INJURY RISK/BENEFIT ANALYSIS OF MOTORCYCLIST PROTECTIVE DEVICES USING COMPUTER SIMULATION AND ISO 13232

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ABSTRACT

International Standard 13232 provides common research methods for assessing the feasibility of proposed protective devices which might be fitted to motorcycles. This paper reviews the Part 7 computer simulation requirements of the Standard; and applies the simulation to an example injury risk/benefit analysis (Part 5) of a proposed UKDS motorcycle leg protector device. Overall, the computer simulation and injury risk/benefit analysis portions of the Standard were found to be practical and feasible. The analysis of the UKDS leg protector indicated that a motorcycle equipped with this device increases total injury costs to motorcycle riders in impacts with passenger cars, and therefore should not be fitted to motorcycles.

INTRODUCTION

During the last 25 years, research on the feasibility of rider crash protection devices which might be fitted to motorcycles has occurred in Great Britain, Japan, Germany, and the United States. One example of such research in the 1980's was the leg protector work of TRRL, the United Kingdom's Transport and Road Research Laboratory (now TRL), which led to a proposed Draft Specification (UKDS) for motorcycle leg protectors.

Subsequently, several UKDS leg protector designs were evaluated in full scale tests by TRRL and by the motorcycle industry, with generally opposite results [1,2,3]. In particular, one leg protector design was separately evaluated by TRRL and by the industry, using different test methods [4], and this resulted in large differences in measurements and conclusions.

An International Leg Protector Seminar [5] and the recommendation of experts in the crash protection field led to the conclusion that an internationally accepted motorcyclist crash dummy and research methodology were necessary first steps, before further objective and meaningful research could be pursued. This led to international development and approval of ISO 13232 [6].

Full scale tests involving the proposed UKDS leg protector were conducted using the Standard and reported by Rogers, et al [7]. This paper extends that work by reviewing the development, content, and status of a common research methodology for computer simulation which has been standardized in ISO 13232; and by illustrating the application of the Standard to an overall evaluation of the proposed UKDS leg protector device by means of computer simulation.

BACKGROUND

Development of ISO 13232

Recognizing the need for common test and evaluation methods, the United Nations Expert Group for General Vehicle Safety Provisions (UN/ECE/TRANS/WP29/GRSG) decided in March 1992, at the suggestion of the International Motorcycle Manufacturers Association (IMMA), to ask the International Organization for Standardization (ISO), to establish a common research methodology for motorcycle crash testing.

Six meetings of working group ISO/TC22/SC22/WG22 were held between November 1992 and April 1994 involving some 25 experts and observers from the United Kingdom, Germany, France, the Netherlands, Belgium, Italy, the United States of America, Japan, Canada, and China, with input from both the motorcycle industry worldwide and technical experts in the crash research field [8]. In summer 1994, a committee draft (CD) was balloted and approved within ISO/TC22/SC22. This was followed by balloting of a Draft International Standard (DIS); and final approval of the DIS by the ISO National Member Bodies in March

1996. Publication of ISO 13232 occurred in December 1996.

Review of ISO 13232 Provisions

ISO 13232 consists of eight interacting and mutually dependent parts:

Part 1: Definitions
Part 2: Definition of impact conditions in relation to accident data.
Part 3: Motorcyclist dummy
Part 4: Measurements
Part 5: Injury indices and risk/benefit analysis
Part 6: Full scale impact test procedures
Part 7: Computer simulation procedures
Part 8: Test and simulation documentation

The injury risk/benefit analysis enables an overall evaluation of the predicted effects on injuries of a given proposed protective device. This analysis is performed across a sample of the accident population, based on a calibrated computer simulation, and 200 pairs of simulated impacts (with and without the device fitted). A description of the provisions and rationale for each part of the Standard is given by Van Driessche [8]. In addition, specific rationale for the provisions is included in the Standard.

Continued Refinement of the Standard

It is anticipated that the Standard will be amended whenever necessary to take into account new research needs, technological progress, and practical experience.

Currently, WG22 technical work is continuing toward definition of a possible first revision of the Standard, taking into account practical experience and new technology.

EXAMPLE APPLICATION OF THE STANDARD TO IMPACT SIMULATION

Objectives of this Study

The objectives of the research reported herein were:

- To assess the practicality and feasibility of the ISO 13232 simulation requirements; and

- To apply ISO 13232 in an overall evaluation of UKDS leg protectors using computer simulation.

The UKDS leg protector device was designed and fitted by TRRL to a Kawasaki GPZ 500 motorcycle. This specific design has been the subject of previous reports, namely those of:

- Chinn [9], using test methods quite different from those of ISO 13232;

- Rogers [4], using test methods similar but not identical to those of ISO 13232;

- Rogers [7], using the test methods of ISO 13232.

Simulation Basis

The computer simulation was based on a proprietary version of the Articulated Total Body (ATB) program originally developed by Calspan for the National Highway Traffic Safety Administration [10]. The ATB simulation comprises generalized multi body equations of motion based on a Newton-Euler formulation, as required by the Standard. The software was executed on a Silicon Graphics Onyx Infinite Reality workstation containing eight 200 MHz R10000 CPUs for computation and a high-speed graphics pipeline for rendering the corresponding animations.

Simulation Models

An ISO Motorcyclist Anthropometric Test Dummy (MATD) was modeled, based on a modified Hybrid III 50th percentile male dummy in accordance with ISO 13232-3 and as summarized in Table 1.

The motorcycle that was modeled was a Kawasaki GPZ 500 with a summary given in Table 2.

The opposing vehicle that was modeled was a production Toyota Corolla 4 door sedan, Japan domestic model, model year 1988 to 1990, inclusive, as specified in ISO 13232-6. A summary appears in Table 3.

A summary of the UKDS leg protector that was modeled is found in Table 4.

Table 1.
MATD Dummy Description

Basis dummy:	M50 Hybrid III
Overall height:	1720 mm
Mass:	71 kg
Bodies:	30
Joints:	29
Ellipsoids:	28
Planes:	0

Table 2.
Motorcycle Description

Size:	Medium
UKDS category:	3a
Manufacturer:	Kawasaki
Model:	GPZ
Model year:	1988
Overall length:	2125 mm
Overall width:	675 mm
Overall height:	1165 mm
Mass - motorcycle with LP:	189 kg (dry)
Bodies:	7
Joints:	6
Ellipsoids:	18
Planes:	0

Table 3.
Opposing Vehicle Description

Type:	Sedan
Manufacturer:	Toyota
Model:	Corolla
Model year:	1988-1990
Overall length:	4200 mm
Overall width:	1660 mm
Overall height:	1340 mm
Mass:	1100 kg
Bodies:	7
Joints:	6
Ellipsoids:	26
Planes:	4

Table 4.
UKDS Leg Protector Description

Type:	UKDS
Components:	Primary Impact Element Rigid Support Element Knee Protection Element
Bodies (total left + right):	2
Joints (total left + right):	2
Ellipsoids (total left + right):	4
Planes (total left + right):	10

Basis for Simulation Model Parameters

The model parameters for the MATD dummy were based in part on Hybrid III measurements made by the US Air Force [11]. Modifications were made to that database to account for the frangible femurs, knees, and tibias that are specified in the Standard. In addition, a compliant chest and abdomen were added to the model to allow computation of the compression based injury measures of these body regions. The neck model was also modified to account for the special torsional module present in the MATD, as specified in the Standard.

Mass properties, dimensions, joint locations, and suspension properties for the motorcycle and opposing vehicle were determined by laboratory measurements of exemplar vehicles.

Model Calibration

ISO 13232-7 specifies that 20 dynamic and 11 static laboratory component tests be done and compared with the corresponding computer simulations of these tests in order to help indicate the quality of the computer simulation model. In addition, a motorcycle barrier test is specified in order to provide a comparison between the modelled and measured response characteristics related to the front wheel, front suspension, and front fork bending properties and their effects on the motorcycle forces and motions resulting from frontal impact.

For all static tests, the Standard requires plotting the force vs. displacement laboratory test results overlaid with the simulation results. For dynamic tests, the Standard requires plotting the force vs. displacement and force vs. time laboratory test results overlaid with the simulation results. The Standard requires that the simulation parameters used in these calibration tests be used for all subsequent simulation runs. The component calibration results for this analysis can be found in Appendix A.

The Standard also requires comparison and correlation of the simulation with full scale impact test results. For this analysis, the results of 14 full scale tests were available for correlation. Figure 1 shows a plot of peak resultant head acceleration correlation, for which the r^2 correlation coefficient was found to be 0.91. Figure 2 shows the correlation of the change in peak resultant head acceleration. This second plot is not required by the Standard, but was found to be important in quantifying the correlation of the effect of the protective device. If the points on the plot were mainly in the upper left portion of the plot, it would indicate that the simulation over predicts the harmful effects of a given device. If the points on the plot were mainly in the lower right portion, it would indicate that the computer simulation over predicts the beneficial effects of a given device. In this example, it was found that the simulation accurately predicted the change in head acceleration due to the leg protectors. The r^2 correlation coefficient for this plot was 0.84.

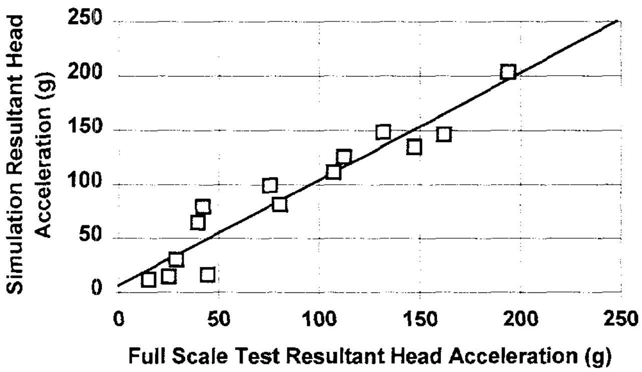

Figure 1. Correlation of peak resultant head acceleration.

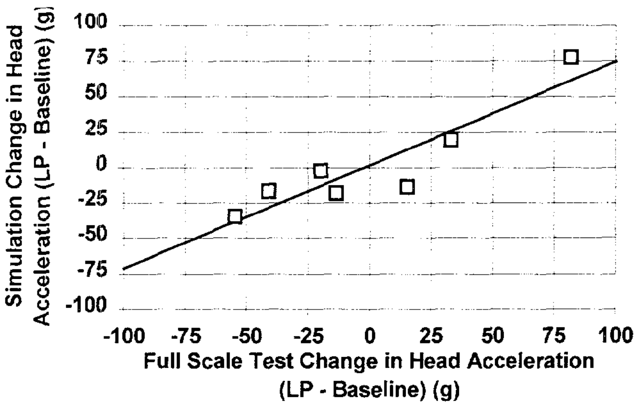

Figure 2. Correlation of change in peak resultant head acceleration due to fitment of leg protectors.

ISO 13232 also requires correlating femur and tibia fractures and knee dislocations for the 14 full scale tests to indicate the accuracy level of the simulation. Tables 5, 6, and 7 show the lower extremity injury results. The percentage of femur fractures correctly predicted by the simulation was 92.9%, the percentage of tibia fractures correctly predicted was 92.9%, and the percentage of knee dislocations correctly predicted was 100.0%.

Table 5.
Femur Fracture Correlation

		Full Scale Test	
		Fracture	No Fracture
Computer Simulation	Fracture	2	2
	No Fracture	0	24

Table 6.
Tibia Fracture Correlation

		Full Scale Test	
		Fracture	No Fracture
Computer Simulation	Fracture	2	2
	No Fracture	0	24

Table 7.
Knee Dislocation Correlation

		Full Scale Test	
		Fracture	No Fracture
Computer Simulation	Fracture	0	0
	No Fracture	0	28

The final calibration requirement is to plot various kinematic simulation parameters described in the Standard, overlaid with the corresponding full scale test variable. Maximum tolerances for the difference between the simulation variable and the full scale test variable at 10 ms before head contact are specified in the Standard. An example of this is shown in Figure 3. This portion of the Standard was found to have some limitations for full scale impact test comparisons, because it compares only the end points of the time histories. In some cases, this can result in acceptance of a simulation time history which has large deviations from full scale test results, during most of its duration; or it may reject a simulation time history which closely follows the full scale test result, except at one time instant. An alternate, revised method to compare these time history variables, has been proposed as an amendment to the Standard [12]. With this proposal, a correlation factor, analogous to an r^2 correlation coefficient, is calculated over the time history as follows:

$$C = 1 - \frac{\sum_{i,k} \left(d_{i,k} - \bar{d}_i\right)^2}{\sum_{i,k} \left(r_{i,k} - \bar{r}_i\right)^2} \qquad (1)$$

where:

C = correlation factor

i	=	subscript for each impact configuration
k	=	subscript for each time step
$d_{i,k}$	=	$r_{i,k}$ - $\hat{r}_{i,k}$
$\bar{d}_i$	=	average value (over time) of $d_{i,k}$
$r_{i,k}$	=	value for test i at time k
$\bar{r}_i$	=	average value (over time) of $r_{i,k}$
$\hat{r}_{i,k}$	=	value for computer simulation i at time k

Using this method, the average correlation across all tests and all 13 variables was found to be 0.82.

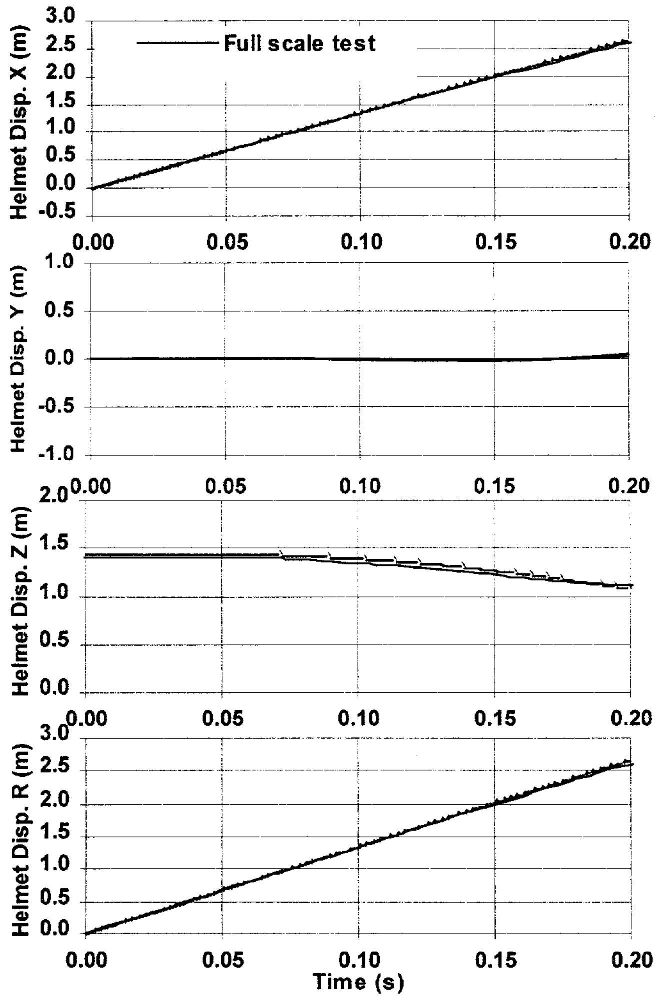

Figure 3. Example time history comparison overlay.

Simulation Output

As specified in the Standard, the computer simulation model was used to compute the following injury assessment variables and injury potential variables:

- Head maximum GAMBIT
- Head Injury Criterion (HIC)
- Head maximum resultant linear acceleration
- Sternum maximum normalized compression
- Sternum maximum velocity-compression (VC)
- Abdomen maximum penetration
- Femur fracture occurrence
- Knee dislocation occurrence
- Tibia fracture occurrence

The probability of each discrete AIS injury severity level was calculated for each of the four body regions: the head, thorax, abdomen, and lower extremities, in accordance with ISO 13232-5 requirements. These were used to calculate the Total Normalized Injury Cost (TNIC).

The computer simulation also generated three dimensional animations, in accordance with the provisions of ISO 13232-7, to display, graphically, the motions of the motorcycle, opposing vehicle, dummy, and protective device. The animation displayed only the actual modeled rigid body surfaces in their proper shapes, relative positions, and orientations, and these were useful in understanding the simulation results.

Injury Risk/Benefit Analysis

An injury risk/benefit analysis was performed via computer simulation using the procedures specified in ISO 13232-5. In summary, this portion of the Standard requires analyzing calibrated simulations of 200 impact configurations – with and without the protective device - which represent 501 accidents that occurred in standardized databases from Los Angeles and Hanover. The change in each injury index and injury assessment variable due to the fitment of the leg protector are tabulated and sorted for all 200 impact configurations. These are used to create cumulative frequency histograms for each injury index and injury assessment variable. The percentage of accidents that are beneficial, show no effect, and are harmful are tabulated for each of these histograms.

An additional injury risk/benefit definition has been proposed as an amendment to the Standard [13]. This amendment is needed because the current risk/benefit calculations, though useful, are not sufficient to describe the magnitude of the injury risks and benefits of a protective device and can lead to erroneous conclusions. Currently, the Standard requires reporting only the percentages of benefit, no effect, and harm without reporting the total magnitude of injury benefit and risk. The amendment proposes adding the calculation of risk/benefit and net benefit as follows:

$$BLI = \sum_{n=1}^{N_{total}} \left(x_{n,i} * FO_n \right) \tag{2}$$

$$r = \sum_{k=1}^{N_{risk}} \left(\Delta x_{k,i} * FO_k \right) \tag{3}$$

$$b = \sum_{l=1}^{N_{benefit}} \left(-\Delta x_{l,i} * FO_l \right) \tag{4}$$

where:

BLI = Sum of the values for the baseline vehicle injury index or injury assessment variable

b = Sum of the changes in injury index or injury assessment variable for the accidents in which the protective device decreased the injury (ie, a benefit)

r = Sum of the changes in injury index or injury assessment variable for the accidents in which the protective device increased the injury (ie, a risk)

$N_{benefit}$ = Number of configurations in which the protective device was beneficial for a given injury index or injury assessment variable

N_{risk} = Number of configurations in which the protective device was harmful for a given injury index or injury assessment variable

N_{total} = Total number of configurations

i = Subscript for each injury assessment variable

l = Subscript for each benefit configuration

k = Subscript for each risk configuration

n = Subscript for all configurations

Δx = Change in injury assessment variable (protective device - baseline)

x = Value of the injury assessment variable for the baseline motor cycle

FO = Frequency of occurrence

$$Benefit = \frac{b}{BLI} * 100\% \tag{5}$$

$$Risk = \frac{r}{BLI} * 100\% \tag{6}$$

Injury Risk/Benefit ratio is then defined as r/b * 100%, and Net Benefit is defined as Benefit - Risk. (A method for handling special cases, such as when r, b, or BLI are zero, is described in the proposed amendment.)

A plot of the Total Normalized Injury Cost cumulative frequency histogram for the leg protector device is presented in Figure 4, and a table of the injury risk/benefit analysis results is presented in Appendix D. The histogram plot for total normalized injury cost indicates that the total injury risk (area above the curve in the right half of the plot) is approximately equal to the total injury benefit (area below the curve in the left half of the plot). This is in agreement with the proposed injury risk/benefit calculations in which the risk/benefit ratio was found to be 116% and the net benefit was found to be -5%.

However, the percentage harmful was calculated to be only 17% of the accidents, and the percentage beneficial was calculated to be 26% of the accidents. Use of the latter indices alone, would lead to the incorrect implication that the overall effect of the leg protector would be beneficial, when, in fact, on an overall basis, it was found that the injury risks exceed the injury benefits. This example demonstrates why the proposed amendment to the Standard is necessary.

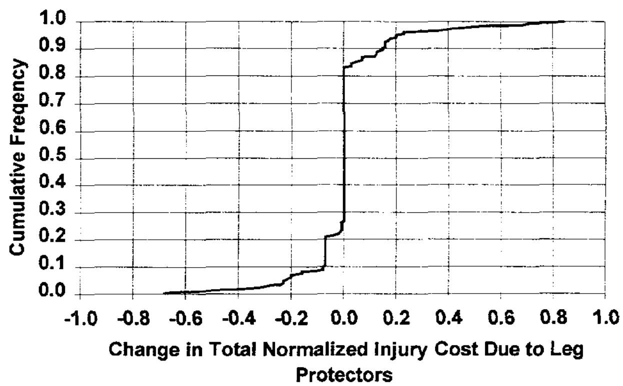

Figure 4. Total normalized injury cost cumulative frequency histogram.

The reasons that the UKDS leg protector is, overall, a harmful device can be observed in the second table of Appendix D. The leg protector is harmful (ie, has injury risk/benefit exceeding 100 percent) with respect to femur AIS, has little net effect on head AIS (ie, has nearly 100% risk/benefit), and is beneficial (ie, has small injury risk/benefit) with respect to chest, knee, and tibia AIS. However, the baseline motorcycle does not result in many injuries to the chest and knee, so the total possible number of leg protector benefits in these body regions is small. In addition, injury costs for each femur injury are much greater than those for each tibia injury, giving the femur body region more influence in the total normalized injury cost.

ISO 13232 Reporting Recommendations

ISO 13232 recommends the following to be reported in any publication which is intended to meet this International Standard:

- Injury Risk/benefit analysis data (provided in Appendix B);
- Injury Risk/benefit analysis basis (provided in Appendix C);
- Injury Risk/benefit analysis results (provided in Appendix D);
- Injury Risk/benefit analysis checklist (provided in Appendix E).

CONCLUSIONS AND RECOMMENDATIONS

Simulation According to ISO 13232

ISO 13232 computer simulation requirements were found to be practical and achievable, and the Standard appears to be useful for research in assessing the feasibility of proposed protective devices.

Experience with the Standard revealed two areas for possible refinement of the Standard. First, the injury risk/benefit calculations should be amended to include the magnitude of the risk and benefit, not just the percentage of cases having risk and benefit. Second, a "single point" time history comparison methodology is not useful. It is technically more descriptive to correlate the time histories over the entire period of time than to compare them only at the end points.

UKDS Leg Protectors

In an evaluation of UKDS leg protectors via computer simulation over the wide range of impact configurations defined in ISO 13232, the devices were found to increase the total normalized injury cost to the dummy in impacts with a passenger car. Specifically, the leg protectors increased costly femur injuries, and decreased less costly tibia injuries. This resulted in a risk/benefit ratio of 116% (ie, the ratio of total increases in normalized injury cost to the total decreases in normalized injury cost was 1.16). This means that the UKDS leg protectors increased rather than decreased total injury costs. The transference of injuries from the tibia to the femur and the net increase in injury cost is in agreement with previous full scale test results which were over a smaller sample of impact conditions.

Based on the overall evaluation of this device, using ISO 13232 procedures, it is recommended that such a device not be fitted to production motorcycles.

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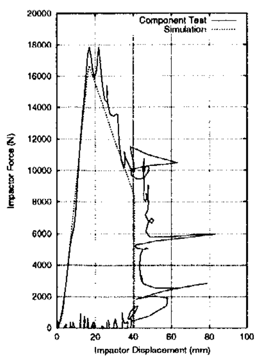
13. Kebschull, S., Zellner, J., Van Auken, M., "Proposed Amendment to: Part 5, 5.10.4", ISO/TC22/SC22/WG22 N236, May 1997.

Appendix A. Component calibration results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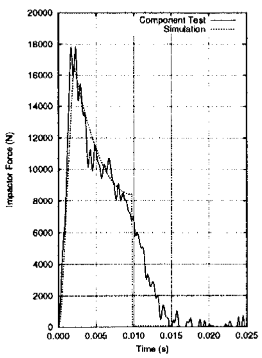
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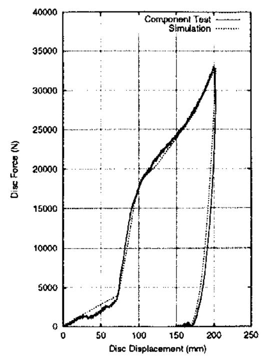
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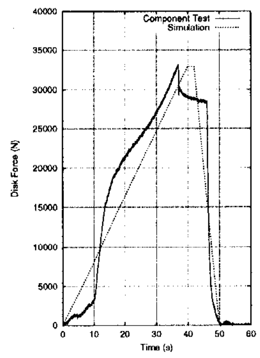
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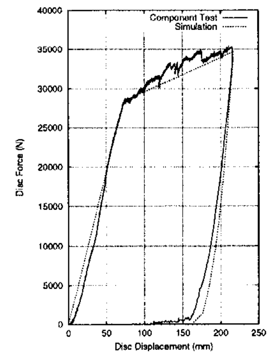
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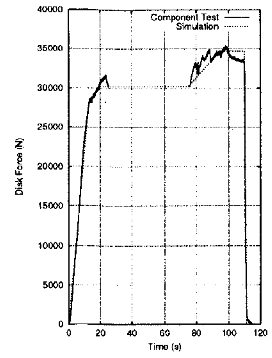
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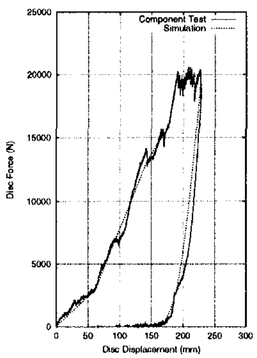
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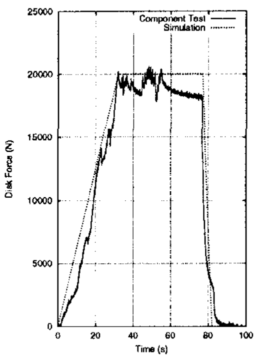
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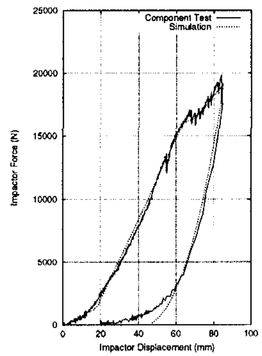
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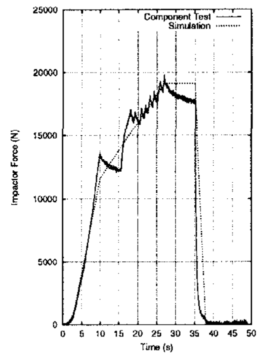
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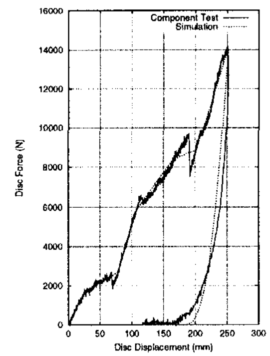
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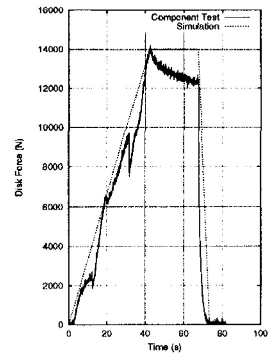
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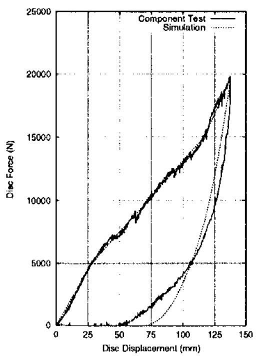
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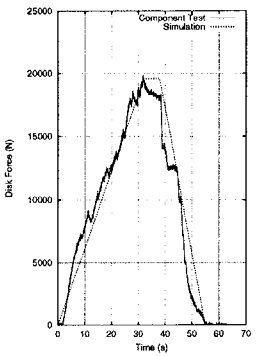
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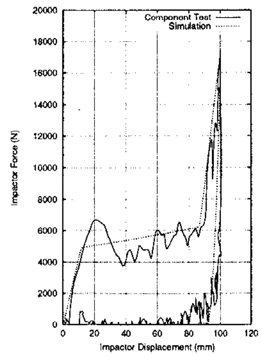
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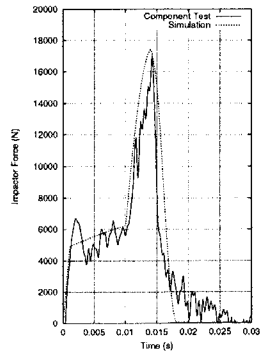
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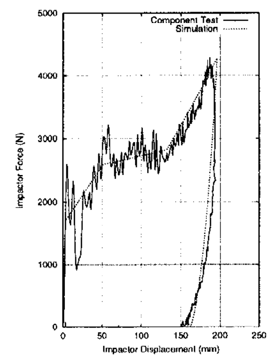
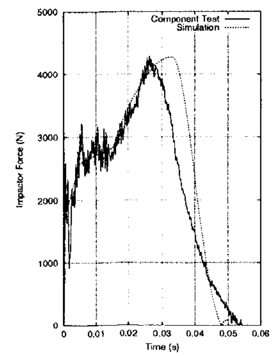
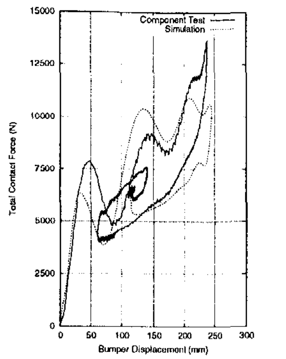
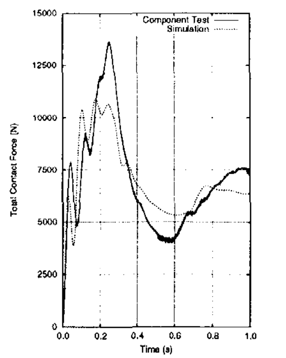

Sphere/OV front windscreen


Sphere/OV front windscreen

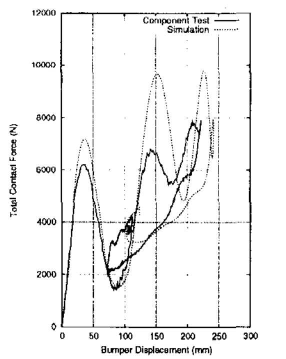
Appendix A. Component calibration results (cont.)



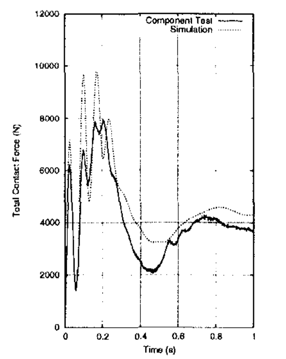
Ground/OV front suspension



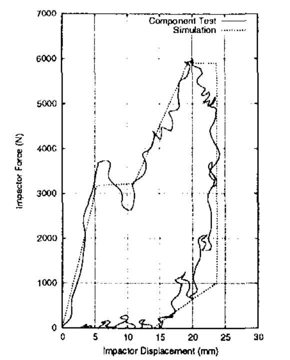
Ground/OV front suspension



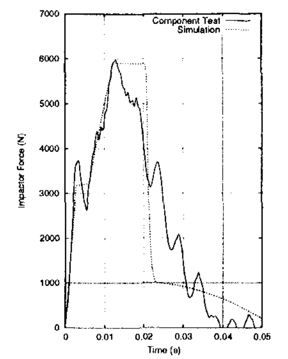
Ground/OV rear suspension



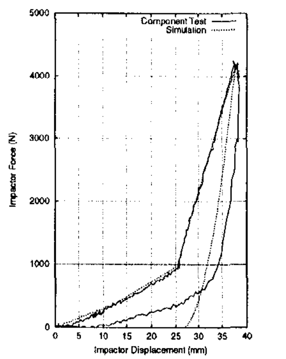
Ground/OV rear suspension



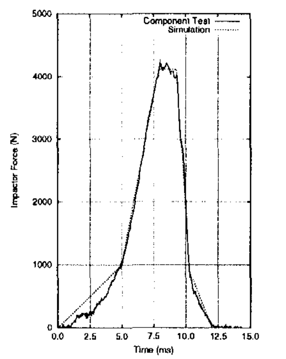
Cylinder/MC fuel tank



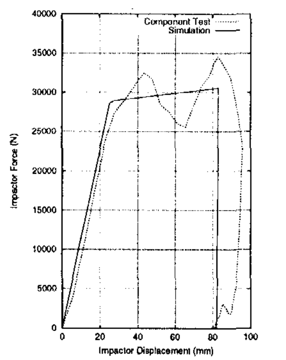
Cylinder/MC fuel tank



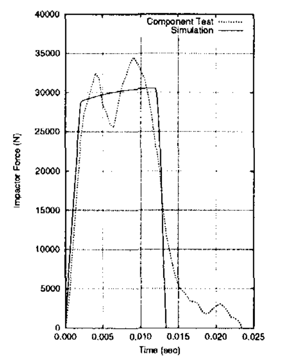
Cylinder/MC seat



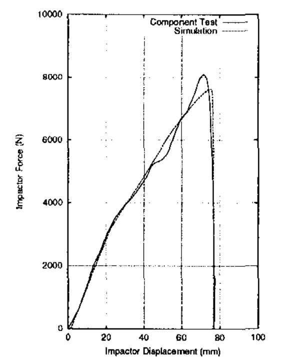
Cylinder/MC seat



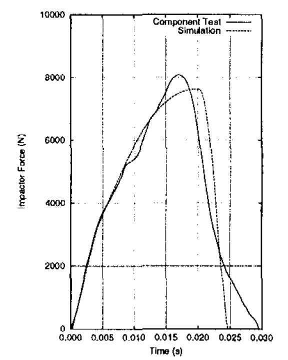
Flat/PIE



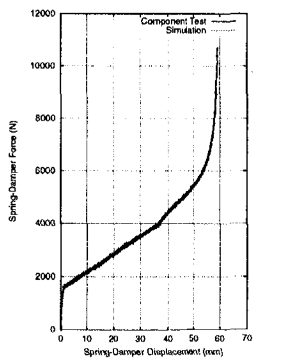
Flat/PIE



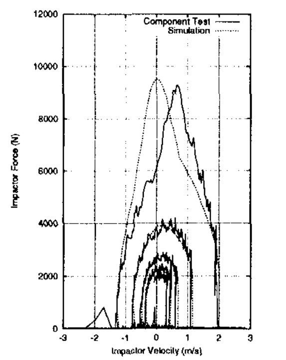
Knee form/KPE



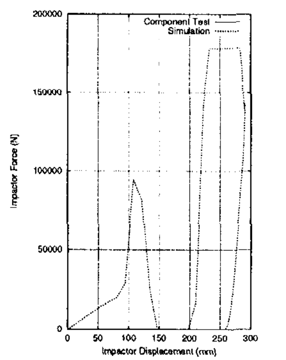
Knee form/KPE



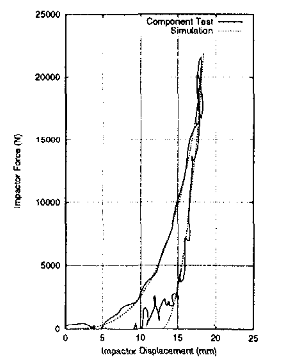
MC rear spring damper



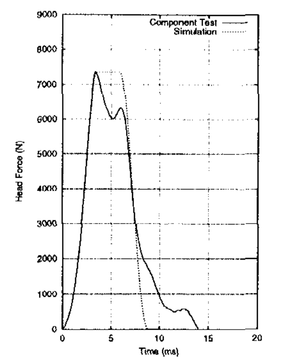
MC rear spring damper



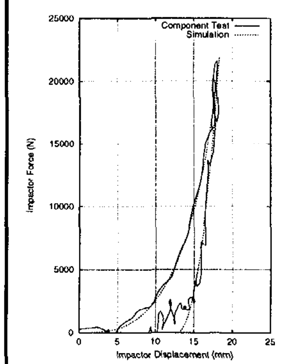
Barrier/MC front wheel



Flat anvil/Helmeted head

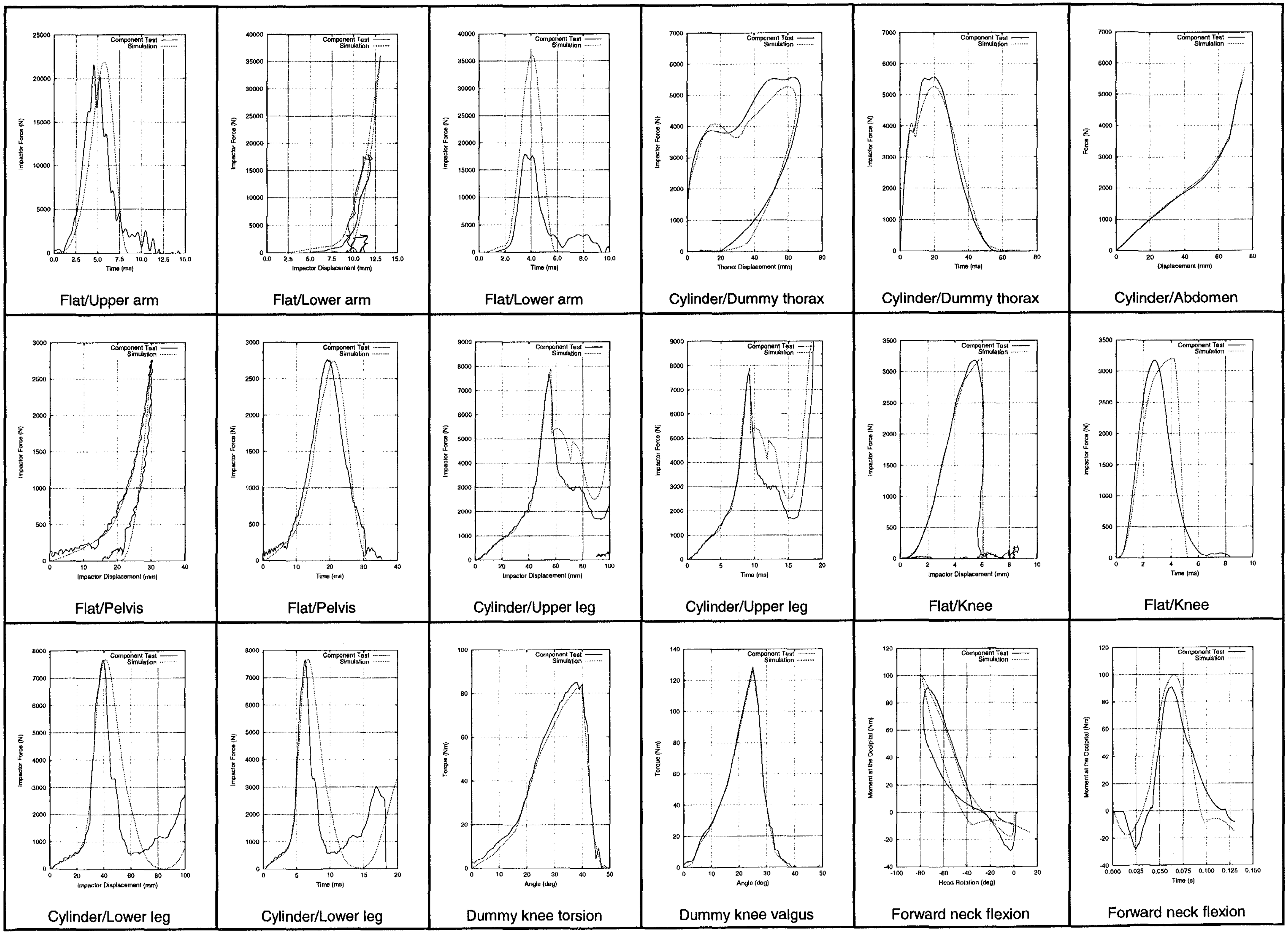


Flat anvil/Helmeted head



Flat/Upper arm

Appendix A. Component calibration results (cont.)

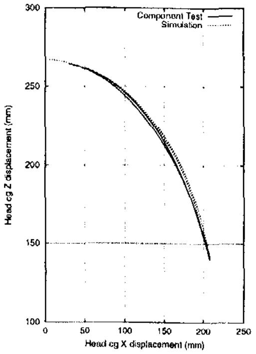


Flat/Upper arm | Flat/Lower arm | Flat/Lower arm | Cylinder/Dummy thorax | Cylinder/Dummy thorax | Cylinder/Abdomen

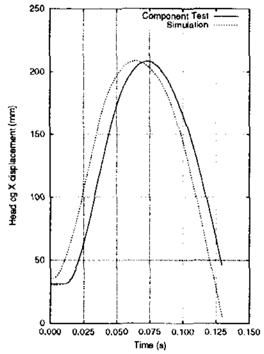
Flat/Pelvis | Flat/Pelvis | Cylinder/Upper leg | Cylinder/Upper leg | Flat/Knee | Flat/Knee

Cylinder/Lower leg | Cylinder/Lower leg | Dummy knee torsion | Dummy knee valgus | Forward neck flexion | Forward neck flexion

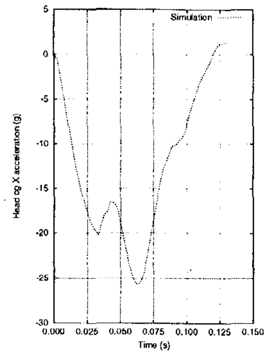
Appendix A. Component calibration results (cont.)



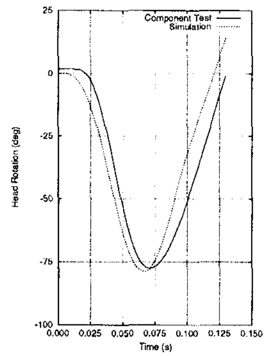
Forward neck flexion



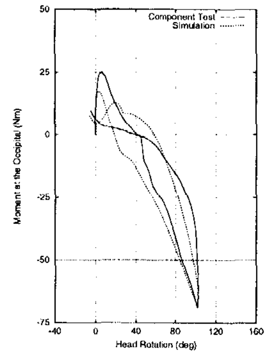
Forward neck flexion



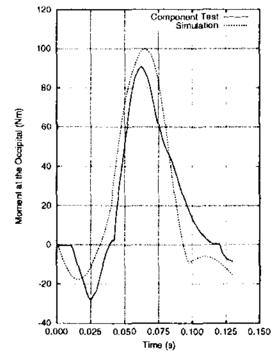
Forward neck flexion



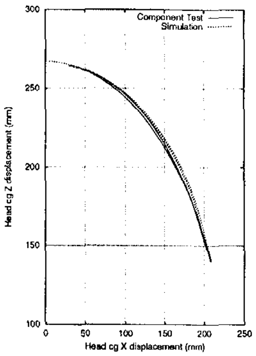
Forward neck flexion



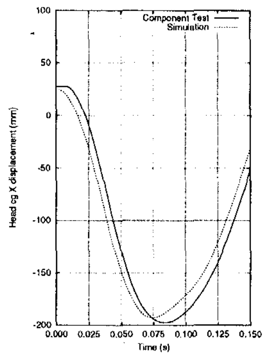
Rearward neck extension



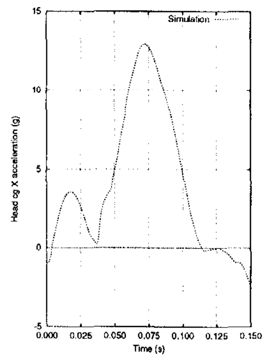
Rearward neck extension



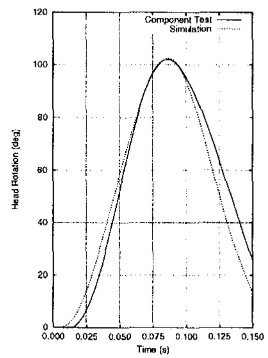
Rearward neck extension



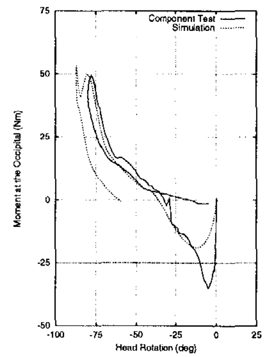
Rearward neck extension



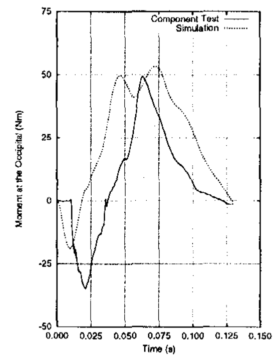
Rearward neck extension



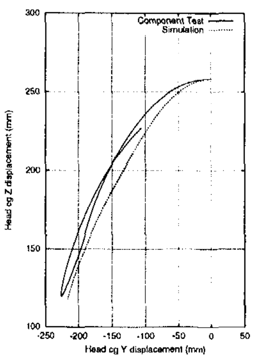
Rearward neck extension



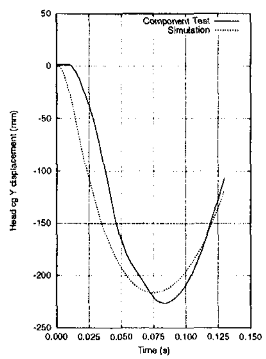
Lateral neck flexion



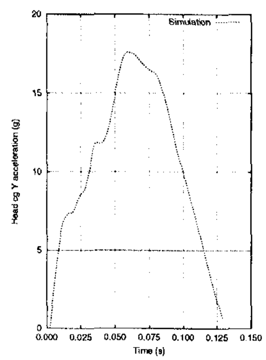
Lateral neck flexion



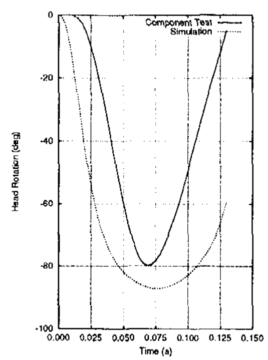
Lateral neck flexion



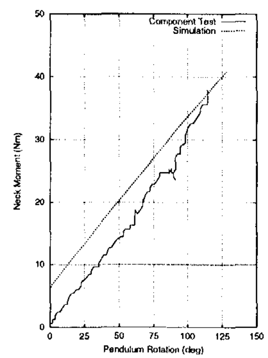
Lateral neck flexion



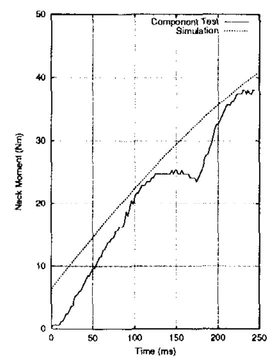
Lateral neck flexion



Lateral neck flexion



Neck torsion



Neck torsion

Appendix B. Risk/benefit analysis data

Impact Configuration Code	Values																																		
	Head																	Chest			Abdomen			Femur (L+R)			Knee (L+R)			Tibia (L+R)					
	ar,H,max			Ar,H,max			Gmax			HIC			PAIS			hT	hV	PAIS			PAIS			PAIS			PAIS			PAIS			ICnorm		
	B	P	C	B	P	C	B	P	C	B	P	C	B	P	C	C	C	B	P	C	B	P	C	B	P	C	B	P	C	B	P	C	B	P	C
114- 0.0/ 6.7	26	11	-16	1.5	1.2	-0.3	0.1	0.1	-0.1	19	5	-14	0	0	0	-0.14	0.19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
114- 0.0/ 9.8	10	6	-4	0.6	0.4	-0.2	0.0	0.0	0.0	13	4	-9	0	0	0	0.16	0.60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
114- 0.0/13.4	14	7	-7	1.1	0.4	-0.7	0.1	0.0	0.0	29	7	-22	0	0	0	0.28	0.26	0	0	0	0	0	0	0	0	0	0	0	0	2	2	-2	0.07	0.00	-0.07
114- 0.0/20.1	21	13	-8	1.5	0.8	-0.7	0.1	0.1	0.0	90	29	-61	0	0	0	0.13	0.56	0	0	0	0	0	0	0	0	3	0	0	0	2	2	0	0.07	0.23	0.16
114- 6.7/ 0.0	63	23	-40	2.1	2.0	-0.1	0.3	0.1	-0.1	55	15	-40	0	0	0	-0.54	-1.22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
114- 6.7/ 6.7	81	83	3	5.3	5.7	0.3	0.3	0.4	0.1	422	292	-130	0	0	0	-0.33	1.54	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0.07	0.07	0.00
114- 6.7/ 9.8	82	65	-17	4.7	6.2	1.5	0.4	0.3	0.0	257	220	-37	0	0	0	-0.32	2.85	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0.07	0.07	0.00
114- 6.7/13.4	79	99	20	8.0	6.5	-1.5	0.4	0.4	0.0	544	567	23	0	0	0	-0.24	2.36	0	0	0	0	0	0	3	3	0	0	0	0	2	2	0	0.23	0.23	0.00
114- 6.7/20.1	348	96	-253	23.0	10.7	-12.3	1.7	0.5	-1.2	4175	810	-3365	6	0	-6	-0.29	2.88	0	0	0	0	0	0	3	6	3	0	0	0	2	4	2	0.95	0.30	-0.65
114- 9.8/ 0.0	47	43	-4	3.9	2.3	-1.6	0.2	0.2	0.0	57	17	-40	0	0	0	-0.97	0.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
114- 9.8/ 6.7	61	71	10	6.6	7.3	0.6	0.3	0.3	0.0	243	246	2	0	0	0	-0.16	1.23	0	0	0	0	0	0	0	0	3	0	0	0	2	2	0	0.07	0.23	0.16
114- 9.8/ 9.8	100	66	-34	9.3	9.2	0.0	0.4	0.4	0.0	644	313	-331	0	0	0	-0.21	2.66	0	0	0	0	0	0	3	3	0	0	0	0	2	2	0	0.23	0.23	0.00
114- 9.8/13.4	126	76	-51	9.5	10.6	1.0	0.5	0.5	-0.1	1028	489	-539	0	0	0	-0.20	1.44	0	0	0	0	0	0	3	6	3	0	0	0	2	2	0	0.23	0.30	0.07
114- 9.8/20.1	364	126	-238	45.2	15.5	-29.7	1.9	0.7	-1.2	6552	1508	-5043	6	1	-5	-0.26	2.14	0	0	0	0	0	0	3	6	3	0	0	0	4	4	0	0.99	0.31	-0.68
114-13.4/ 0.0	52	19	-34	2.7	1.5	-1.2	0.2	0.1	-0.1	85	5	-80	0	0	0	-1.01	-0.26	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0.00	0.07	0.07
114-13.4/ 6.7	163	161	-2	9.5	16.3	6.9	0.8	0.9	0.2	525	1191	666	1	3	2	-0.37	-0.54	0	0	0	0	0	0	0	0	3	0	0	0	2	2	0	0.10	0.39	0.29
114-20.1/ 6.7	334	249	-85	22.8	18.4	-4.4	1.6	1.1	-0.6	3240	4685	1446	6	4	-2	-0.44	-6.48	1	0	-1	0	0	0	3	3	3	0	0	0	2	2	2	0.94	0.59	-0.35
123- 6.7/ 0.0	37	35	-2	2.6	2.7	0.1	0.2	0.2	0.0	71	54	-17	0	0	0	-0.53	0.57	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
123- 6.7/ 6.7	7	7	0	0.4	0.8	0.4	0.0	0.0	0.0	9	7	-2	0	0	0	-0.13	0.34	0	0	0	0	0	0	0	0	0	0	0	0	2	2	-2	0.07	0.00	-0.07
123- 6.7/ 9.8	7	7	0	0.4	0.7	0.3	0.0	0.0	0.0	8	7	-1	0	0	0	-0.12	0.06	0	0	0	0	0	0	0	0	0	0	0	0	2	2	-2	0.07	0.00	-0.07
123- 6.7/13.4	7	6	-1	0.4	0.7	0.3	0.0	0.0	0.0	8	6	-2	0	0	0	-0.11	-0.13	0	0	0	0	0	0	0	0	0	0	0	0	2	2	-2	0.07	0.00	-0.07
123- 9.8/ 0.0	81	65	-17	3.9	3.6	-0.3	0.3	0.3	-0.1	356	297	-59	0	0	0	-0.48	0.46	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
123- 9.8/ 6.7	82	65	-17	3.4	1.7	-1.7	0.3	0.3	-0.1	143	62	-81	0	0	0	-0.18	0.10	0	0	0	0	0	0	0	0	0	0	0	0	2	2	-2	0.07	0.00	-0.07
123- 9.8/ 9.8	12	8	-3	0.7	0.6	-0.1	0.1	0.0	0.0	29	11	-17	0	0	0	0.14	0.33	0	0	0	0	0	0	0	0	0	0	0	0	2	2	-2	0.07	0.00	-0.07
123-13.4/ 0.0	202	118	-83	11.9	5.1	-6.8	0.8	0.5	-0.4	2760	617	-2142	2	0	-2	-0.36	3.44	0	0	0	0	0	0	3	3	-3	0	0	0	2	2	0	0.31	0.07	-0.24
123-13.4/ 6.7	161	109	-52	10.6	5.2	-5.4	0.8	0.5	-0.3	590	717	126	2	0	-2	0.13	-0.17	0	0	0	0	0	0	3	3	-3	0	0	0	2	2	0	0.27	0.07	-0.20
123-13.4/ 9.8	130	20	-109	7.5	0.8	-6.7	0.6	0.1	-0.5	290	44	-246	0	0	0	0.13	1.14	0	0	0	0	0	0	3	3	0	0	0	0	2	2	0	0.23	0.23	0.00
123-13.4/13.4	93	10	-82	4.2	0.6	-3.6	0.4	0.0	-0.3	167	25	-142	0	0	0	0.37	2.38	0	0	0	0	0	0	3	3	0	0	0	0	2	2	0	0.23	0.23	0.00
123-20.1/ 0.0	469	279	-190	26.4	7.7	-18.7	2.0	1.1	-0.9	13294	4731	-8563	6	5	-1	-0.35	6.38	0	0	0	0	0	0	6	3	-3	0	0	0	4	4	0	0.99	0.68	-0.31
123-20.1/ 6.7	286	247	-39	18.3	21.0	2.8	1.4	1.3	-0.1	3307	2743	-564	6	5	-1	0.19	4.59	0	0	0	0	0	0	3	3	0	0	0	0	4	4	0	0.85	0.82	-0.04
123-20.1/ 9.8	345	213	-132	28.6	16.7	-12.0	1.7	1.0	-0.7	4142	1681	-2461	6	4	-2	0.13	1.08	0	0	0	0	0	0	6	3	-3	0	0	0	4	4	0	0.97	0.56	-0.41
413- 0.0/ 6.7	64	54	-9	5.2	3.5	-1.7	0.3	0.3	-0.1	236	155	-82	0	0	0	-0.11	0.76	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
413- 0.0/ 9.8	166	84	-81	15.4	6.9	-8.5	0.9	0.4	-0.5	896	371	-524	3	0	-3	-0.08	-1.77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.23	0.00	-0.23
413- 0.0/13.4	127	207	81	5.9	18.2	12.3	0.5	1.1	0.6	945	1362	418	0	4	4	-0.10	1.33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.54	0.54
413- 0.0/20.1	124	319	195	5.7	10.2	4.5	0.5	1.3	0.8	453	3676	3223	0	5	5	-0.07	1.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.78	0.78
413- 6.7/ 6.7	103	86	-17	7.2	5.5	-1.8	0.5	0.4	-0.1	421	360	-61	0	0	0	-0.06	0.98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
413- 6.7/ 9.8	95	98	3	6.3	9.1	2.9	0.5	0.5	0.1	542	494	-48	0	0	0	-0.11	0.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.01	0.00
413- 6.7/13.4	146	112	-34	7.7	10.9	3.1	0.7	0.6	0.0	809	450	-358	1	1	0	-0.11	1.14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0.02	0.07	0.05
413- 6.7/20.1	94	203	109	5.5	11.9	6.4	0.4	0.8	0.4	250	2447	2197	0	2	2	-0.07	0.05	2	0	-2	0	0	0	0	0	3	0	0	0	0	0	2	0.06	0.30	0.23
413- 9.8/ 6.7	9	12	3	0.6	1.0	0.4	0.0	0.1	0.0	8	9	1	0	0	0	0.31	0.22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
413- 9.8/ 9.8	57	73	16	5.2	5.2	0.0	0.3	0.4	0.1	116	248	132	0	0	0	-0.11	1.51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
413- 9.8/20.1	118	195	77	7.5	15.7	8.2	0.6	1.0	0.4	398	2134	1736	0	3	3	-0.07	-1.67	2	0	-2	0	0	0	0	0	3	0	0	0	0	0	2	0.05	0.45	0.40
413-13.4/ 6.7	8	6	-2	0.6	0.3	-0.2	0.0	0.0	0.0	7	6	0	0	0	0	0.11	1.17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
413-13.4/ 9.8	9	10	2	0.5	0.9	0.4	0.0	0.1	0.0	16	18	3	0	0	0	-0.27	0.99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
413-13.4/13.4	23	15	-8	1.4	1.2	-0.2	0.1	0.1	0.0	53	46	-7	0	0	0	0.45	0.97	0	0	0	0	0	0	0	0	3	2	0	-2	0	2	4	0.12	0.30	0.18
413-20.1/ 6.7	6	5	-1	0.5	0.4	-0.2	0.0	0.0	0.0	3	4	1	0	0	0	-0.08	1.37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
711- 0.0/ 6.7	81	74	-7	3.7	3.9	0.2	0.3	0.3	0.0	334	267	-67	0	0	0	-0.06	-0.82	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
711- 0.0/ 9.8	89	87	-2	4.5	4.2	-0.3	0.4	0.4	0.0	468	434	-34	0	0	0	-0.11	-0.92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00

Appendix B. Risk/benefit analysis data (cont.)

Impact Configuration Code	Values: Head ar,H,max			Ar,H,max			Gmax			HIC			PAIS			hT	hV	Chest PAIS			Abdomen PAIS			Femur (L+R) PAIS			Knee (L+R) PAIS			Tibia (L+R) PAIS			ICnorm		
	B	P	C	B	P	C	B	P	C	B	P	C	B	P	C	C	C	B	P	C	B	P	C	B	P	C	B	P	C	B	P	C	B	P	C
711- 0.0/13.4	61	17	-45	6.9	1.2	-5.7	0.3	0.1	-0.2	302	37	-265	0	0	0	-0.24	1.69	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
711- 0.0/20.1	62	73	11	2.7	5.3	2.6	0.3	0.3	0.0	406	580	174	0	0	0	-0.13	-0.15	0	0	0	0	0	0	0	0	0	0	0	0	4	2	-4	0.20	0.00	-0.20
711- 6.7/ 9.8	19	21	1	1.2	1.1	0.0	0.1	0.1	0.0	20	19	-1	0	0	0	-0.07	-0.13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
711- 6.7/13.4	81	74	-7	3.7	3.9	0.2	0.3	0.3	0.0	340	267	-72	0	0	0	-0.06	-0.85	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
711- 9.8/13.4	27	13	-14	2.6	1.1	-1.5	0.2	0.1	-0.1	19	9	-10	0	0	0	-0.08	0.17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
711- 9.8/20.1	98	89	-9	4.5	4.2	-0.3	0.4	0.4	0.0	508	458	-49	0	0	0	-0.11	-0.42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
414- 0.0/ 6.7	188	68	-121	4.2	3.9	-0.3	0.8	0.3	-0.5	1023	170	-853	1	0	-1	-0.10	0.80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.07	0.00	-0.07
414- 0.0/ 9.8	196	228	32	4.7	5.3	0.5	0.8	0.9	0.1	1358	1600	241	2	3	1	-0.09	0.42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.11	0.27	0.17
414- 0.0/13.4	151	360	209	5.2	7.0	1.9	0.6	1.5	0.8	1309	4824	3516	1	6	5	-0.09	0.09	1	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0.02	0.86	0.84
414- 0.0/20.1	164	434	270	5.9	10.6	4.8	0.7	1.8	1.1	1530	7809	6279	1	6	5	-0.07	-0.08	2	2	0	0	0	0	6	6	-3	0	0	0	0	0	0	0.26	0.97	0.71
414- 6.7/ 6.7	6	13	7	0.8	1.1	0.3	0.0	0.1	0.0	2	3	1	0	0	0	-0.11	0.33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
414- 6.7/ 9.8	9	10	0	1.0	1.0	0.0	0.0	0.1	0.0	4	4	-1	0	0	0	-0.10	1.97	1	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.00	-0.01
414- 6.7/13.4	16	14	-2	1.4	0.9	-0.5	0.1	0.1	0.0	17	15	-2	0	0	0	-0.12	1.71	1	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0.02	0.00	-0.02
414- 6.7/20.1	98	165	67	3.8	5.1	1.4	0.4	0.7	0.3	190	993	803	0	1	1	-0.08	-0.73	0	0	0	0	0	0	6	3	-6	0	0	0	0	0	0	0.23	0.03	-0.20
414- 9.8/ 6.7	4	4	1	0.5	0.3	-0.2	0.0	0.0	0.0	1	1	0	0	0	0	-0.14	0.67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
414- 9.8/ 9.8	24	16	-9	2.5	1.1	-1.5	0.1	0.1	-0.1	8	4	-4	0	0	0	-0.13	1.60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
414- 9.8/13.4	12	12	0	2.2	1.7	-0.5	0.1	0.1	0.0	17	9	-8	0	0	0	0.35	0.83	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
414- 9.8/20.1	23	18	-4	2.0	1.2	-0.9	0.1	0.1	0.0	38	24	-14	0	0	0	0.24	1.16	1	0	-1	0	0	0	6	3	-3	0	0	0	0	0	0	0.23	0.15	-0.08
412- 0.0/ 6.7	59	87	28	3.0	4.2	1.2	0.2	0.4	0.2	172	223	51	0	0	0	-0.09	0.29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
412- 0.0/ 9.8	57	65	7	2.1	3.5	1.4	0.2	0.3	0.0	134	174	40	0	0	0	-0.08	0.09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
412- 0.0/13.4	45	58	13	2.4	2.8	0.4	0.2	0.2	0.1	162	143	-19	0	0	0	-0.08	-3.48	1	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.00	-0.01
412- 0.0/20.1	63	87	24	4.1	3.3	-0.8	0.3	0.4	0.1	211	561	350	0	0	0	-0.13	2.48	5	1	-4	0	0	0	3	6	3	0	0	0	2	0	-2	0.51	0.23	-0.28
412- 6.7/ 6.7	10	24	14	0.8	1.8	1.1	0.1	0.1	0.1	14	16	2	0	0	0	-0.07	-0.20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
412- 6.7/ 9.8	149	143	-6	5.9	4.6	-1.4	0.6	0.6	0.0	1013	524	-489	1	1	0	-0.08	-0.05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0.00
412- 6.7/13.4	149	135	-14	7.2	7.0	-0.1	0.7	0.6	-0.1	1226	1231	5	1	0	-1	-0.08	-0.29	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0.02	0.15	0.13
412- 6.7/20.1	187	447	260	8.1	13.7	5.7	0.8	1.8	1.0	1830	7717	5887	2	6	4	-0.07	11.32	3	2	-1	0	0	0	3	6	0	0	0	0	0	0	0	0.30	0.98	0.68
412- 9.8/ 6.7	3	4	1	0.2	0.4	0.1	0.0	0.0	0.0	1	1	0	0	0	0	0.16	0.89	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
412- 9.8/13.4	142	126	-17	10.5	5.3	-5.2	0.7	0.5	-0.2	1006	986	-20	1	0	-1	-0.08	0.32	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0.04	0.07	0.03
412-13.4/ 6.7	2	2	0	0.2	0.2	0.0	0.0	0.0	0.0	1	1	-1	0	0	0	-0.26	0.59	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
412-20.1/ 6.7	1	2	1	0.1	0.1	0.0	0.0	0.0	0.0	0	0	0	0	0	0	-0.12	0.73	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
115- 0.0/ 6.7	45	27	-18	1.8	1.4	-0.4	0.2	0.1	-0.1	52	28	-25	0	0	0	-0.10	0.13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
115- 0.0/ 9.8	30	25	-5	1.6	1.4	-0.2	0.1	0.1	0.0	120	107	-13	0	0	0	-0.23	0.38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
115- 0.0/20.1	130	105	-25	14.1	5.6	-8.6	0.6	0.5	-0.2	775	759	-16	1	0	-1	-0.32	1.00	0	0	0	0	0	0	0	3	6	0	0	0	0	0	0	0.02	0.23	0.21
115- 6.7/ 6.7	41	41	0	2.8	3.0	0.3	0.2	0.2	0.0	88	330	242	0	0	0	-0.52	-4.08	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0.00	0.15	0.15
115- 6.7/ 9.8	56	55	-1	6.7	4.3	-2.4	0.3	0.2	-0.1	272	446	174	0	0	0	-0.43	-3.37	0	0	0	0	0	0	0	3	6	0	0	0	0	0	0	0.00	0.23	0.23
115- 6.7/20.1	148	122	-26	18.5	10.7	-7.8	0.8	0.5	-0.3	2255	1748	-507	2	0	-2	-0.24	0.07	0	0	0	0	0	0	6	6	0	0	0	0	4	4	0	0.38	0.30	-0.08
115- 9.8/ 0.0	12	14	2	1.3	1.4	0.2	0.1	0.1	0.0	22	44	22	0	0	0	-0.54	-2.84	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
115- 9.8/ 9.8	123	101	-22	10.8	7.8	-3.0	0.6	0.5	-0.1	1149	775	-374	0	0	0	-0.46	-2.67	0	0	0	0	0	0	0	3	6	0	0	0	2	2	-2	0.07	0.23	0.16
115- 9.8/13.4	119	124	5	6.5	5.5	-1.0	0.5	0.5	0.0	1120	947	-173	0	0	0	-0.25	-2.06	0	0	0	0	0	0	0	3	6	0	0	0	4	2	-4	0.20	0.23	0.03
115- 9.8/20.1	188	136	-51	16.1	11.2	-4.9	0.8	0.6	-0.3	3633	2539	-1094	2	0	-2	-0.29	1.58	0	0	0	0	0	0	6	6	0	0	0	0	4	4	0	0.37	0.30	-0.07
115-13.4/ 6.7	123	120	-3	10.9	7.9	-3.0	0.6	0.5	0.0	1105	1227	122	0	0	0	-0.47	-2.19	0	0	0	0	0	0	0	3	6	0	0	0	2	2	-2	0.07	0.23	0.16
115-13.4/ 9.8	104	124	21	7.0	4.5	-2.5	0.5	0.5	0.1	977	911	-65	0	0	0	-0.31	-2.26	0	0	0	0	0	0	0	3	6	0	0	0	4	2	-4	0.20	0.23	0.03
115-13.4/20.1	219	222	3	13.4	11.9	-1.5	0.9	1.0	0.1	4032	4316	283	3	4	1	-0.28	3.32	0	0	0	0	0	0	6	6	0	0	0	0	4	4	0	0.47	0.54	0.07
313- 0.0/ 6.7	31	31	0	3.0	3.0	0.0	0.1	0.1	0.0	52	59	7	0	0	0	-0.09	-3.27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
313- 0.0/ 9.8	31	31	0	2.8	2.8	0.0	0.1	0.1	0.0	66	75	9	0	0	0	-0.21	-0.60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
313- 0.0/13.4	27	39	12	2.2	2.7	0.5	0.1	0.2	0.1	47	100	54	0	0	0	-0.29	-1.26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
313- 0.0/20.1	128	100	-27	6.9	5.0	-1.9	0.6	0.5	-0.1	366	268	-98	1	0	-1	-0.07	0.63	0	0	0	0	0	0	3	6	3	0	0	0	0	0	0	0.16	0.23	0.08
313- 6.7/ 6.7	255	66	-190	21.9	4.9	-17.0	1.3	0.3	-1.0	2747	222	-2525	5	0	-5	-0.15	0.13	0	0	0	0	0	0	0	0	3	0	0	0	2	2	0	0.79	0.23	-0.56

Appendix B. Risk/benefit analysis data (cont.)

Impact Configuration Code	Values																																		
	Head																	Chest PAIS			Abdomen PAIS			Femur (L+R) PAIS			Knee (L+R) PAIS			Tibia (L+R) PAIS			ICnorm		
	ar,H,max			Ar,H,max			Gmax			HIC			PAIS			hT	hV																		
	B	P	C	B	P	C	B	P	C	B	P	C	B	P	C	C	C	B	P	C	B	P	C	B	P	C	B	P	C	B	P	C	B	P	C
313- 6.7/ 9.8	88	94	6	5.1	11.6	6.5	0.4	0.6	0.2	214	474	261	0	1	1	-0.13	-3.97	2	0	-2	0	0	0	0	0	0	0	0	0	0	0	0	0.03	0.01	-0.01
313- 6.7/13.4	194	137	-57	9.8	6.7	-3.1	0.9	0.6	-0.3	1831	858	-973	2	1	-1	-0.11	-1.39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.17	0.01	-0.16
313- 6.7/20.1	56	121	65	5.0	8.3	3.2	0.3	0.5	0.2	370	654	284	0	0	0	-0.12	2.43	2	3	1	0	0	0	0	3	6	2	2	-2	0	0	2	0.14	0.34	0.20
313- 9.8/13.4	145	301	157	9.5	20.3	10.9	0.7	1.5	0.8	727	3620	2893	1	6	5	-0.12	-2.71	4	0	-4	0	0	0	3	6	3	0	0	0	2	2	-2	0.46	0.88	0.42
313-13.4/20.1	215	397	182	14.7	16.1	1.3	1.0	1.6	0.6	2182	9292	7110	4	6	2	-0.08	-0.37	3	3	0	0	0	0	3	6	3	0	0	0	2	4	2	0.59	0.95	0.36
513- 0.0/ 6.7	65	59	-6	3.8	3.5	-0.3	0.3	0.2	-0.1	205	160	-46	0	0	0	-0.09	0.12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
513- 0.0/ 9.8	128	93	-35	9.6	7.4	-2.2	0.6	0.5	-0.1	798	424	-374	1	0	-1	-0.07	3.30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.02	0.00	-0.01
513- 6.7/ 6.7	6	7	0	0.5	0.4	-0.1	0.0	0.0	0.0	5	6	1	0	0	0	-0.30	1.42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
513- 6.7/ 9.8	8	10	2	0.5	0.5	0.0	0.0	0.0	0.0	12	14	2	0	0	0	-0.19	0.38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
513- 6.7/13.4	8	13	5	1.0	0.9	-0.1	0.1	0.1	0.0	11	31	20	0	0	0	-0.27	-2.39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
513- 6.7/20.1	14	24	10	1.8	1.5	-0.3	0.1	0.1	0.0	26	111	85	0	0	0	-0.31	2.39	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0.00	0.15	0.15
513- 9.8/ 6.7	4	4	0	0.3	0.4	0.1	0.0	0.0	0.0	2	2	0	0	0	0	-0.09	1.08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
513- 9.8/ 9.8	8	8	0	0.6	0.6	0.0	0.0	0.0	0.0	10	12	3	0	0	0	-0.14	1.52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
513-13.4/ 6.7	2	4	2	0.1	0.3	0.2	0.0	0.0	0.0	1	1	1	0	0	0	-0.14	0.68	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
224- 0.0/ 6.7	31	4	-27	1.8	0.4	-1.4	0.1	0.0	-0.1	10	3	-8	0	0	0	-0.38	-1.07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
224- 0.0/ 9.8	11	4	-7	0.8	0.4	-0.4	0.1	0.0	0.0	8	2	-5	0	0	0	-0.07	-0.25	0	0	0	0	0	0	0	0	0	0	0	0	2	0	-2	0.07	0.00	-0.07
224- 0.0/13.4	8	3	-5	0.7	0.3	-0.4	0.0	0.0	0.0	7	2	-5	0	0	0	-0.06	-0.37	0	0	0	0	0	0	0	0	0	0	0	0	2	0	-2	0.07	0.00	-0.07
224- 6.7/ 6.7	20	74	54	1.7	4.0	2.3	0.1	0.3	0.2	28	72	44	0	0	0	0.40	0.18	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0.07	0.07	0.00
224- 6.7/ 9.8	20	86	66	1.6	2.9	1.3	0.1	0.4	0.3	25	85	60	0	0	0	0.31	-1.26	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0.07	0.07	0.00
224- 6.7/13.4	83	40	-43	5.9	1.6	-4.3	0.4	0.2	-0.2	107	25	-82	0	0	0	0.29	-0.34	0	0	0	0	0	0	3	3	0	0	0	0	2	2	0	0.23	0.23	0.00
224- 9.8/ 9.8	118	51	-67	6.3	3.6	-2.6	0.5	0.2	-0.3	207	39	-168	0	0	0	0.13	-2.21	0	0	0	0	0	0	3	3	0	0	0	0	2	2	0	0.23	0.23	0.00
224- 9.8/13.4	97	18	-79	5.7	1.4	-4.3	0.4	0.1	-0.3	127	6	-121	0	0	0	0.44	-0.63	0	0	0	0	0	0	3	3	0	0	0	0	2	2	0	0.23	0.23	0.00
224-13.4/ 6.7	132	56	-76	6.6	3.8	-2.8	0.6	0.3	-0.3	246	48	-199	1	0	-1	-0.57	0.01	0	0	0	0	0	0	3	3	0	0	0	0	2	2	0	0.23	0.23	0.00
131- 6.7/ 0.0	10	10	0	0.4	0.3	-0.1	0.0	0.0	0.0	4	5	0	0	0	0	0.38	1.70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
131- 9.8/ 0.0	18	22	4	1.4	1.1	-0.3	0.1	0.1	0.0	55	43	-13	0	0	0	0.29	1.14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
131- 9.8/ 6.7	4	3	-1	0.2	0.2	0.0	0.0	0.0	0.0	1	1	0	0	0	0	-0.25	-0.40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
131-13.4/ 0.0	48	57	9	3.6	3.5	-0.1	0.2	0.3	0.0	516	188	-328	0	0	0	0.40	-0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
131-13.4/ 6.7	11	17	6	0.8	0.3	-0.4	0.1	0.1	0.0	10	23	13	0	0	0	0.35	0.20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
131-20.1/ 0.0	151	213	62	7.2	10.0	2.8	0.6	0.9	0.3	3066	5394	2327	1	3	2	-0.27	-2.37	0	0	0	0	0	0	0	3	3	0	0	0	4	4	0	0.20	0.44	0.23
131-20.1/ 6.7	41	50	9	3.2	5.3	2.1	0.2	0.3	0.1	327	161	-166	0	0	0	0.36	-0.99	0	0	0	0	0	0	0	0	0	0	0	0	0	2	4	0.00	0.20	0.20
131-20.1/ 9.8	30	28	-2	1.8	1.2	-0.6	0.1	0.1	0.0	81	53	-28	0	0	0	0.23	2.07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
131-20.1/13.4	15	19	4	0.9	0.5	-0.5	0.1	0.1	0.0	14	29	15	0	0	0	0.37	-0.06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
514- 0.0/ 6.7	17	29	12	0.7	2.2	1.5	0.1	0.1	0.1	6	12	6	0	0	0	-0.11	-0.19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
514- 0.0/ 9.8	7	76	69	0.7	5.2	4.6	0.0	0.3	0.3	5	83	78	0	0	0	-0.10	0.45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
514- 0.0/20.1	18	146	127	2.5	9.6	7.1	0.1	0.7	0.6	27	331	303	0	1	1	0.34	0.57	1	0	-1	0	0	0	3	3	0	0	0	0	0	0	0	0.15	0.16	0.01
514- 6.7/ 6.7	3	4	2	0.3	0.3	0.0	0.0	0.0	0.0	1	1	0	0	0	0	-0.18	0.35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
514- 6.7/ 9.8	4	13	9	0.5	1.4	0.9	0.0	0.1	0.1	2	3	1	0	0	0	-0.20	1.04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
514- 6.7/20.1	10	58	48	1.2	4.4	3.2	0.1	0.3	0.2	17	45	28	0	0	0	0.15	-0.10	0	0	0	0	0	0	3	3	0	0	0	0	2	0	-2	0.23	0.15	-0.08
514- 9.8/ 6.7	2	6	3	0.3	0.5	0.3	0.0	0.0	0.0	0	1	1	0	0	0	-0.13	0.49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
514- 9.8/ 9.8	3	5	2	0.3	0.5	0.2	0.0	0.0	0.0	1	2	1	0	0	0	0.00	1.77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
514- 9.8/13.4	5	20	15	0.5	1.4	0.9	0.0	0.1	0.1	3	5	3	0	0	0	-0.19	2.21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
314- 0.0/ 6.7	86	112	26	3.5	4.3	0.9	0.4	0.5	0.1	273	479	206	0	0	0	-0.15	1.27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
314- 0.0/13.4	71	199	128	2.9	5.6	2.7	0.3	0.8	0.5	200	1895	1695	0	2	2	-0.07	0.88	0	0	0	0	0	0	0	3	3	0	0	0	0	0	2	0.00	0.29	0.29
314- 6.7/ 6.7	76	46	-30	3.6	3.1	-0.5	0.3	0.2	-0.1	195	90	-106	0	0	0	-0.08	0.83	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
314- 6.7/ 9.8	344	237	-107	5.6	8.1	2.5	1.4	1.0	-0.4	3925	2071	-1854	6	3	-3	-0.08	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.82	0.35	-0.47
314- 6.7/13.4	650	702	52	24.9	37.2	12.3	2.0	2.0	0.0	19508	25304	5796	6	6	0	-0.06	0.00	0	0	0	0	0	0	3	0	-3	0	0	0	0	2	2	0.99	0.99	0.00
314- 9.8/ 6.7	8	13	5	0.9	0.9	0.0	0.0	0.1	0.0	3	5	2	0	0	0	0.21	0.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
314- 9.8/ 9.8	141	48	-94	4.8	2.2	-2.6	0.6	0.2	-0.4	961	46	-915	1	0	-1	-0.09	0.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.00	-0.01

Appendix B. Risk/benefit analysis data (cont.)

Impact Configuration Code	Values																																		
	Head																	Chest PAIS			Abdomen PAIS			Femur (L+R) PAIS			Knee (L+R) PAIS			Tibia (L+R) PAIS			ICnorm		
	ar,H,max			Ar,H,max			Gmax			HIC			PAIS			hT	hV																		
	B	P	C	B	P	C	B	P	C	B	P	C	B	P	C	C	C	B	P	C	B	P	C	B	P	C	B	P	C	B	P	C	B	P	C
223- 6.7/ 0.0	2	8	6	0.2	0.9	0.7	0.0	0.1	0.0	1	5	5	0	0	0	-1.35	-4.00	0	0	0	0	0	0	0	0	3	0	0	0	2	2	-2	0.07	0.15	0.08
223- 6.7/ 6.7	73	79	6	5.0	5.3	0.3	0.3	0.3	0.0	230	339	109	0	0	0	-0.26	0.44	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0.00	0.15	0.15
223- 6.7/ 9.8	78	46	-32	5.8	5.5	-0.2	0.3	0.2	-0.1	365	168	-197	0	0	0	-0.29	0.46	0	0	0	0	0	0	3	3	0	0	0	0	2	2	0	0.23	0.23	0.00
223- 6.7/13.4	37	30	-7	4.5	2.1	-2.4	0.2	0.1	-0.1	109	112	2	0	0	0	-0.25	0.10	0	0	0	0	0	0	3	3	-3	0	0	0	2	2	0	0.23	0.07	-0.16
223- 9.8/ 6.7	37	28	-9	4.3	2.9	-1.4	0.2	0.1	-0.1	102	52	-51	0	0	0	-0.15	0.89	0	0	0	0	0	0	0	0	0	0	0	0	0	2	4	0.00	0.20	0.20
223- 9.8/ 9.8	50	80	30	6.7	6.0	-0.7	0.3	0.4	0.1	158	398	240	0	0	0	-0.17	0.59	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0.00	0.07	0.07
223-13.4/ 9.8	98	79	-19	11.7	8.2	-3.6	0.6	0.4	-0.2	824	276	-548	1	0	-1	-0.07	0.69	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0.01	0.07	0.06
223-20.1/ 6.7	312	315	3	19.5	33.4	13.9	1.3	1.6	0.3	2501	4029	1527	5	6	1	-0.06	1.16	0	0	0	0	0	0	3	3	0	0	0	0	0	0	0	0.76	0.93	0.17
223-20.1/ 9.8	390	286	-104	20.9	14.6	-6.3	1.6	1.2	-0.5	4081	2486	-1596	6	5	-1	-0.06	-0.53	0	2	2	0	0	0	6	3	-3	0	0	0	0	0	2	0.94	0.68	-0.26
222- 0.0/ 6.7	8	10	2	0.5	0.6	0.2	0.0	0.0	0.0	2	4	2	0	0	0	-0.74	0.69	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
222- 0.0/ 9.8	17	5	-12	0.7	0.6	-0.2	0.1	0.0	-0.1	6	3	-3	0	0	0	-0.51	1.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
222- 0.0/13.4	18	4	-14	0.9	0.4	-0.5	0.1	0.0	-0.1	6	3	-3	0	0	0	-0.42	0.07	0	0	0	0	0	0	0	0	0	0	0	0	2	2	-2	0.07	0.00	-0.07
222- 6.7/ 6.7	33	10	-24	2.7	1.3	-1.4	0.2	0.1	-0.1	38	5	-32	0	0	0	0.08	0.31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
222- 6.7/ 9.8	10	4	-6	0.7	0.3	-0.4	0.1	0.0	0.0	7	4	-3	0	0	0	-0.06	-0.72	0	0	0	0	0	0	0	0	0	0	0	0	2	2	-2	0.07	0.00	-0.07
222- 6.7/13.4	69	5	-64	3.0	0.5	-2.5	0.3	0.0	-0.3	64	6	-58	0	0	0	-0.17	-1.21	0	0	0	0	0	0	0	0	0	0	0	0	2	2	-2	0.07	0.00	-0.07
222- 9.8/ 6.7	34	37	2	3.1	1.9	-1.1	0.2	0.2	0.0	56	70	14	0	0	0	-0.06	-0.48	0	0	0	0	0	0	3	3	0	0	0	0	0	0	0	0.15	0.15	0.00
222- 9.8/ 9.8	30	27	-3	2.1	1.7	-0.5	0.1	0.1	0.0	49	28	-21	0	0	0	0.11	-0.30	0	0	0	0	0	0	3	3	-3	0	0	0	0	0	0	0.15	0.00	-0.15
222- 9.8/13.4	8	7	-1	0.7	0.7	0.0	0.0	0.0	0.0	11	10	-1	0	0	0	-0.06	-0.27	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0.07	0.07	0.00
312- 0.0/ 6.7	43	26	-17	3.2	2.0	-1.2	0.2	0.1	-0.1	44	10	-34	0	0	0	-0.08	1.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
312- 0.0/ 9.8	41	13	-28	1.7	0.7	-1.0	0.2	0.1	-0.1	20	4	-16	0	0	0	0.21	-0.21	0	0	0	0	0	0	3	3	0	0	0	0	0	0	0	0.15	0.15	0.00
312- 0.0/13.4	42	6	-36	3.4	0.3	-3.1	0.2	0.0	-0.2	26	6	-19	0	0	0	0.23	1.12	0	0	0	0	0	0	3	3	-3	0	0	0	0	0	2	0.15	0.07	-0.08
312- 6.7/13.4	32	58	26	1.8	4.4	2.7	0.2	0.3	0.2	51	118	66	0	0	0	-0.11	-1.76	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
312- 9.8/ 6.7	82	75	-7	8.4	6.8	-1.6	0.5	0.4	-0.1	221	148	-74	0	0	0	-0.09	0.98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
312- 9.8/20.1	45	37	-8	4.1	2.7	-1.5	0.2	0.2	-0.1	128	171	43	0	0	0	-0.08	-0.12	2	0	-2	0	0	0	3	3	0	0	0	0	0	0	0	0.16	0.15	-0.01
312-13.4/ 6.7	6	3	-3	0.7	0.4	-0.3	0.0	0.0	0.0	3	2	-1	0	0	0	0.12	0.40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
621- 0.0/ 6.7	25	3	-22	1.8	0.4	-1.5	0.1	0.0	-0.1	10	1	-9	0	0	0	0.58	-2.48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
621- 0.0/ 9.8	24	3	-21	2.1	0.4	-1.7	0.1	0.0	-0.1	17	1	-15	0	0	0	0.66	-4.28	0	0	0	0	0	0	0	0	0	0	0	0	2	2	-2	0.07	0.00	-0.07
621- 0.0/20.1	33	10	-23	1.6	0.6	-1.0	0.1	0.1	-0.1	18	5	-13	0	0	0	-0.06	-2.22	0	0	0	0	0	0	3	3	-3	0	0	0	2	2	0	0.23	0.07	-0.16
621- 6.7/ 9.8	2	7	5	0.3	0.5	0.2	0.0	0.0	0.0	0	2	1	0	0	0	-0.26	0.33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
621- 6.7/20.1	55	4	-51	2.8	0.4	-2.4	0.2	0.0	-0.2	108	3	-105	0	0	0	0.27	-3.77	0	0	0	0	0	0	0	0	0	0	0	0	2	2	-2	0.07	0.00	-0.07
621- 9.8/13.4	5	7	2	0.4	0.5	0.1	0.0	0.0	0.0	1	2	1	0	0	0	-0.20	0.33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
132- 6.7/ 0.0	88	34	-53	3.6	1.7	-1.9	0.4	0.1	-0.2	268	49	-219	0	0	0	0.15	-0.36	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0.00	0.12	0.12
132- 6.7/ 6.7	2	2	0	0.2	0.3	0.2	0.0	0.0	0.0	1	1	0	0	0	0	-0.09	-0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
132- 9.8/ 6.7	5	3	-2	0.3	0.5	0.2	0.0	0.0	0.0	1	1	0	0	0	0	-0.24	-0.91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
132-13.4/ 0.0	92	46	-46	6.6	3.3	-3.3	0.4	0.2	-0.2	466	404	-62	0	0	0	-0.39	-0.65	0	0	0	0	0	0	3	3	0	0	0	0	2	2	2	0.23	0.30	0.07
132-20.1/ 6.7	106	20	-86	5.6	1.4	-4.2	0.5	0.1	-0.4	176	97	-79	0	0	0	0.70	0.80	0	0	0	0	0	0	3	3	0	0	0	0	2	2	0	0.23	0.23	0.00
132-20.1/20.1	2	4	1	0.2	0.4	0.2	0.0	0.0	0.0	1	1	0	0	0	0	-0.08	-0.80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
225- 0.0/ 9.8	29	5	-24	2.1	0.6	-1.5	0.1	0.0	-0.1	13	4	-9	0	0	0	-0.17	-1.09	0	0	0	0	0	0	0	0	0	0	0	0	2	0	-2	0.07	0.00	-0.07
225- 0.0/13.4	34	13	-22	2.3	0.8	-1.5	0.1	0.1	-0.1	31	5	-25	0	0	0	-0.06	-2.47	0	0	0	0	0	0	3	0	-3	0	0	0	2	0	-2	0.23	0.00	-0.23
225- 6.7/ 9.8	41	32	-9	2.9	1.9	-1.0	0.2	0.2	-0.1	24	15	-8	0	0	0	0.07	-3.49	0	0	0	0	0	0	3	0	-3	0	0	0	2	0	-2	0.23	0.00	-0.23
225- 6.7/13.4	49	39	-10	2.8	2.6	-0.2	0.2	0.2	0.0	33	24	-10	0	0	0	0.12	-3.13	0	0	0	0	0	0	3	3	0	0	0	0	2	2	0	0.23	0.23	0.00
225-20.1/ 9.8	93	45	-48	7.1	3.8	-3.3	0.5	0.2	-0.2	131	25	-105	0	0	0	-0.48	1.21	0	0	0	0	0	0	3	3	0	0	0	0	2	2	0	0.23	0.23	0.00
622- 0.0/ 6.7	4	8	4	0.2	0.4	0.2	0.0	0.0	0.0	1	3	2	0	0	0	-0.22	0.61	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
622- 0.0/ 9.8	6	10	4	0.5	0.4	-0.1	0.0	0.0	0.0	1	2	1	0	0	0	-0.23	-0.07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
622- 0.0/13.4	2	9	7	0.2	0.3	0.1	0.0	0.0	0.0	0	1	1	0	0	0	-0.44	0.02	0	0	0	0	0	0	0	0	0	0	0	0	2	2	-2	0.07	0.00	-0.07
712- 0.0/ 6.7	8	35	28	0.7	2.2	1.4	0.0	0.1	0.1	4	36	32	0	0	0	-0.10	-3.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
712- 0.0/13.4	58	11	-46	1.7	0.9	-0.8	0.2	0.1	-0.2	90	10	-80	0	0	0	-0.08	-3.86	0	0	0	0	0	0	0	0	0	0	0	0	2	0	-2	0.07	0.00	-0.07
712- 6.7/ 9.8	1	1	0	0.1	0.0	-0.1	0.0	0.0	0.0	0	0	0	0	0	0	-0.09	-0.09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00

Appendix B. Risk/benefit analysis data (cont.)

Impact Configuration Code	Values																																		
	Head																	Chest PAIS			Abdomen PAIS			Femur (L+R) PAIS			Knee (L+R) PAIS			Tibia (L+R) PAIS			ICnorm		
	ar,H,max			Ar,H,max			Gmax			HIC			PAIS			hT	hV																		
	B	P	C	B	P	C	B	P	C	B	P	C	B	P	C	C	C	B	P	C	B	P	C	B	P	C	B	P	C	B	P	C	B	P	C
712- 6.7/13.4	15	8	-6	1.2	0.7	-0.4	0.1	0.0	0.0	11	3	-8	0	0	0	-0.10	-0.32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
712- 6.7/20.1	6	7	0	0.4	0.4	0.0	0.0	0.0	0.0	4	3	-1	0	0	0	-0.08	-0.47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
512- 0.0/ 6.7	112	51	-60	5.2	3.7	-1.4	0.5	0.2	-0.2	539	107	-432	0	0	0	-0.11	1.27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
512- 6.7/ 9.8	55	34	-21	1.8	3.3	1.4	0.2	0.2	-0.1	46	35	-12	0	0	0	-0.08	-0.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
512-20.1/20.1	6	4	-3	0.8	0.4	-0.4	0.0	0.0	0.0	15	3	-12	0	0	0	0.12	6.76	0	0	0	0	0	0	3	3	-3	0	0	0	2	2	-2	0.23	0.00	-0.23
221-13.4/ 9.8	4	4	0	0.2	0.2	0.0	0.0	0.0	0.0	1	1	0	0	0	0	-0.11	-0.33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
623- 0.0/ 6.7	25	3	-21	1.3	0.5	-0.8	0.1	0.0	-0.1	18	1	-17	0	0	0	0.22	-1.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
624- 6.7/20.1	2	2	1	0.3	0.3	0.0	0.0	0.0	0.0	0	1	1	0	0	0	-0.62	0.35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00

ar,H,max Maximum linear resultant head acceleration
Ar,H,max Maximum angular resultant head accelertaion
Gmax Maximum GAMBIT
HIC Head Injury Criterion
PAIS Probable AIS
hT Change in helmet trajectory in millimeters
hV Percentage change in helmet velocity at helmet impact
ICnorm Normalized injury cost
B Baseline motorcycle
P Motorcycle with protective device
C Change due to protective device, i.e., "P" - "B"

Appendix C. Risk/benefit analysis basis

Impact configuration code	Basis is: (mark with "x")			Required documentation per ISO 13232 is attached	
	ISO 13232		Other (describe)		
	Full-scale test	Computer simulation		Yes	No
All		x		x	

Appendix D. Risk/benefit analysis results

Percentage of impacts which are:	Head							Chest PAIS	Abdomen PAIS	Femur (L+R) PAIS	Knee (L+R) PAIS	Tibia (L+R) PAIS	ICnorm
	$a_{r,H,max}$	$\alpha_{r,H,max}$	G_{max}	HIC	PAIS	hT	hV						
Beneficial	57	58	55	59	11	18	39	8	0	7	1	14	26
No effect	1	1	3	0	82	1	0	92	100	81	99	78	57
Harmful	42	42	42	41	7	81	61	1	0	12	0	8	17
Total	100	100	100	100	100	100	100	100	100	100	100	100	100

	Head						Chest PAIS	Abdomen PAIS	Femur (L+R) PAIS	Knee (L+R) PAIS	Tibia (L+R) PAIS	ICnorm
	$a_{r,H,max}$	$\alpha_{r,H,max}$	G_{max}	HIC	PAIS	hV						
Risk/Benefit	72	91	72	152	95	141	6	Undef.*	217	20	58	116
Net Benefit	6	2	6	-11	2	-3	72	None	-39	80	18	-5

* - Undefined (benefit = 0, risk = 0)

Appendix E. Risk/benefit analysis checklist

Part 5 Injury indices and risk/benefit analysis (all referenced tables are in ISO 13232-5)	Req[1)]	Rec[1)]	Complied with: Yes	Complied with: No	Explanation, if not complied with (If necessary, attach additional pages)
5.10.1 Calculations of injury assessment variables and injury indices (see table 9)	x		x		
5.10.2 Change in head injury potential	x		x		
5.10.2.1 Change in helmet trajectory	x		x		
5.10.2.2 Percentage change in helmet velocity at helmet impact	x		x		
5.10.3 Distributions of injury assessment variables, change in head injury potential, and injury indices (see table 10)	x		x		
5.10.4 Risk/benefit calculations	x		x		

1) "Req" denotes a requirement of ISO 13232; "Rec" denotes a recommendation of ISO 13232