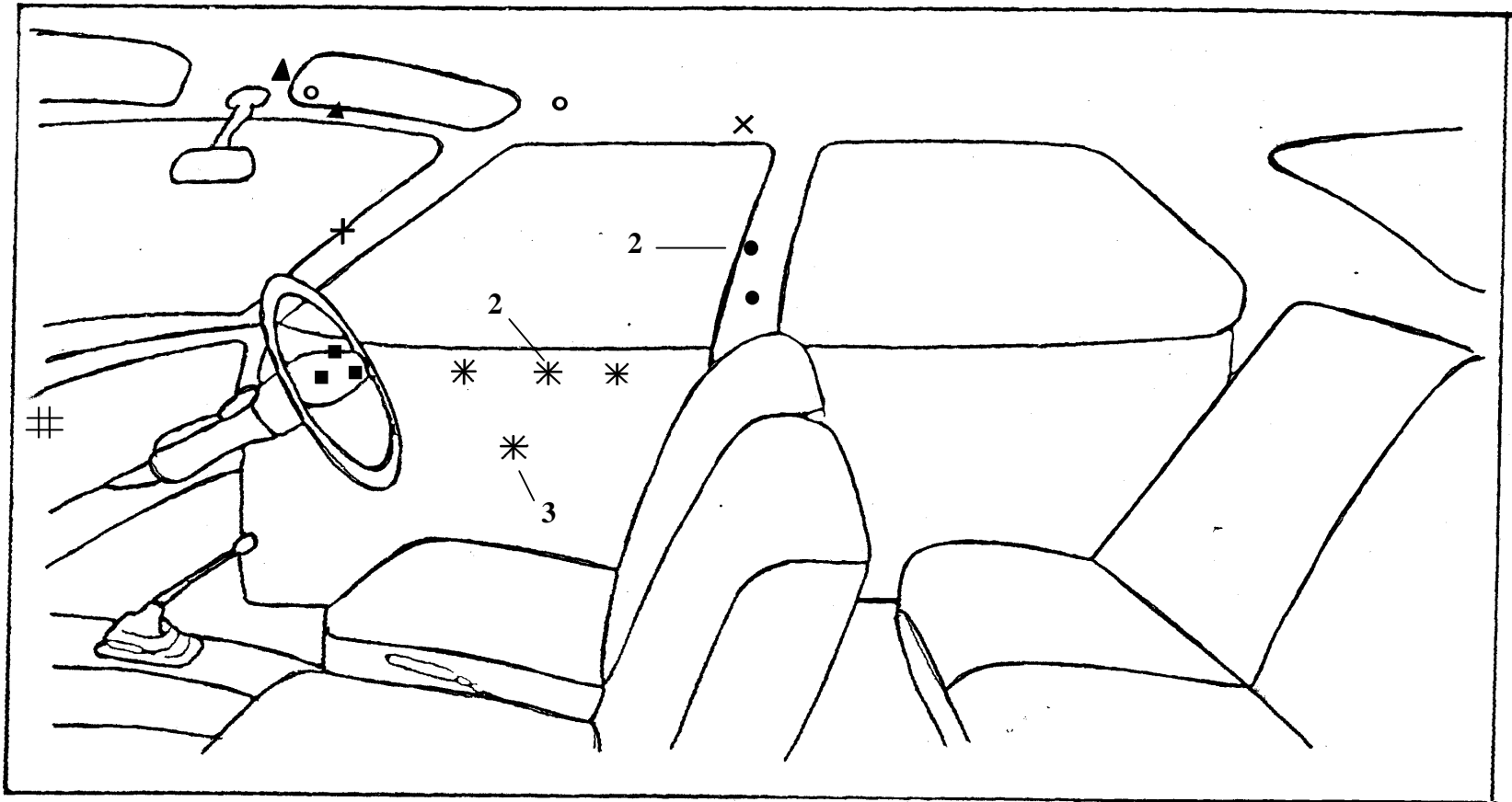


Figure 10: Graphical Representation of Frequent Head Contact Regions, Front Seat, Non-Struck Side Occupants - TRL Data

Key	Contact Region	Total in figure	Total no of contacts	Key	Contact Region	Total in figure	Total no of contacts	Key	Contact Region	Total in figure	Total no of contacts
●	B Pillar	3	6	▲	Header	2	2	∇	Upper Anchorage	0	0
+	A Pillar	1	2	#	Facia Top	1	2	■	Steering Wheel	3	7
	Side Other	1	3	O	Roof	2	3	◆	Head Restraint	0	3
	Side Roof Rail	1	3								

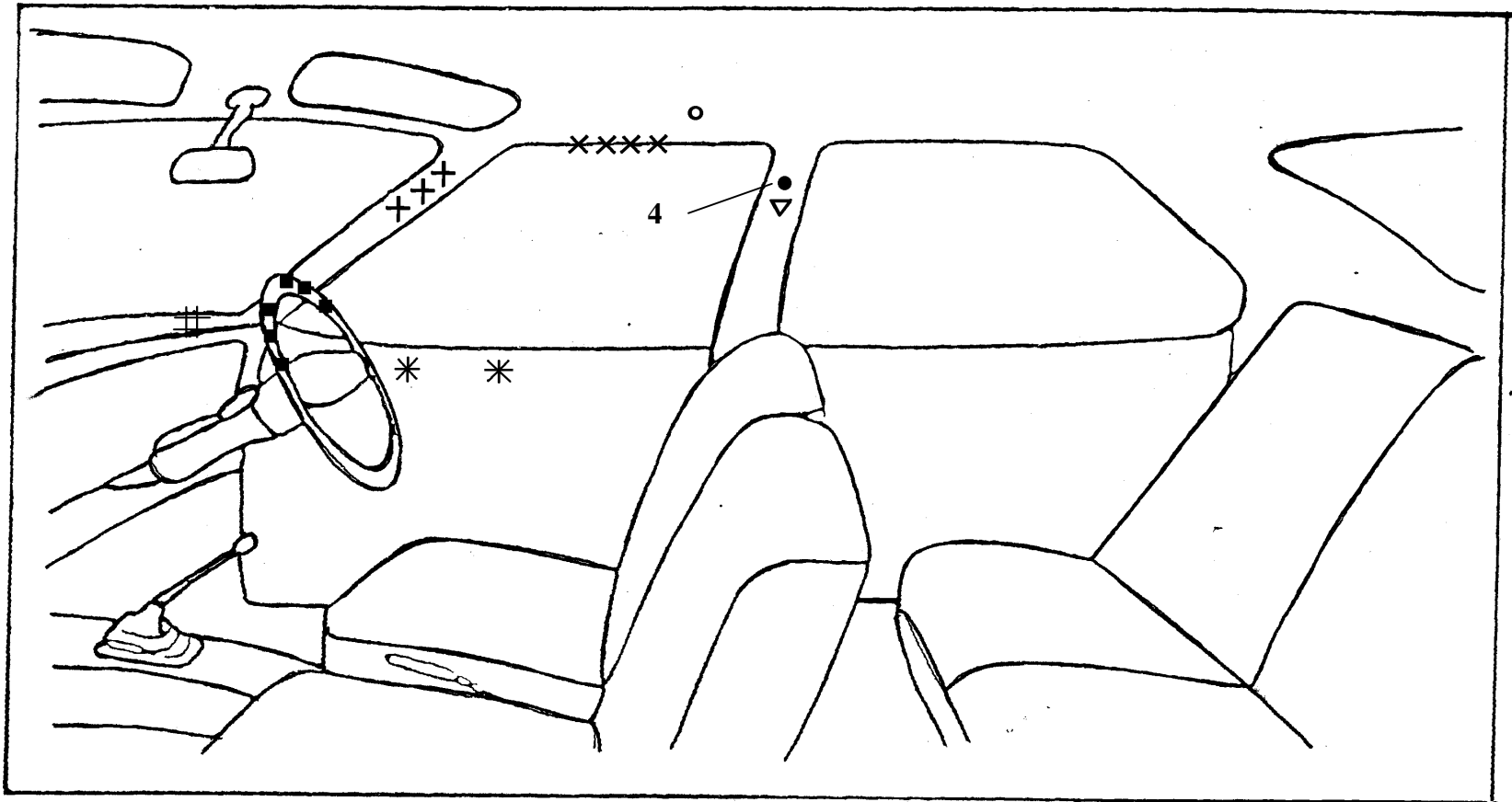


Figure 11: Graphical Representation of Frequent Head Contact Regions, Front Seat, Non-Struck Side Occupants - BAST Data

Key	Contact Region	Total in figure	Total no of contacts	Key	Contact Region	Total in figure	Total no of contacts	Key	Contact Region	Total in figure	Total no of contacts
●	B Pillar	4	4	▲	Header	0	0	▽	Upper Anchorage	1	1
+	A Pillar	3	3	#	Facia Top	1	1	■	Steering Wheel	6	6
	Side Other	2	2	O	Roof	1	1	◆	Head Restraint	0	2
	Side Roof Rail	4	4								

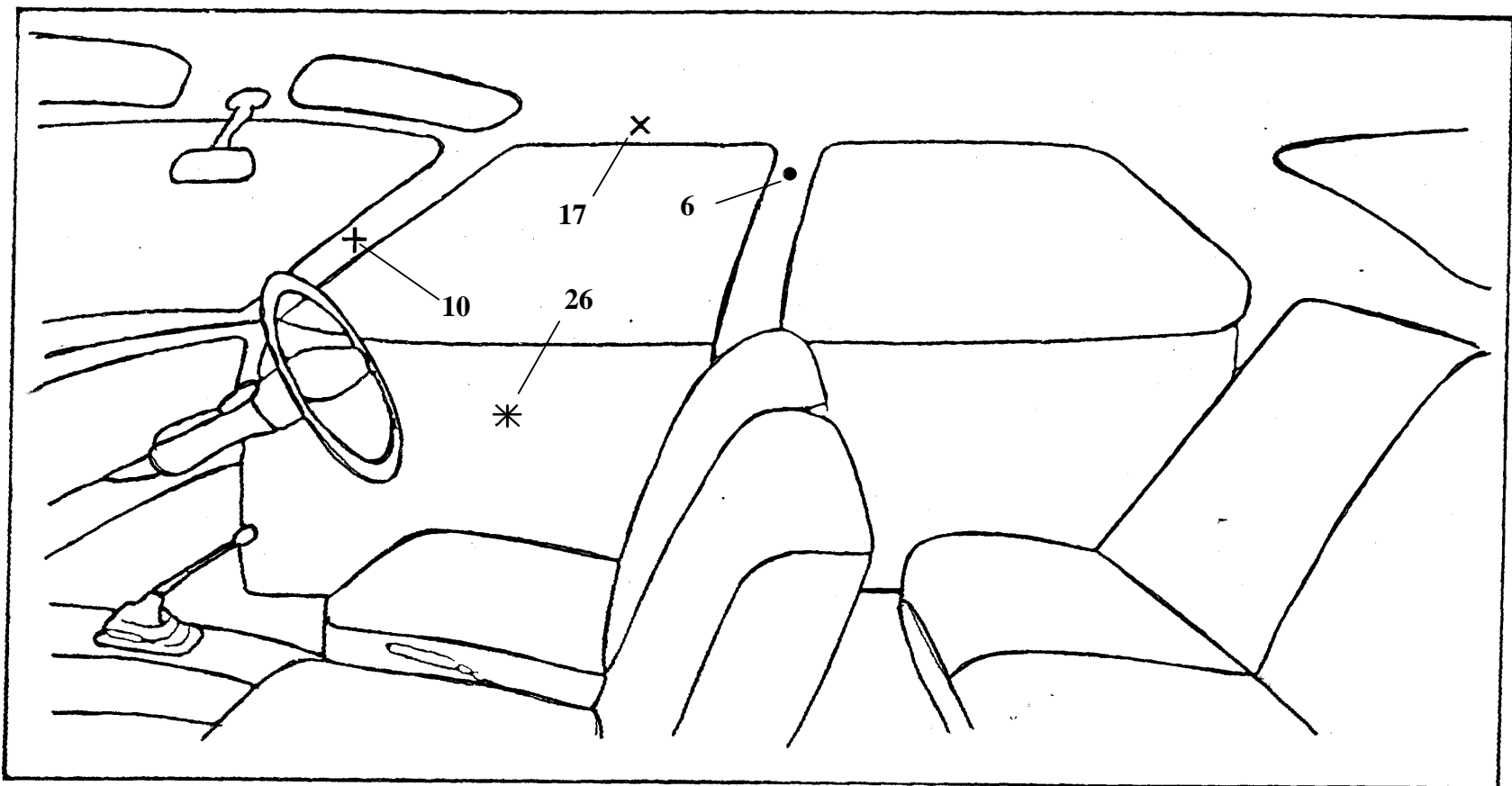


Figure 12 - Graphical Representation of Frequent Head Contact Regions, Front Seat, Non Struck Side Occupants - LAB Data

Key	Contact Region	Total in figure	Total no of contacts	Key	Contact Region	Total in figure	Total no of contacts	Key	Contact Region	Total in figure	Total no of contacts
●	B Pillar	127	27	▲	Header			∇	Upper Anchorage		
+	A Pillar	0	0	#	Facia Top			■	Steering Wheel		
	Side Other	26	26	O	Roof			◆	Head Restraint		
	Side Roof Rail	15	15								

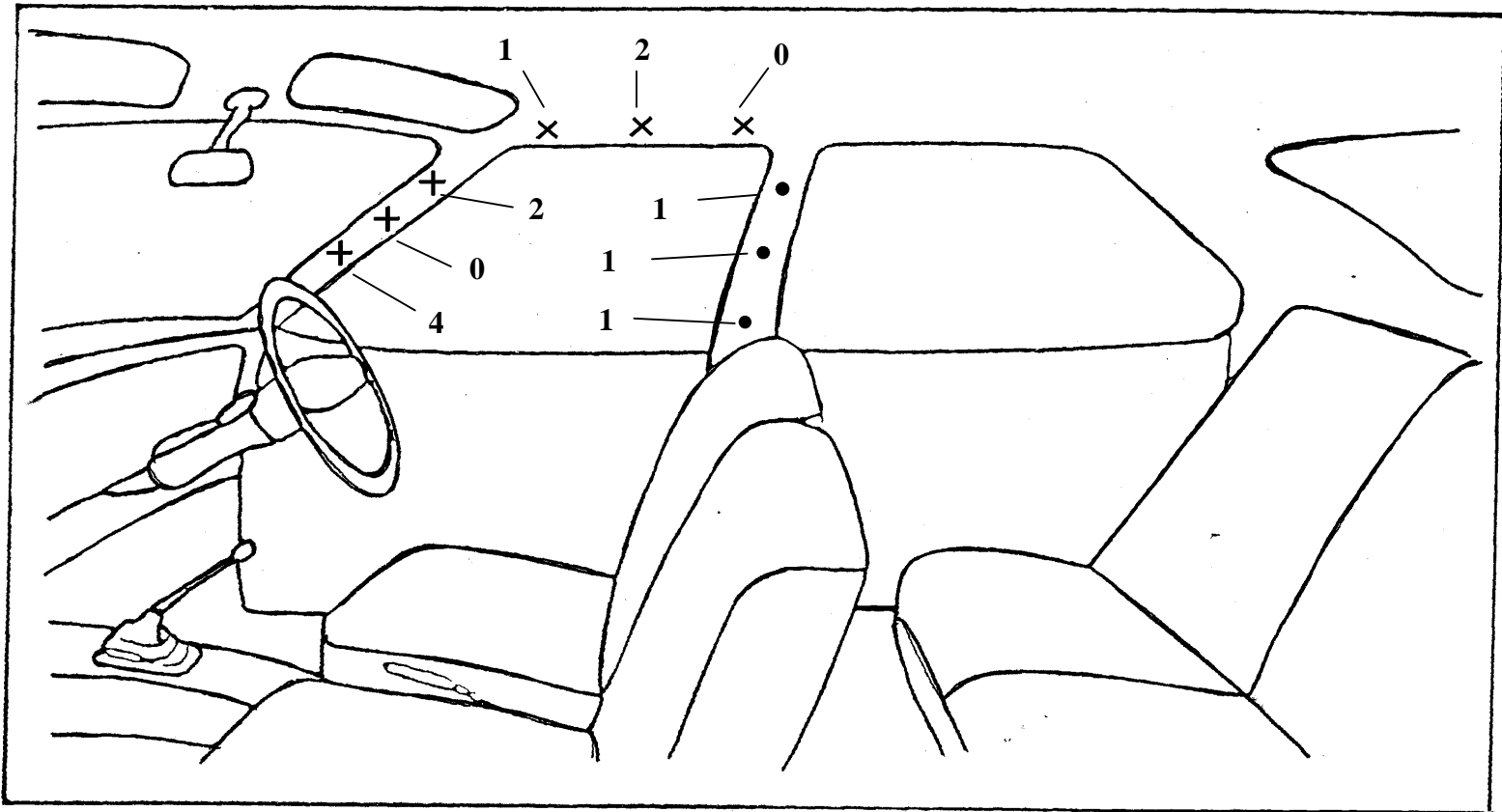


Figure 13 - Graphical Representation of Frequent Head Contact Regions, Front Seat, Struck Side Occupants - NHTSA Data

Key	Contact Region	Total in figure	Total no of contacts	Key	Contact Region	Total in figure	Total no of contacts	Key	Contact Region	Total in figure	Total no of contacts
●	B Pillar	3	8	▲	Header			∇	Upper Anchorage		
+	A Pillar	6	10	#	Facia Top			■	Steering Wheel		
	Side Other			O	Roof			◆	Head Restraint		
	Side Roof Rail	3	7								

3.2.4 ALL FRONT SEAT OCCUPANTS

Contact Site	TRL		BAST		LAB		NHTSA	
	AIS 3+ No.	AIS 1+ No.	AIS 3+ No.	AIS 1+ No.	AIS 3+ No.	AIS 1+ No.	AIS 3+ No.	AIS 1+ No.
Non Contact Injury	2	11	2	3				
Airbag	0	1	0	0				
A Pillar	2	11	2	6	2	10	11	50
B Pillar	5	24	11	18	7	33	22	64
External Object	31	54	9	15	15	27		
Facia Top	0	3	0	1				
Flying Glass	0	23	0	6				
Header	0	3	0	0				
Head Restraint	1	5	1	2				
Mirror	0	5	0	0				
Seat	1	2	0	0				
Side Roof Rail	10	15	2	8	2	32	12	46
Side Glass	3	83	4	13	0	93		
Side Other	8	16	1	6	2	26		
Steering Wheel	2	10	0	7				
Sunroof	0	1	0	0				
Roof	2	6	1	4				
Upper Anch' Point	0	2	0	2				
Windscreen	0	8	0	2				
Occupant Contact	4	12	0	1				
Window Frame					1	21		
Unknown	18	113			1	62		
Total	89	408	33	93	30	304	45	160

Table 11 - Contact regions and injury severity all front seat occupants

Table 11 shows the combined results for all front seat occupants (restrained/unrestrained/unknown belt use, occupants on both the struck and non-struck sides). Figures 14-17 show head contact regions on the vehicle structure for all front seat occupants. Shaded areas denote contact site not recorded

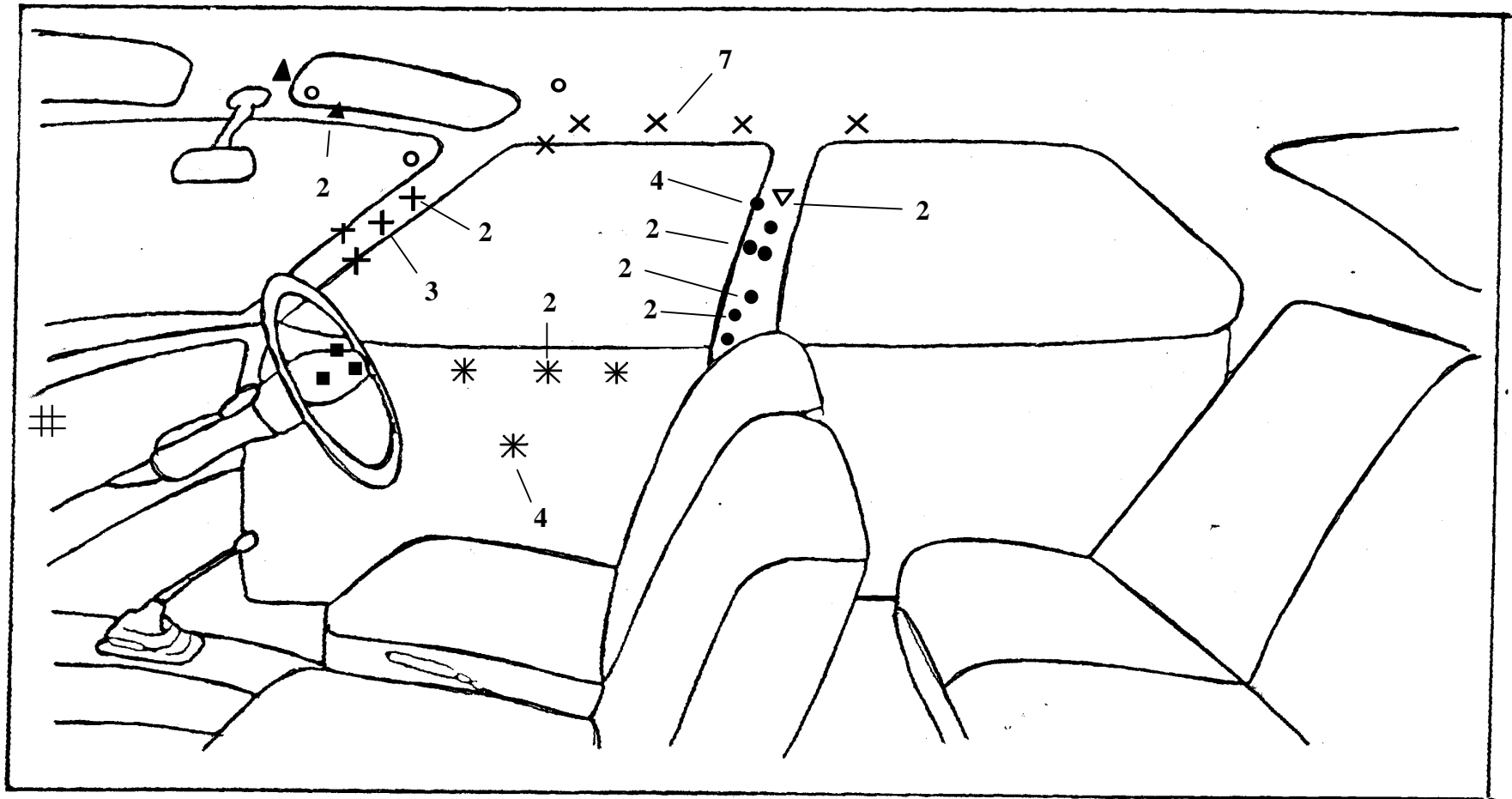


Figure 14 Graphical Representation of Frequent Head Contact Regions, All Front Seat Occupants - TRL Data

Key	Contact Region	Total in figure	Total no of contacts	Key	Contact Region	Total in figure	Total no of contacts	Key	Contact Region	Total in figure	Total no of contacts
●	B Pillar	13	24	▲	Header	3	3	▽	Upper Anchorage	2	2
+	A Pillar	7	11	#	Facia Top	1	3	■	Steering Wheel	3	10
	Side Other	8	16	O	Roof	3	6	◆	Head Restraint	0	5
	Side Roof Rail	11	15								

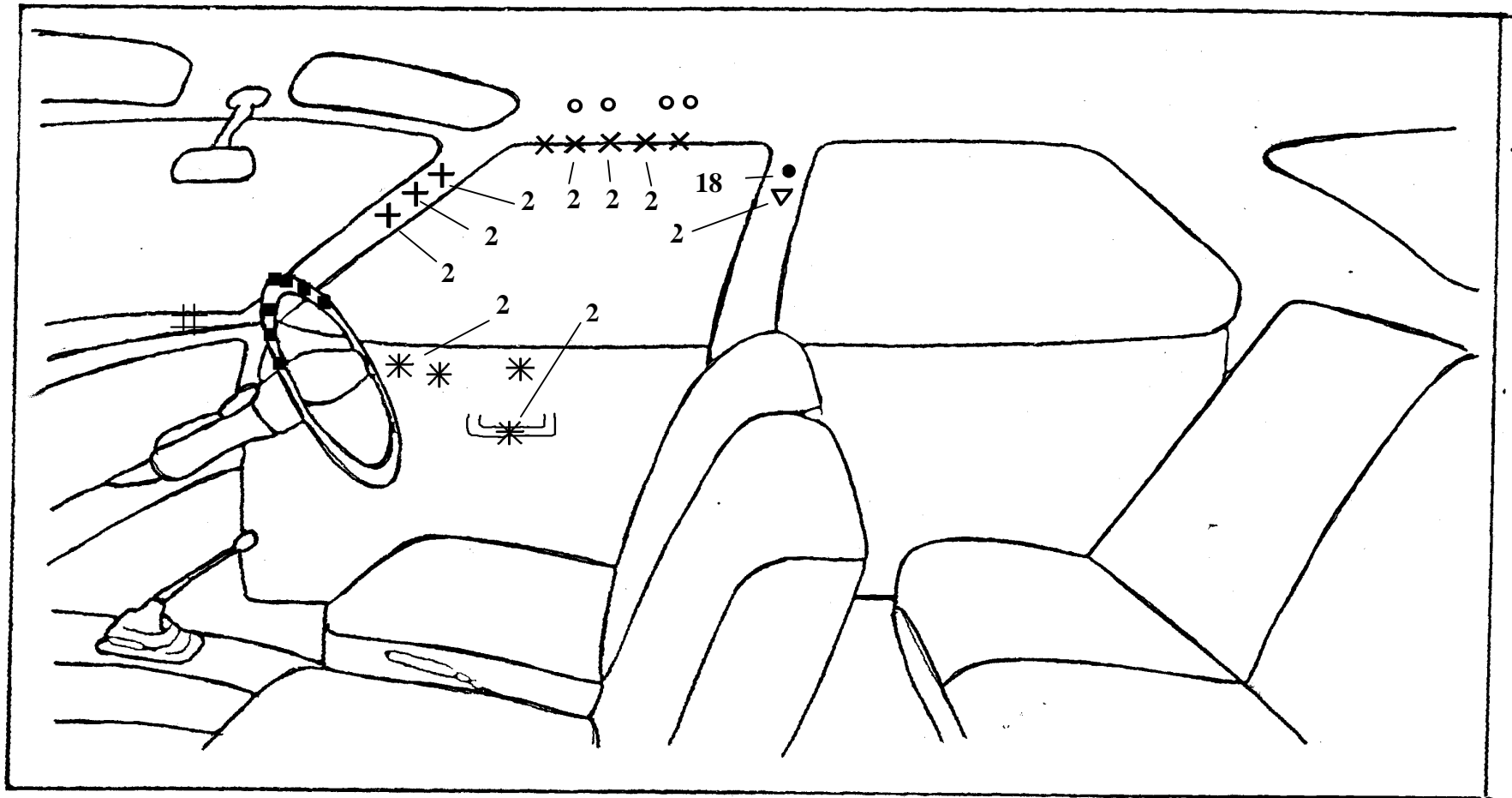


Figure 15 Graphical Representation of Frequent Head Contact Regions, All Front Seat Occupants - BAST Data

Key	Contact Region	Total in figure	Total no of contacts	Key	Contact Region	Total in figure	Total no of contacts	Key	Contact Region	Total in figure	Total no of contacts
●	B Pillar	18	18	▲	Header	0	0	▽	Upper Anchorage	2	2
+	A Pillar	6	6	#	Facia Top	0	0	■	Steering Wheel	1	7
	Side Other	8	16	O	Roof	4	4	◆	Head Restraint	0	2
	Side Roof Rail	8	8								

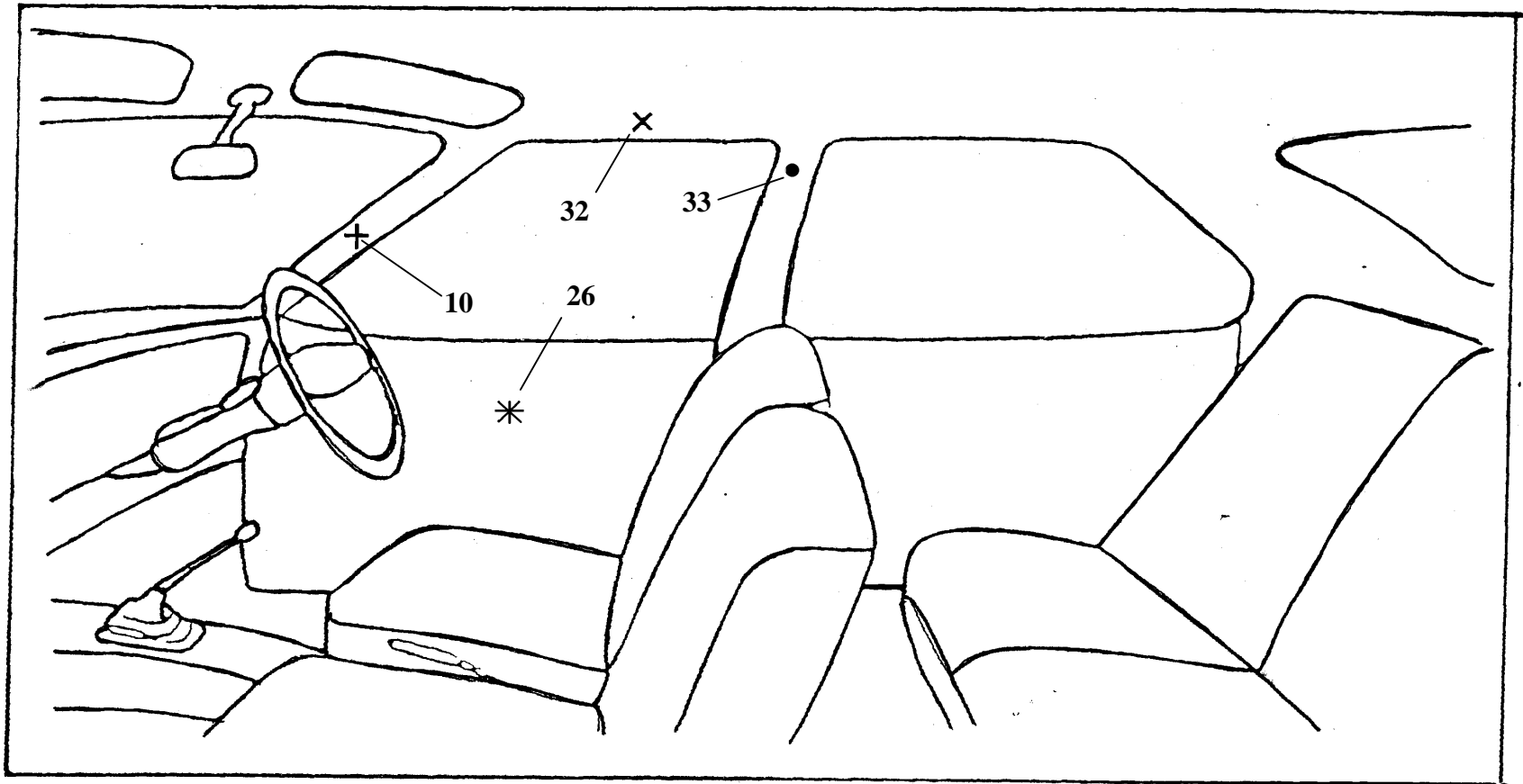


Figure 16 - Graphical Representation of Frequent Head Contact Regions, All Front Seat Occupants - LAB Data

Key	Contact Region	Total in figure	Total no of contacts	Key	Contact Region	Total in figure	Total no of contacts	Key	Contact Region	Total in figure	Total no of contacts
●	B Pillar	127	27	▲	Header			∇	Upper Anchorage		
+	A Pillar	0	0	#	Facia Top			■	Steering Wheel		
	Side Other	26	26	O	Roof			◆	Head Restraint		
	Side Roof Rail	15	15								

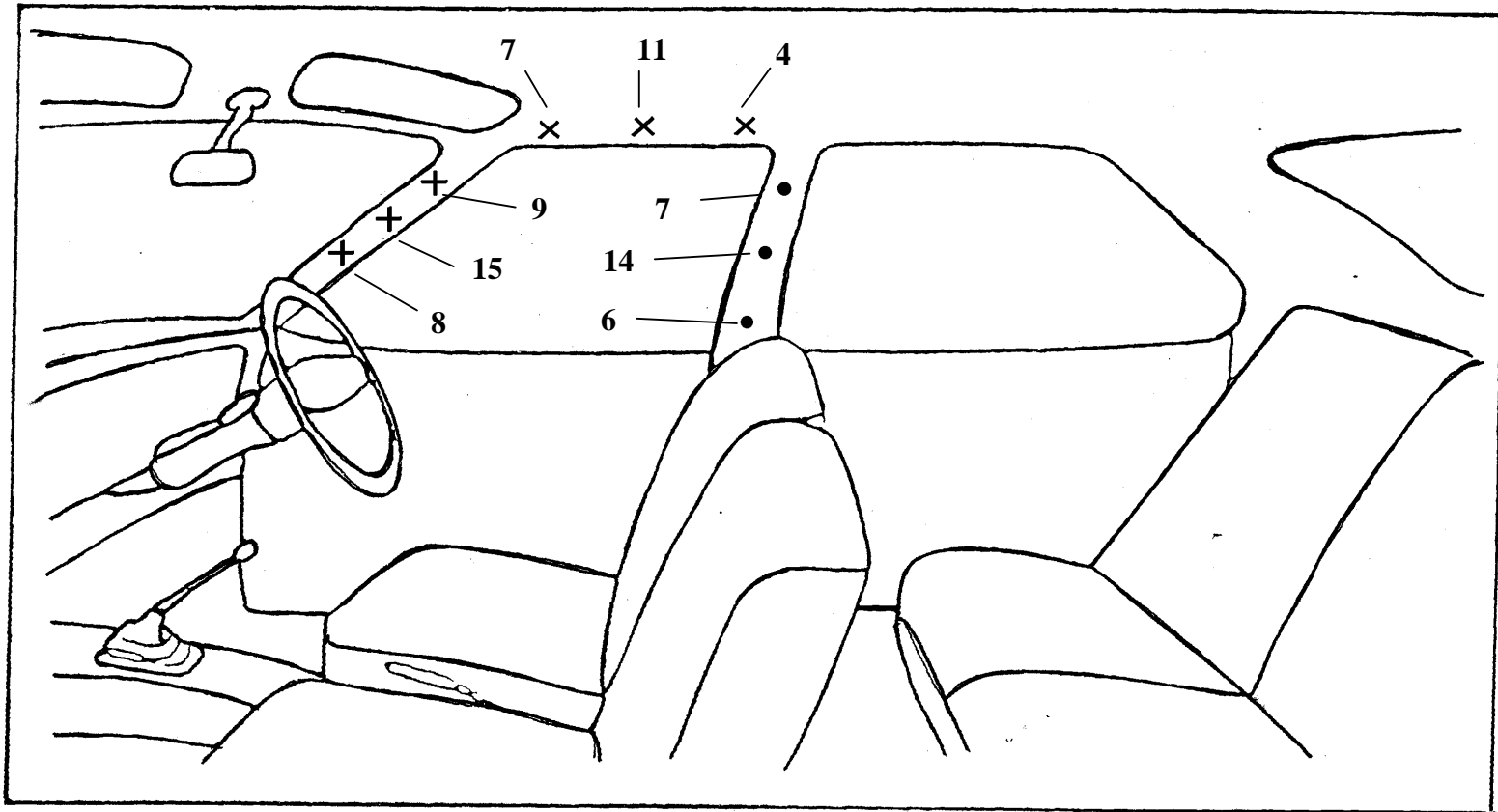


Figure 17 - Graphical Representation of Frequent Head Contact Regions, All Front Seat Occupants - NHTSA Data

Key	Contact Region	Total in figure	Total no of contacts	Key	Contact Region	Total in figure	Total no of contacts	Key	Contact Region	Total in figure	Total no of contacts
●	B Pillar	27	64	▲	Header			∇	Upper Anchorage		
+	A Pillar	32	50	#	Facia Top			■	Steering Wheel		
	Side Other			O	Roof			◆	Head Restraint		
	Side Roof Rail	22	46								

3.2.5 INTRUSION –FRONT SEAT OCCUPANTS

This section assesses the effect of intrusion at the point of head contact. This information is only available in the TRL (CCIS) database. There are three categories:

- No intrusion
- Supported intrusion – The contact region was supported by the intruding object, (i.e. bullet vehicle, lamp post, etc).
- Unsupported Intrusion – The contact region was not supported.

The number of cases for each type of intrusion is shown in Table 12 - Table 14. For some cases, the intrusion could not be classified. This category is recorded as ‘unknown’ and has been excluded from the following tables. Contacts to external objects have been excluded.

3.2.5.1 Struck Side Occupants

Table 12 shows the intrusion types for struck side occupants.

No Intrusion		Supported Intrusion		Unsupported Intrusion	
AIS 3+	AIS 1+	AIS 3+	AIS 1+	AIS 3+	AIS 1+
No	No	No	No	No	No
27	176	15	31	6	17

Table 12 - Intrusion – Struck Side Occupants

3.2.5.2 Non-Struck Side Occupants

Table 13 shows the intrusion type for non-struck side occupants.

No Intrusion		Supported Intrusion		Unsupported Intrusion	
AIS 3+	AIS 1+	AIS 3+	AIS 1+	AIS 3+	AIS 1+
No	No	No	No	No	No
16	112	14	19	2	4

Table 13 - Intrusion – Non Struck Side Occupants

3.2.5.3 All Front Seat Occupants

The type of intrusion for all front seat occupants is shown in Table 14.

No Intrusion		Supported Intrusion		Unsupported Intrusion	
AIS 3+	AIS 1+	AIS 3+	AIS 1+	AIS 3+	AIS 1+
No	No	No	No	No	No
44	288	29	50	8	21

Table 14: Intrusion – All Occupants

This section of the analysis investigates whether the intrusion type affects the severity of the resulting injury. As the aim of this investigation is to define an appropriate test procedure, the effect of intrusion is concerned only with head contacts to the structure of the vehicle. Therefore, contacts with the vehicle glazing, vehicle furnishings and non vehicle contacts are excluded from Report obtained from EEVC web site www.eevc.org

this analysis. The contact region and severity of injury associated with each type of intrusion is shown below in Table 15 - Table 17.

Contact Site	TRL	
	AIS 3+ No.	AIS 1+ No.
A Pillar	2	10
B Pillar	1	12
Header	0	2
Side Roof Rail	3	6
Side Other	2	6
Roof	1	4
Upper Anch' Point	0	2
Total	9	42

Table 15 - Contact Regions and Injury Severity with No Intrusion

Contact Site	TRL	
	AIS 3+ No.	AIS 1+ No.
A Pillar	0	1
B Pillar	3	8
Side Roof Rail	6	7
Side Other	3	6
Roof	1	2
Total	13	24

Table 16 - Contact Regions and Injury Severity with Supported Intrusion

Contact Site	TRL	
	AIS 3+ No.	AIS 1+ No.
Side Other	1	1
Total	1	1

Table 17 - Contact Regions and Injury Severity with Unsupported Intrusion

3.3 REAR SEAT OCCUPANTS

There are very few cases involving a rear seat occupant, in comparison with the number of front seat occupants. Belt use for rear occupants has only recently become a legal requirement. There are a large number of cases involving occupants where the belt was not used or even not fitted, especially with the LAB data.

3.3.1 RESTRAINED REAR SEAT OCCUPANTS

3.3.1.1 Struck Side Occupants

Table 18 shows the results for struck side restrained occupants.

Contact Site	TRL		BAST		LAB	
	AIS 3+ No.	AIS 1+ No.	AIS 3+ No.	AIS 1+ No.	AIS 3+ No.	AIS 1+ No.
B Pillar	1	2	0	0	0	1
C Pillar	0	0	0	0	0	1
External Object	0	0	0	0	2	2
Flying Glass	0	1	0	1		
Seat	0	1	0	0		
Side Roof Rail	0	0	0	0	0	1
Side Glass	0	1	0	0	0	0
Unknown	0	8			0	0
Total	1	13	0	1	2	5

Table 18 - Contact regions and injury severity for restrained occupants on the struck side

3.3.1.2 Non-Struck Side Occupants

Results for restrained occupants on the non-struck side are tabulated for all contacts, in Table 19.

Contact Site	TRL		BAST		LAB	
	AIS 3+ No.	AIS 1+ No.	AIS 3+ No.	AIS 1+ No.	AIS 3+ No.	AIS 1+ No.
Seat	0	2	0	0		
Side Roof Rail	0	1	0	0	0	0
Side Glass	0	1	0	0	0	0
Side Other	0	0	0	0	1	1
Unknown	0	2			0	3
Total	0	6	0	0	1	4

Table 19 - Contact regions and injury severity for restrained occupants on the non-struck side

Shaded areas denote contact site not recorded

3.3.1.3 Struck and Non-Struck Side Occupants

Results for restrained occupants on any side are shown in Table 20.

Contact Site	TRL		BASt		LAB	
	AIS 3+ No.	AIS 1+ No.	AIS 3+ No.	AIS 1+ No.	AIS 3+ No.	AIS 1+ No.
B Pillar	1	2	0	0	0	1
C Pillar	0	0	0	0	0	1
External Object	0	0	0	0	2	2
Flying Glass	0	1	0	1		
Seat	0	3	0	0		
Side Roof Rail	0	1	0	0	0	1
Side Glass	0	2	0	0	0	0
Side Other	0	0	0	0	1	1
Unknown	0	10			0	3
Total	1	19	0	1	3	9

Table 20 - Contact regions and injury severity for restrained, rear seat occupants on either side

3.3.2 UNRESTRAINED REAR SEAT OCCUPANTS

3.3.2.1 Struck Side Occupants

Table 21 shows the results for unrestrained rear seat occupants on the struck side.

Contact Site	TRL		BASt		LAB	
	AIS 3+ No.	AIS 1+ No.	AIS 3+ No.	AIS 1+ No.	AIS 3+ No.	AIS 1+ No.
B Pillar	0	0	0	0	1	3
C Pillar	0	0	0	1	1	2
External Object	1	1	0	0	0	0
Head Restraint	0	1	0	1		
Side Glass	0	0	0	0	0	9
Side Other	0	0	0	0	1	4
Window Frame					0	1
Occupant Contact	1	1	0	0		
Unknown	1	4			0	3
Total	3	7	0	2	3	22

Table 21 - Contact regions and injury severity for unrestrained occupants on the struck side

Shaded areas denote contact site not recorded

3.3.2.2 Non-Struck Side Occupants

Table 22 shows the results for all unrestrained occupants on the non-struck side.

Contact Site	TRL		BAST		LAB	
	AIS 3+ No.	AIS 1+ No.	AIS 3+ No.	AIS 1+ No.	AIS 3+ No.	AIS 1+ No.
B Pillar	0	0	0	0	0	3
C Pillar	0	0	1	1	0	0
External Object	0	1	0	0	0	0
Seat	0	4	0	0		
Side Glass	0	1	0	1	0	2
Side Other	0	0	0	0	0	2
Unknown	1	2			0	3
Total	0	4	1	2	0	5

Table 22 - Contact regions and injury severity for unrestrained occupants on the non-struck side

3.3.2.3 Struck and Non-Struck Side Occupants

The results for all unrestrained rear seat occupants are shown in Table 23.

Contact Site	TRL		BAST		LAB	
	AIS 3+ No.	AIS 1+ No.	AIS 3+ No.	AIS 1+ No.	AIS 3+ No.	AIS 1+ No.
B Pillar	0	0	0	0	1	6
C Pillar	0	0	1	2	1	2
External Object	1	2	0	0	0	0
Head Restraint	0	1	0	1		
Seat	0	4	0	0		
Side Glass	0	1	0	1	0	11
Side Other	0	0	0	0	1	6
Occupant Contact	1	1	0	0		
Window Frame					0	1
Unknown	2	6			0	6
Total	4	15	1	4	3	32

Table 23 -Contact regions and injury severity for unrestrained occupants on any side

Shaded areas denote contact site not recorded

3.3.3 POSITION OF REAR SEAT OCCUPANTS.

3.3.3.1 Struck Side Occupants

The results for all struck side occupants in a rear seat are shown in Table 24.

Contact Site	TRL		BAST		LAB	
	AIS 3+ No.	AIS 1+ No.	AIS 3+ No.	AIS 1+ No.	AIS 3+ No.	AIS 1+ No.
B Pillar	1	2	0	0	1	4
C Pillar	0	0	0	1	1	3
External Object	2	3	0	0	2	2
Flying Glass	0	2	0	1		
Head Restraint	0	1	0	1		
Seat	0	1	0	0		
Side Roof Rail	0	0	0	0	0	1
Side Glass	1	6	0	0	0	9
Side Other	0	0	0	0	1	4
Occupant Contact	1	1	0	0		
Window Frame					0	1
Unknown	1	16			0	3
Total	6	32	0	3	5	27

Table 24 - Contact regions and injury severity for restrained and unrestrained occupants on the struck side

3.3.3.2 Non-Struck Side Occupants

The results for all non-struck side occupants in a rear seat are shown in Table 25.

Contact Site	TRL		BAST		LAB	
	AIS 3+ No.	AIS 1+ No.	AIS 3+ No.	AIS 1+ No.	AIS 3+ No.	AIS 1+ No.
B Pillar	0	0	0	0	0	3
C Pillar	0	0	0	1	0	0
External Object	1	2	0	0	0	0
Seat	0	6	0	0		
Side Roof Rail	0	3	0	0	0	0
Side Glass	0	3	0	2	0	2
Side Other	0	1	0	0	1	3
Occupant Contact	0	1	0	0		
Unknown	0	14			0	6
Total	1	30	0	3	1	14

Table 25 - Contact regions and injury severity for restrained and unrestrained occupants on the non-struck side

Shaded areas denote contact site not recorded

3.3.4 ALL REAR SEAT OCCUPANTS

Contact Site	TRL		BAST		LAB	
	AIS 3+ No.	AIS 1+ No.	AIS 3+ No.	AIS 1+ No.	AIS 3+ No.	AIS 1+ No.
B Pillar	1	2	0	0	1	7
C Pillar	0	0	1	2	1	3
External Object	3	5	0	0	2	2
Flying Glass	0	2	0	1		
Head Restraint	0	1	0	1		
Seat	0	7	0	0		
Side Roof Rail	0	3	0	0	0	1
Side Glass	1	9	0	2	0	11
Side Other	0	1	0	0	2	7
Occupant Contact	1	2	0	0		
Window Frame					0	1
Unknown	4	30			0	9
Total	10	62	1	6	6	41

Table 26 - Contact regions and injury severity for restrained and unrestrained occupants on the struck side

The results for all rear seat occupants are shown in Table 26. The specific points of contact on the vehicle structure are shown in figures 18-20.

Shaded areas denote contact site not recorded

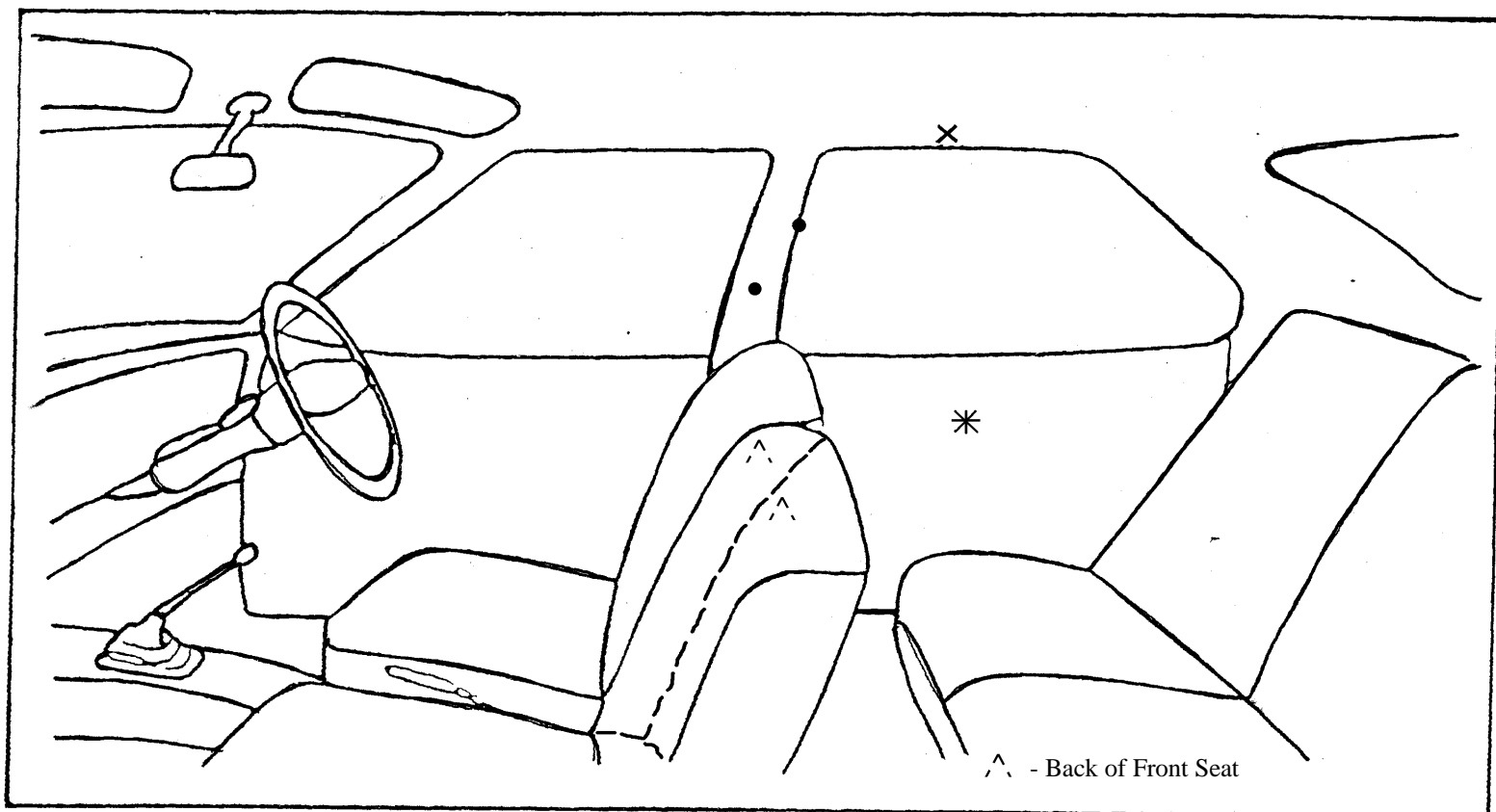


Figure 18 - Graphical Representation of Frequent Head Contact Regions, All Rear Seat Occupants - TRL Data

Key	Contact Region	Total in figure	Total no of contacts	Key	Contact Region	Total in figure	Total no of contacts
●	B Pillar	2	2	▲	Seat	2	7
	Side Other	1	1	◆	Head Restraint	0	1
	Side Roof Rail	1	3	ÿ	C Pillar	0	0

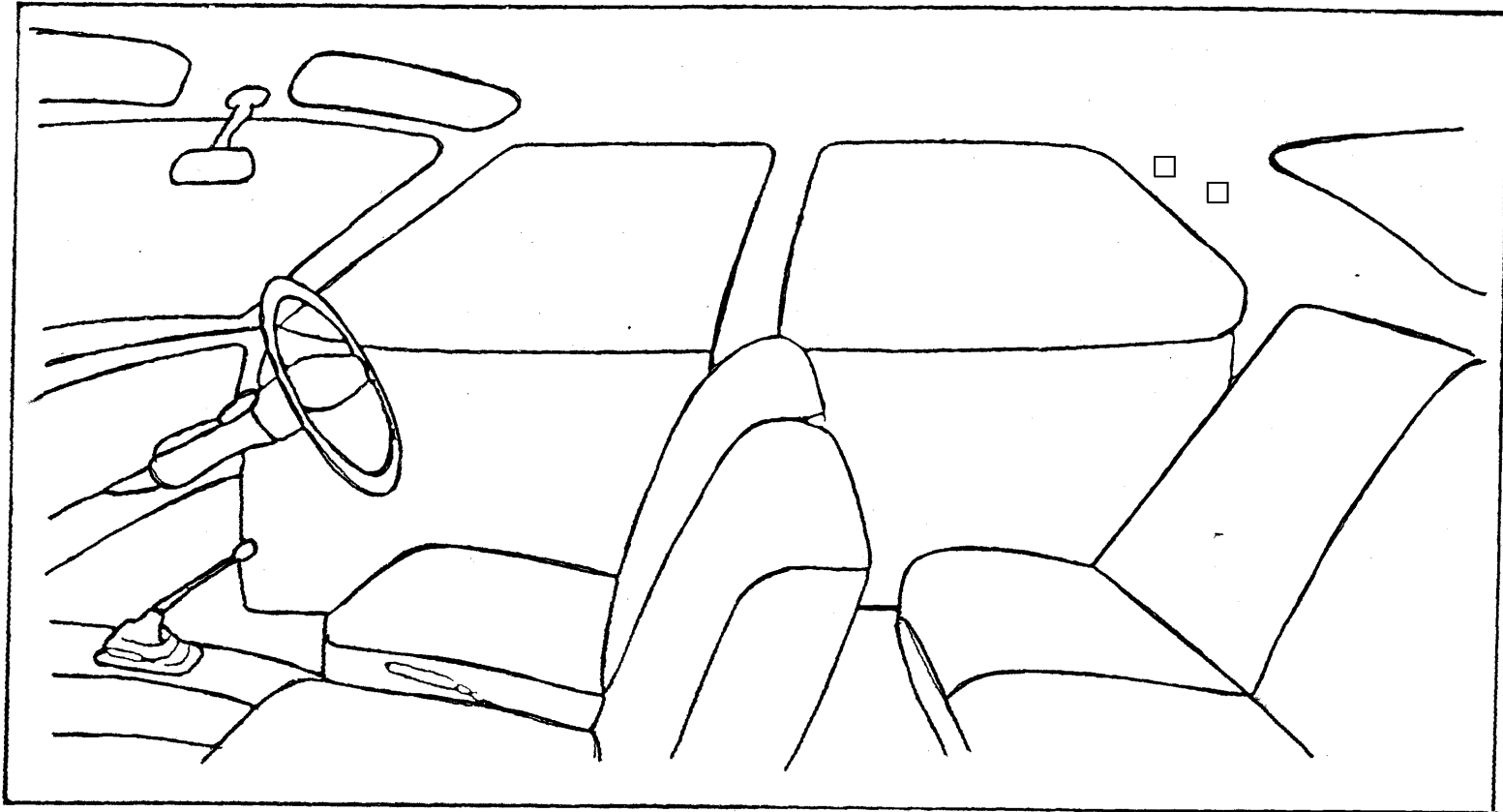


Figure 19 - Graphical Representation of Frequent Head Contact Regions, All Rear Seat Occupants - BASt Data

Key	Contact Region	Total in figure	Total no of contacts	Key	Contact Region	Total in figure	Total no of contacts
●	B Pillar	0	0	^	Seat	0	0
	Side Other	0	0	◆	Head Restraint	0	1
	Side Roof Rail	0	0	ÿ	C Pillar	2	2

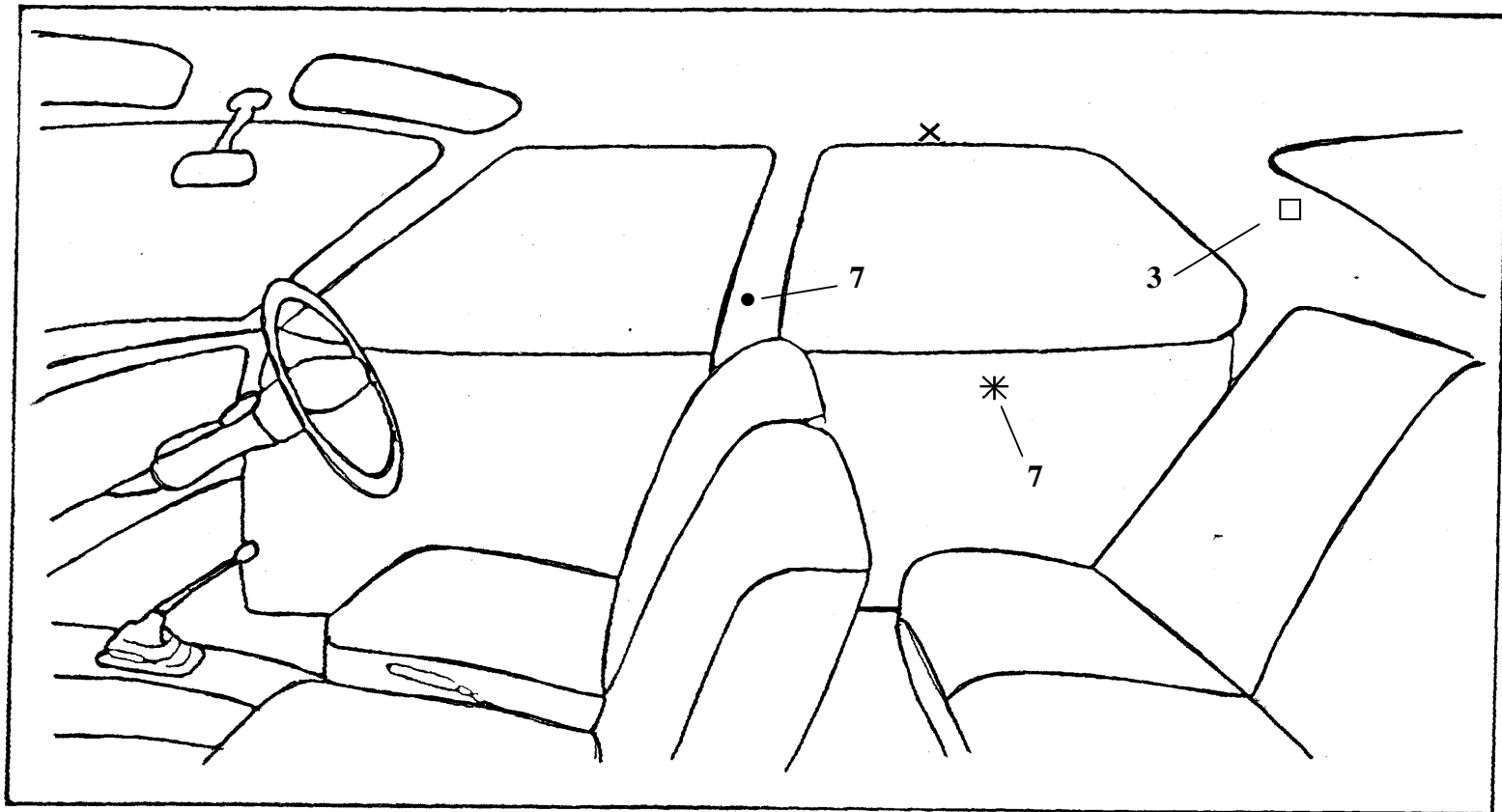


Figure 20 - Graphical Representation of Frequent Head Contact Regions, All Rear Seat Occupants - LAB Data

Key	Contact Region	Total in figure	Total no of contacts	Key	Contact Region	Total in figure	Total no of contacts
●	B Pillar	7	7	▲	Seat		
	Side Other	7	7	◆	Head Restraint		
	Side Roof Rail	1	1	ÿ	C Pillar	7	7

3.3.5 EFFECT OF INTRUSION AT POINT OF CONTACT

The final phase of the analysis selected those cases involving rear seat occupants where there was intrusion at the point of contact, and assesses the effect of supported and unsupported intrusion with respect to severity of injury.

No Intrusion		Supported Intrusion		Unsupported Intrusion	
AIS 3+ No	AIS 1+ No	AIS 3+ No	AIS 1+ No	AIS 3+ No	AIS 1+ No
4	43	2	3	0	2

Table 27 –Intrusion – All Rear Seat Occupants

Only a few cases were recorded where intrusion occurred. The severity of injury associated with the type of intrusion is shown below, Table 28 - Table 30, for head contacts with the structure of the vehicle as defined in 3.2.5.3.

Contact Site	TRL	
	AIS 3+ No.	AIS 1+ No.
Side Roof Rail	0	2
Side Other	0	1
Total	3	40

Table 28 - Contact Regions and Injury Severity with No Intrusion

Contact Site	TRL	
	AIS 3+ No.	AIS 1+ No.
B Pillar	0	1
Total	0	1

Table 29 - Contact Regions and Injury Severity with Supported Intrusion

Contact Site	TRL	
	AIS 3+ No.	AIS 1+ No.
Side Roof Rail	0	1
Total	0	2

Table 30 - Contact Regions and Injury Severity with Unsupported Intrusion

4. DISCUSSION

4.1 GENERAL

The primary objective of this analysis has been to establish potential contact zones for the head of car occupants in side impacts. Since any proposed sub-system test is seen as supplementary to the EEVC full-scale side impact test procedure, it should duplicate the occupant condition. Therefore the contact zones for restrained occupants on the struck side form the primary analyses. The contact zones for restrained non-struck side and unrestrained occupants on either side have also been investigated so that the potential for reducing injuries to these occupants might also be considered.

A similar analysis has been performed for rear seat occupants. Clearly the occupancy is much lower than for front seat occupants, so the overall benefits of safety improvement would be commensurably less. Car sharing is currently being encouraged, which may lead to an increase in rear seat occupancy by adults. Rear seat occupants may also feel that they have the right to expect a similar level of safety protection as that afforded to front seat occupants. The results of this analysis can be used to assist in this consideration.

Head contact areas can be divided into three sections:

1. **NON VEHICLE** - External or other occupant contacts, which may suggest the implementation of additional secondary safety systems.
2. **VEHICLE GLAZING** - Including the windscreen, side glass and flying glass, which may also suggest the implementation of additional secondary safety systems.
3. **VEHICLE STRUCTURE** - Rigid members and components on the interior of the car.

Emphasis has been put on contact zones within the vehicle structure, since the aim of this research is to identify regions for a possible interior headform test procedure. External contacts, vehicle glazing, contacts with the other occupant and unknown contact regions have been excluded when defining important contact regions.

Within this study, an unknown contact may occur for two reasons: where the injury was slight, usually AIS 1 and no contact marks were made. In severe impacts usually causing injuries of AIS 5 and 6, the reason would usually have been that it was impossible to identify any contacts due to massive deformation of the vehicle.

The side glass was a frequently struck region but injuries were predominantly minor to moderate, (exclusively in the LAB database). This suggests that, if the glass remains intact, the impact severity is low or if it breaks the impact severity is higher but that injury risk is reduced by glass fracture. All injuries caused by flying glass were minor.

Where external contacts are recorded in the databases, they all agree that this is a particularly common contact site with a high incidence of AIS 3+ injuries. Although contacts to the glazing and external contacts have been shown to be important in terms of frequency and severity of injury, it is not within the scope of this study to discuss them in detail. However, the relatively high incidence of these contacts does suggest that implementation of additional safety systems, such as side window airbags, could substantially reduce the number of injuries which occur during side impact.

The results of this analysis have also highlighted the fact that contacts to the steering wheel, facia top, and head restraint are common in side impact. Impacts to these contact regions are already incorporated into frontal impact assessment and are not discussed in further detail.

Subsequent sections use the term 'key contact region' to define those contact sites which the accident data suggests should be considered for any future supplementary interior headform test procedure, for side impact.

4.2 FRONT SEAT OCCUPANTS

4.2.1 GENERAL

The four accident databases are not fully compatible. Thus it was not possible to combine these results, as the sampling strategies and areas of contact defined are different. The following section looks at each database and ranks the contact sites in order of priority (one being the most important) based on the number of AIS 1+ head impacts for each database

4.2.2 RESTRAINED STRUCK SIDE OCCUPANTS

Based on this analysis, Table 31 shows the key contact regions to protect restrained occupants on the struck side.

Contact Site	Priority in terms of no. of AIS1+ injuries recorded					
	TRL		BASt		LAB	NHTSA
A Pillar	3		=5		No Contacts	3
B Pillar	1		1		1	1
Side Roof Rail	2		=2		2	2
Side Other	4		=2		No Contacts	
Roof	No Contacts		4			
Upper Anch' Point	5		=5			
Window Frame					3	

Table 31 - Key Contact Regions, Restrained Struck Side Occupants

All four databases agree that the B pillar is the most frequent point of contact for restrained occupants on the struck side, followed by the side roof rail, presumably due to the close proximity of these structures to the occupants' head.

The TRL and NHTSA data place the A-pillar as the third priority while BASt puts 'side other' third and LAB the window frame, but this is identified as a distinct contact site only in this database. The BASt sample suggests that the A pillar is of much less importance for restrained occupants on the struck side while the LAB sample has no recorded head contacts to the A-pillar for restrained front seat occupants. In some of the TRL cases with A-pillar contact, there was intrusion which displaced the A-pillar rearwards and inwards. Contact with the A Pillar may occur for restrained occupants on the stuck side, where the direction of force is around 2 o'clock. In this instance, the occupant is able to pivot about the point of interaction between the shoulder and the seat belt and strike the A Pillar. However, taking all samples into account, contact with the A-pillar for restrained struck side occupants is a

second order priority for side impact accidents. It may assume a higher priority if all impact directions are considered.

Beyond this the databases are not consistent in identifying one contact site as more important than another. Head contacts identified as side other are recorded only in the TRL and BAST data. This is a recognised site in the LAB database, but no contacts were recorded here. There is evidence from the BAST data that the roof is also a contact region for restrained occupants on the struck side. There was one contact with the upper anchorage point located on the B pillar in the TRL and BAST data.

4.2.3 RESTRAINED NON-STRUCK SIDE OCCUPANTS

Injury head contacts have been shown to occur for restrained occupants on the non-struck side also. If the protection of these occupants is considered important, the following contact regions are a priority, Table 32.

Contact Site	Priority in terms of no. of AIS1+ injuries recorded						
	TRL	BAST	LAB	NHTSA			
A Pillar	No contacts	=2	4	3			
B Pillar	2	=2	3	2			
Header	=4	No Contacts					
Side Roof Rail	3	1	2	1			
Side Other	1	=2	1				
Roof	=4	5					
Window Frame			5				

Table 32 - Key Contact Regions, Non-Struck Side Occupants

When the study is extended to include restrained non-struck side occupants the range of contact sites increases, this is particularly noticeable in the LAB data. The four databases lack consistency in identifying a single contact site as most important but overall, 'side other' can be considered a priority. Those contact sites identified as important for restrained occupants on the struck side, such as the B pillar, side roof rail and A pillar are also important for restrained non-struck side occupants. Further contacts to the roof and window frame (LAB only) were recorded but they were few in number. An additional contact site, not identified in the analysis of restrained struck side occupants is the header rail. This was identified in the TRL database only. The table ranks only those contact sites at the side of the passenger compartment and ignores internal contacts, such as steering wheel and front header rail

4.2.4 UNRESTRAINED OCCUPANTS –STRUCK AND NON-STRUCK SIDE

A fairly high proportion of those injured in accidents are unrestrained. Contact regions that should be incorporated in a supplementary headform test procedure if the protection of unrestrained occupants is considered important are shown in Table 33 below.

Contact Site	Priority in terms of no. of AIS1+ injuries recorded			
	TRL	BAST	LAB	NHTSA
A Pillar	1	No Contacts	5	1
B Pillar	=2	1	4	2
Header	=5	No Contacts		
Side Roof Rail	=5	No Contacts	1	3

Side Other	=2	No Contacts	2	
Roof	=2	2		
Window Frame			3	

Table 33 – Key Contact Regions, Unrestrained –Struck and Non-Struck Side Occupants

It should be noted that in the BASt database there are very few cases involving unrestrained occupant head contact with the vehicle structure. Analysis of the three remaining samples shows the priority in terms of the number of AIS 1+ injuries is less specific for unrestrained occupants. However, taken overall one can observe that the A pillar has become a more important contact site if the protection of unrestrained occupants is to be considered. The roof also has grown in importance when including unrestrained occupants. Those contact sites already identified as important, such as the B pillar, side roof rail, 'side other' are also important for unrestrained occupants. Further contacts to the header rail and window frame (LAB only) are recorded.

Thus, taking all results into account, the first priority areas for protection against head impacts in lateral impacts are the B-pillar and the side roof rail. Second priority areas are 'side other' and the A-pillar.

4.2.5 EFFECT OF INTRUSION

The effect of intrusion could only be assessed within the TRL data. Three different scenarios exist when discussing intrusion. Firstly where there was no intrusion at the point of head contact, secondly where there was intrusion but it was unsupported and finally where intrusion occurred and it was supported. The effect of intrusion on the severity of injury was assessed to investigate the need for including such a feature in a test procedure.

No intrusion was the most frequent condition. Supported intrusion occurred in a considerably lower number of cases and the intrusion was unsupported in just a few cases.

In section 3.2.5 , Table 14 shows that where no intrusion occurred, around 10% of cases, were of a serious nature. However when intrusion occurred that was supported by the intruding object, the proportion of injuries that were serious rises to 50%. When unsupported intrusion occurred, 30% of injuries were serious. It should also be noted for the B pillar, side roof rail and 'side other' that not only the proportion but, the absolute number of serious injuries is greater for supported intrusion in comparison with unsupported intrusion.

4.3 REAR SEAT OCCUPANTS

The level of occupancy for the rear seat is much less than that for front seat occupants and therefore any discussion is limited. Nevertheless, across the databases the B pillar, C pillar, side roof rail and seat were identified as head contact sites for restrained occupants on the struck side in the rear seating position. In all databases there is a greater number of unrestrained occupants. If protection of unrestrained rear seat occupants is desired the head restraint (front seat) and 'side other' should also be included.

5. CONCLUSIONS

1. Four databases were reviewed in this study. Each of which had a different sampling strategy, therefore it was not possible to combine the samples. In addition the definition of contact sites was not fully consistent.
2. When each database is compared broadly similar results are obtained.
3. All databases agree that the B Pillar is the principal contact area for restrained occupants on the struck side with the side roof rail as the next most important zone. The A pillar and 'side other' are second order priority contact sites. Other head contact sites are; window frame (if treated as a separate contact site), roof, upper anchorage point (if treated as a separate contact site) and head restraint.
4. Analysis of restrained non-struck side and unrestrained front seat occupants, supported this conclusion and suggested that A-pillar contacts become more important and that the header rail becomes an additional head contact site that should be considered for a supplementary headform test for front seat occupants in a side impact.
5. The proportion of severe injuries was higher where the intrusion was supported, than where there was no intrusion. In addition the absolute number of severe injuries from head impact to the B Pillar, side roof rail and 'side other' was greater where the intrusion was supported. To reduce the number of severe injuries in side impact, it would be appropriate to adopt a test procedure, which incorporates a feature to replicate supported intrusion.
6. There were many fewer cases of head contact to rear seat occupants due to the occupancy rate for the rear seat. The cases involving restrained struck side occupants showed that the B and C pillars side roof rail and front seat were contact regions for restrained occupants on the struck side. Analysis of restrained non-struck side and unrestrained occupants showed that it was also possible for the head to contact the head restraint, 'side other' and window frame.
7. It was not possible to draw conclusions on the influence of intrusion for rear seat occupants due to the low number of cases involving intrusion. However, it should be noted that both cases that involved intrusion caused AIS 1-2 type injuries.

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