

MADYMO Quality Report Release Update

WorldSID 50th facet Q model, version 2.1 (R7.4.1)

REPORT NUMBER: QWorldSID50-120531

DATE: May 2012

Table of contents

1	Introduction	1
1.1	Conventions	2
2	Experiments	3
2.1	Tests overview	3
2.2	Descriptions of the tests	5
2.2.1	Full dummy tests	5
2.2.2	Head tests	17
2.2.3	Neck tests	18
2.2.4	Lumbar spine tests	20
2.2.5	Pelvis tests	23
3	Rating of the validation set	27
3.1	Signals excluded from the rating procedure	27
3.2	Overall rating results	27
4	Comparison of results	31
4.1	Range plots	31
4.1.1	Dummy signals	31
4.1.2	Environment signals	35
4.2	CPU Time comparison	37
A	Rating Method	39
A.1	Introduction	39
A.1.1	Rating a MADYMO dummy model	39
A.1.2	Comparing two scalar values	40
A.1.3	Comparing two signals	40
A.1.4	Adding scores	41
A.2	Additional information on calculation of dummy rating scores	41
A.2.1	Comparing two scalar values	41
A.2.2	Adding scores	42
A.2.3	Example	42
A.3	Results for more complex examples	44
B	Signal Results	47
B.1	Signals of the full dummy tests	47
B.2	Signals of the head component tests	108
B.3	Signals of the neck component tests	110
B.4	Signals of the lumbar spine component tests	113
B.5	Signals of the pelvis component tests	119

2 Experiments

This chapter contains the description of the experiments used for the validation and rating of the model.

In the first section, all experiments used for the rating are listed in tables. These tables contain 8 columns. The meaning of the column headers is given below:

ID = Identification number

#F = number of loading signals (forces and moments/torques) measured

#P = number of positional signals (displacements and rotations) measured

#V = number of velocity signals measured

#A = number of acceleration signals measured

#I = number of injury values rated, this includes dummy load cell output

In the second section of this chapter, more detailed descriptions are presented in order to give the reader more insight into the validation set. This information is restricted to non-confidential data.

2.1 Tests overview

The total experimental validation set is divided into different test groups. Each table represents a different test group. The ID of the experiment includes a reference to the test group of which it is part:

F = full dummy test,

H = head component test,

N = neck component test,

L = lumbar spine component test and

P = pelvis component test.

Table 2.1 full dummy tests

ID	Description	Conditions	#F	#P	#V	#A	#I
F1	Full dummy shoulder impact test	$v = 3.0 \text{ m/s}$	4		5	3	
F2	Full dummy shoulder impact test	$v = 4.3 \text{ m/s}$	4		5	3	
F3	Full dummy shoulder impact test	$v = 5.0 \text{ m/s}$	4		5	3	
F4	Full dummy thorax impact test - with arm	$v = 3.0 \text{ m/s}$	3		4	4	
F5	Full dummy thorax impact test - without arm	$v = 4.3 \text{ m/s}$	3		4	4	
F6	Full dummy thorax impact test - without arm	$v = 5.0 \text{ m/s}$	3		4	4	
F7	Full dummy thorax impact test - with arm	$v = 5.0 \text{ m/s}$	6		4	5	
F8	Full dummy thorax impact test - with arm	$v = 6.7 \text{ m/s}$	6		4	5	
F9	Full dummy abdomen impact test	$v = 3.0 \text{ m/s}$	2		5	2	
F10	Full dummy abdomen impact test	$v = 4.3 \text{ m/s}$	2		5	2	
F11	Full dummy abdomen impact test	$v = 5.0 \text{ m/s}$	2		5	2	
F12	Full dummy pelvis impact test - on H-point	$v = 5.0 \text{ m/s}$				3	5
F13	Full dummy pelvis impact test - on H-point	$v = 6.7 \text{ m/s}$				3	5
F14	Full dummy pelvis impact test - forward offset	$v = 5.0 \text{ m/s}$				3	5
F15	Full dummy pelvis impact test - forward offset	$v = 6.7 \text{ m/s}$				2	5
F16	Full dummy pelvis impact test - rearward offset	$v = 5.0 \text{ m/s}$				2	5
F17	Full dummy pelvis impact test - rearward offset	$v = 6.7 \text{ m/s}$				2	5
F18	Full dummy femur impact test	$v = 5.0 \text{ m/s}$				3	5
F19	Full dummy femur impact test	$v = 6.7 \text{ m/s}$				3	5
F20	Full dummy sled impact test - with arm	0/50/50, $v = 4.7 \text{ m/s}$	6		5	10	
F21	Full dummy sled impact test - without arm	0/50/50, $v = 4.7 \text{ m/s}$	5		5	9	
F22	Full dummy sled impact test - without arm	0/50/50, $v = 7.1 \text{ m/s}$	5		4	9	
F23	Full dummy sled impact test - without arm	0/50/50, $v = 4.7 \text{ m/s}$	5		5	9	

Figure 2.2 (r) shows the simulation setup.

F7 In this test the dummy is seated on the WorldSID certification bench, according to certification test conditions. The seat base and back are covered with Teflon(R) sheets. The dummy is set up such that thorax angle is 0 degrees, pelvic angle is 5 degrees, which is coincident with H-point tool at 40 degrees, tilt sensor 25 degrees. The distance between the knee centres is about 279 mm. The pendulum has a mass of 23.4 kg and a diameter of 152.4 mm. The arm is oriented to be along the thorax. The pendulum centreline is aligned with the centreline of the middle thorax rib. The impact velocity is 5.0 m/s. Figure 2.3 (l) shows the experimental setup.

Figure 2.3 (r) shows the simulation setup.

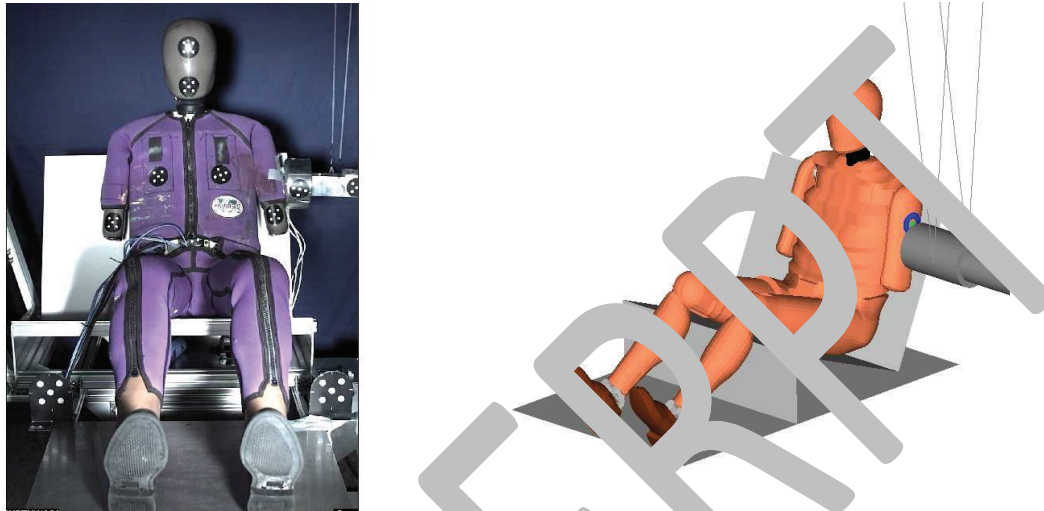


Figure 2.3 Full dummy impact on the arm with pendulum 72. Experiment (l); Model (r)

F8 In this test the dummy is seated on the WorldSID certification bench, according to certification test conditions. The seat base and back are covered with Teflon(R) sheets. The dummy is set up such that thorax angle is 0 degrees, pelvic angle is 5 degrees, which is coincident with H-point tool at 40 degrees, tilt sensor 25 degrees. The distance between the knee centres is about 279 mm. The pendulum has a mass of 23.4 kg and a diameter of 152.4 mm. The arm is oriented to be along the thorax. The pendulum centreline is aligned with the centreline of the middle thorax rib. The impact velocity is 3.7 m/s. Figure 2.3 (l) shows the experimental setup.

Figure 2.3 (r) shows the simulation setup.

F9 In this test the dummy is seated on the WorldSID certification bench, according to certification test conditions. The seat base and back are covered with Teflon(R) sheets. The dummy is set up such that thorax angle is 0 degrees, pelvic angle is 5 degrees, which is coincident with H-point tool at 40 degrees, tilt sensor 25 degrees. The distance between the knee centres is about 279 mm. The pendulum has a mass of 23.4 kg and a diameter of 152.4 mm. The pendulum is equipped with a horizontal arm rest impactor face of 1.0 kg and dimension 70x150 mm. The arm is horizontal. The pendulum centreline is aligned with the middle of the two abdomen ribs. The impact velocity is 3.0 m/s. Figure 2.4 (l) shows the experimental setup.

Figure 2.4 (r) shows the simulation setup.

3 Rating of the validation set

This chapter shows the rating values calculated for the complete validation set presented in this report (53 experiments). The signals of all tests have been numerically rated in an automated process as described in Appendix A. The rating tables presented further list the combined values of all tests, consisting of 3 values (3 criteria) for every signal:

- a value for the peak correlation
- a value for the timing of the peak
- a value for the shape of the simulation curve compared to that of the experiment.

The type and number of signals available per test and included in the rating can be found in Chapter 2.

3.1 Signals excluded from the rating procedure

In some tests, one or more of the experimental sensor output signals are found to be unreliable or erroneous. If a repeat test is available with reliable output signals then this repeat test is used for the rating. Otherwise the related response signals are not taken into account in the rating. Below a listing is given of the signals that are not taken into account in this report. These signals have also been excluded from the range plots in the next chapter and from the signal plots presented in Appendix B of this report:

test F15 : Pendulum_AccX
 test F16 : Pendulum_AccX
 test F17 : Pendulum_AccX
 test F21 : AbdomenRibUp_Dis
 test F22 : T4_AccY, AbdomenRibUp_Dis
 test F23 : AbdomenRibUp_Dis
 test F25 : AbdomenRibUp_Dis
 test F26 : AbdomenRibUp_Dis

3.2 Overall rating results

In this section the rating results are presented in tables. The first four tables list the overall rating results for the dummy model. The first table gives the score per rating criterion for the total dummy validation test set, followed by those for each test group; the fourth table gives the combined score (combining the scores from all three rating criteria) for the total test set, followed by those for each test group. In these tables, the second column shows the weight factor that has been applied to the score of each test group for calculating the total scores. These test group weight factors are calculated as the ratio of the number of tests within the test group and the number of tests in the total dummy validation test set. In this way the sum of the test group weight factors is always 1.0. In the third column of the tables, the scores are given in percentages, with 100% indicating a perfect match with the experimental data.

After these first four tables, additional tables present the combined rating results of the individual tests in each test group. In each test group, all the tests (referred to by their test ID) are given the same test weight factor. The test weight factors are calculated as the inverse of the number of tests in the test group to which it belongs. In this way, the sum of the test weight factors in a test group is always 1.0. Using the combination of test weight factors and test group weight factors, the score from each individual test contributes equally to the total score for the complete dummy validation test set.

4 Comparison of results

This chapter shows results that are obtained directly from the experiments and simulations. Range plots are shown in the first section. A range plot provides information on the range in which the model has been evaluated, for each signal separately. By adding lines indicating the level of correlation, the range plots also provide information about the quality of the prediction of a certain signal.

Time history plots of all signals are given in Appendix B. With these the engineer can visually judge the quality of the simulation results. It also helps to interpret the rating results presented earlier in this report, since the rating value can now be compared with the visual information from the curves.

4.1 Range plots

In this section, all range plots are presented. The range plots show the results of a particular signal over different tests. The peak value of the signal during a simulation is represented by a point in the graph. The horizontal location of the point is proportional to the experimental test signal peak. In general this corresponds to the test severity. The vertical position is proportional to the simulation peak results. If the simulation reproduces the signals of the experiment exactly, the point is on the 100% line which is the line at 45 degrees, printed with a solid line type in the graphs. If the point with a positive value is below this line, the simulation has a lower peak than the experiment, which indicates an underprediction of the simulation. When it is above the line, then the simulation overpredicts. Two additional lines are drawn in each plot. If the point is within the cone drawn by the dotted lines, the peak score is above 80%.

Each result in the range plots is shown using a colored marker. Table 1.1 in the Introduction lists all markers used in this report.

The range plots have been divided over two subsections. In the first subsection, range plots are presented that refer to signals measured with the standard sensors in the dummy. The second subsection adds the signals that refer to environment (non-dummy) measurements like impactor signals, potentiometers, etc.

4.1.1 Dummy signals

This section shows the range plots derived from the standard sensor signals of the dummy. The plots are arranged top-down: from the head to the feet of the dummy.

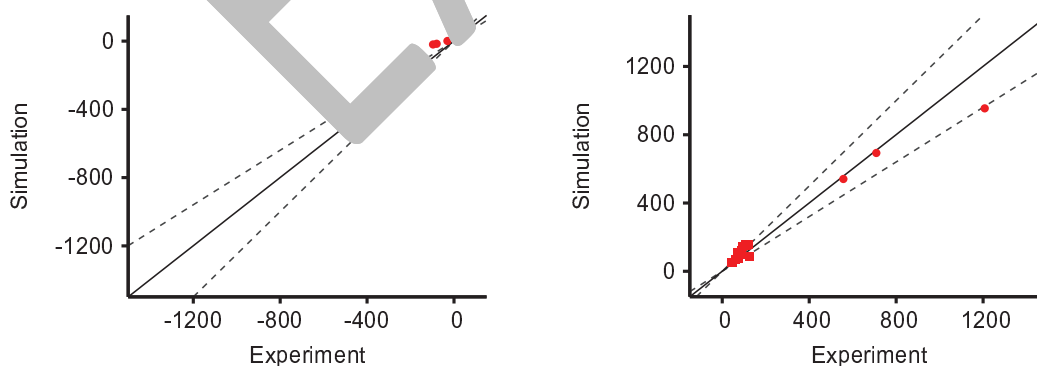


Figure 4.1 Rangeplot of signal Head_AccX (left); Rangeplot of signal Head_AccY (right)

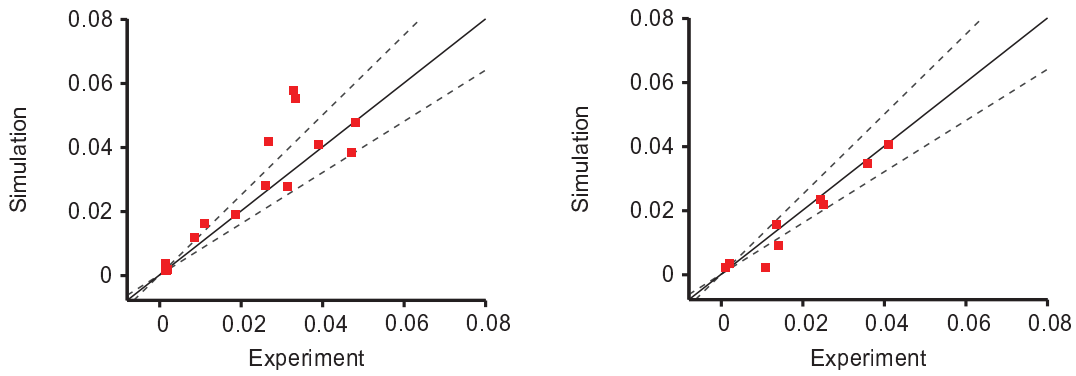


Figure 4.8 Rangeplot of signal ThoraxRibLow_Dis (left); Rangeplot of signal AbdomenRibUp_Dis (right)

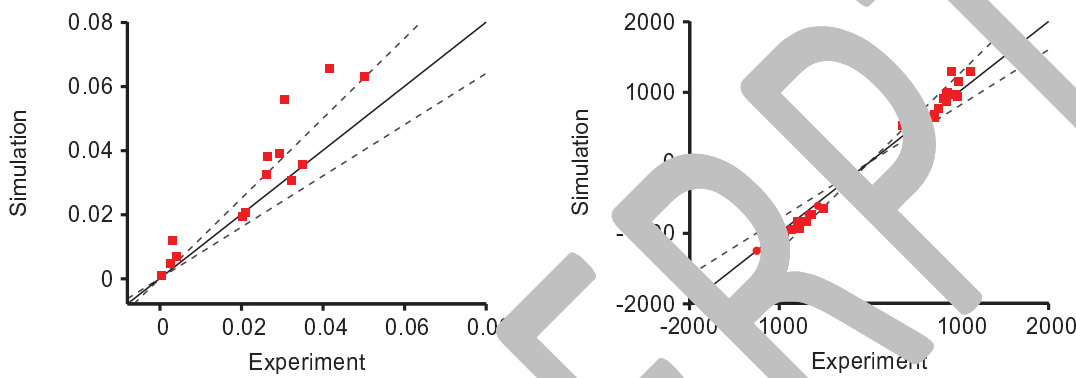


Figure 4.9 Rangeplot of signal AbdomenRibLow_Dis (left); Rangeplot of signal Lumbar_FrcY (right)

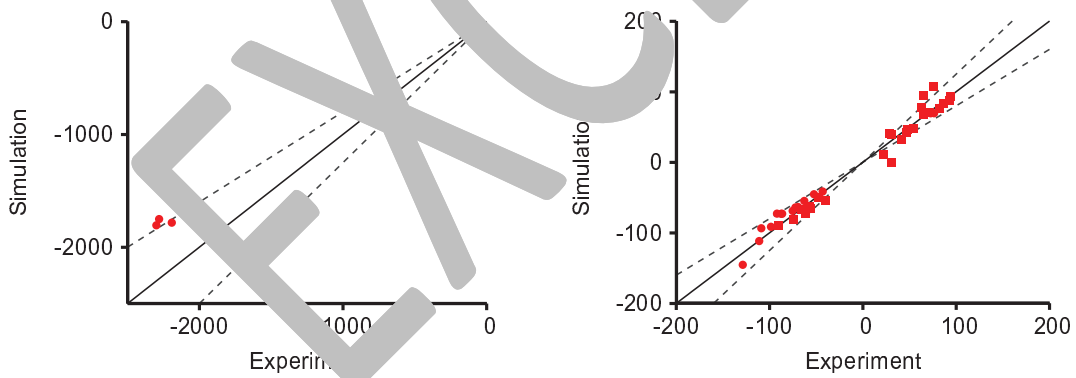


Figure 4.10 Rangeplot of signal Lumbar_FrcZ (left); Rangeplot of signal Lumbar_MomX (right)

B Signal Results

In this Appendix the signals of all the tests are presented.

B.1 Signals of the full dummy tests

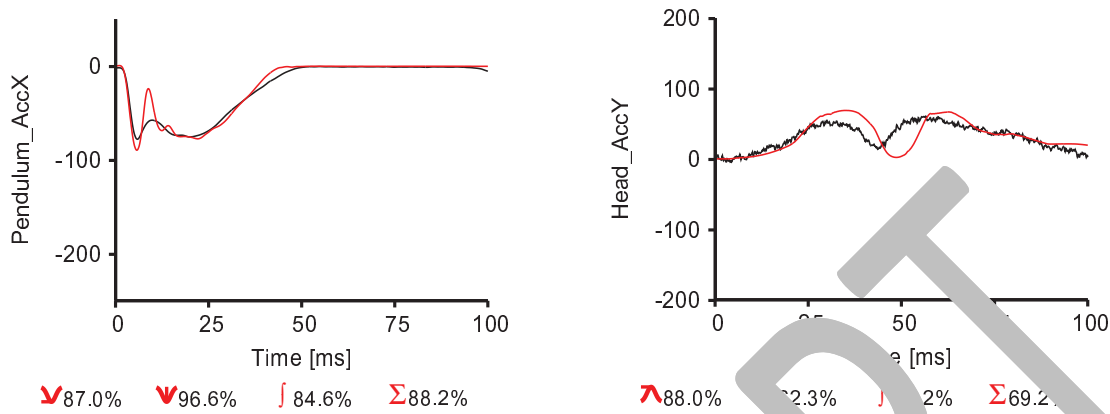


Figure B.1 Test F1 signal Pendulum_AccX (l); Test F1 signal Head_AccY (r)

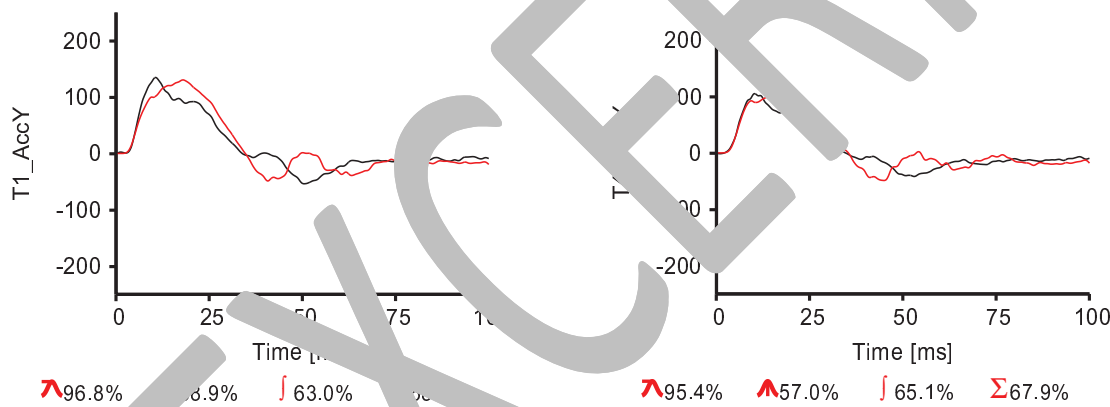


Figure B.2 Test F1 signal T1_AccY (l); Test F1 signal T4_AccY (r)

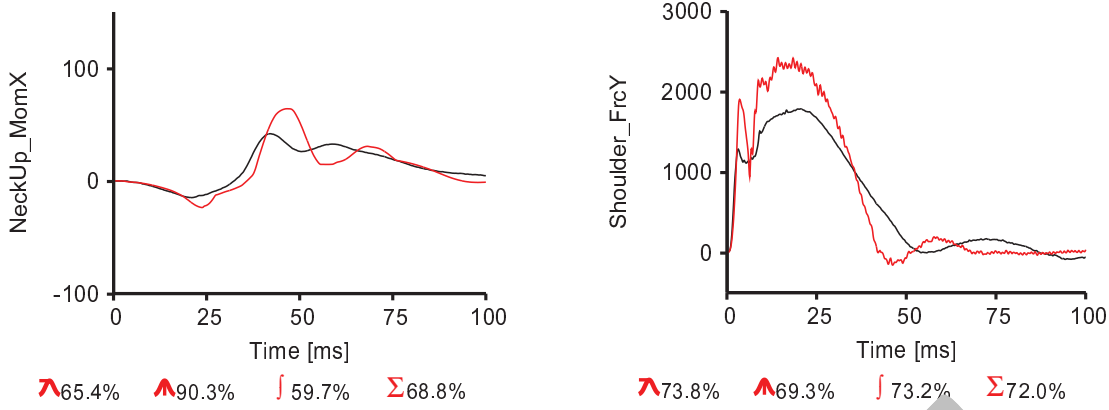


Figure B.18 Test F3 signal NeckUp_MomX (l); Test F3 signal Shoulder_FrcY (r)

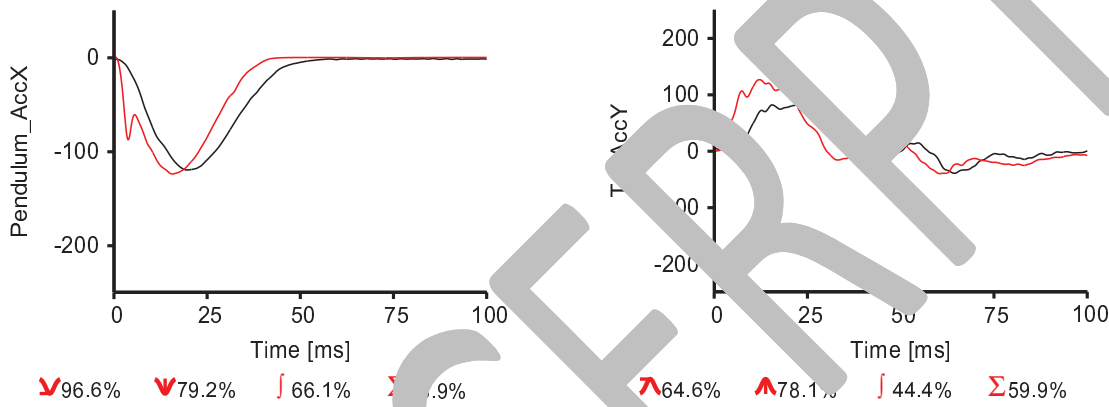


Figure B.19 Test F4 signal Pendulum_AccX (l); Test F4 signal T12_AccY (r)

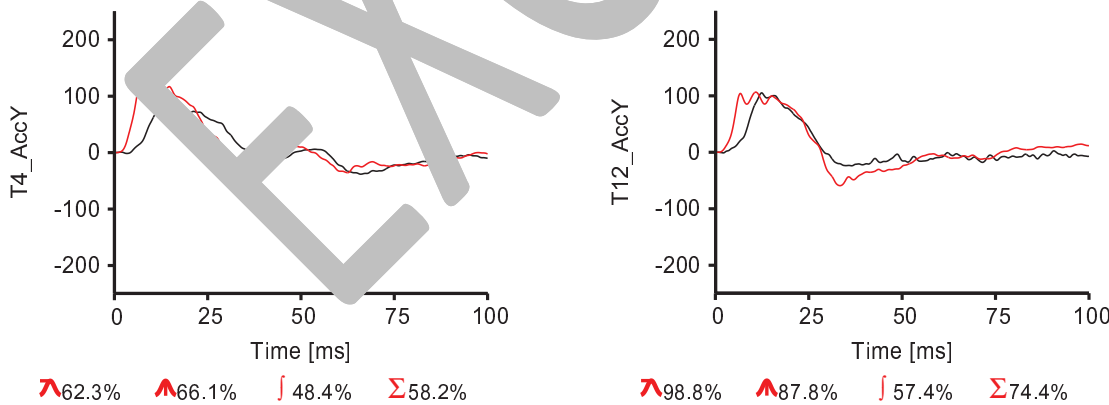


Figure B.20 Test F4 signal T4_AccY (l); Test F4 signal T12_AccY (r)

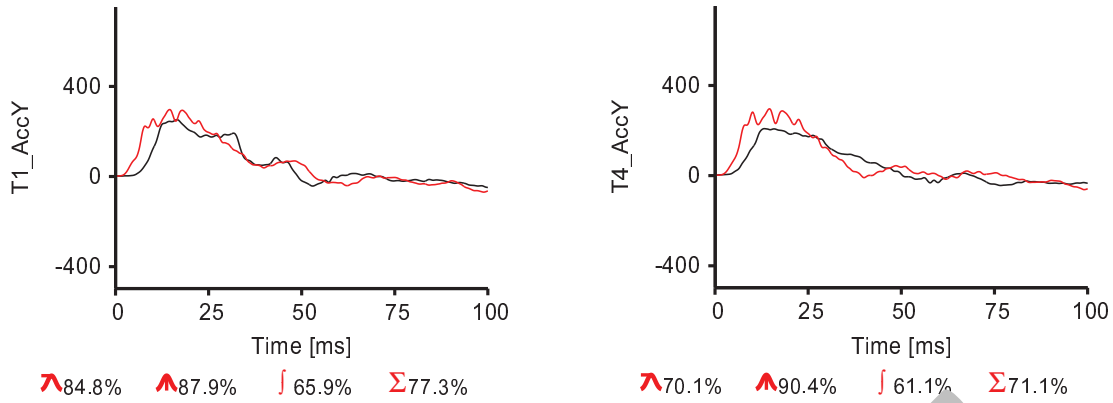


Figure B.177 Test F29 signal T1_AccY (l); Test F29 signal T4_AccY (r)

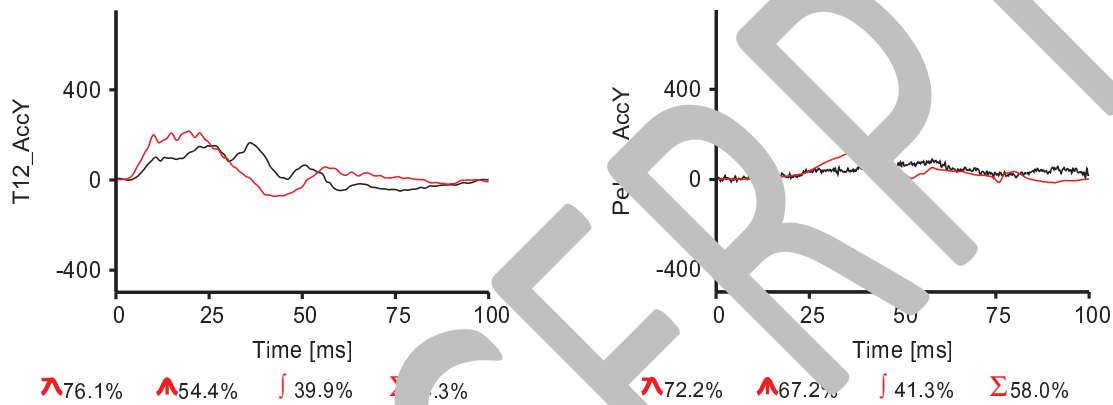


Figure B.178 Test F29 signal T12_AccY (l); Test F29 signal Pel'_AccY (r)

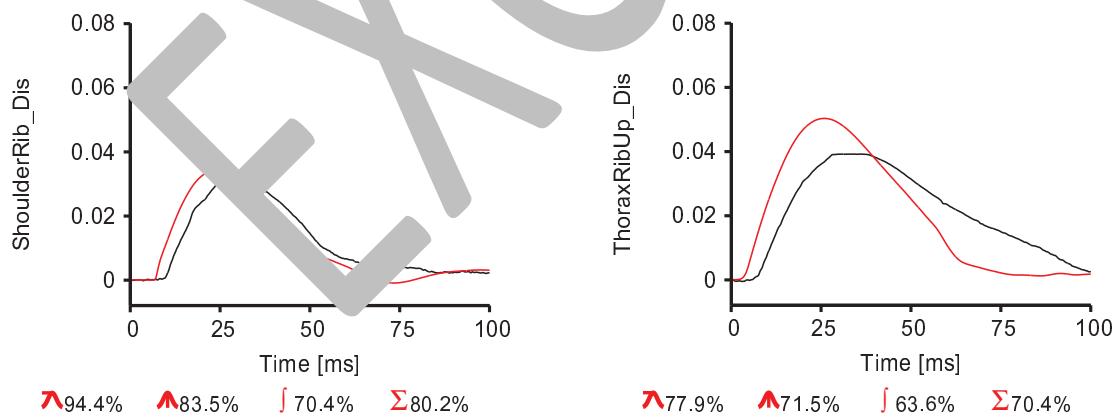


Figure B.179 Test F29 signal ShoulderRib_Dis (l); Test F29 signal ThoraxRibUp_Dis (r)