**MADYMO Quality Report Release Update**

BioRID-II facet Q model version 3.3.1 (R7.4.1)
BioRID-II fem Q model version 2.3.1 (R7.4.1)

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## 2     Experiments

For the validation and rating of the model, many experiments have been used. This chapter presents descriptions of the experiments that are used for the quality rating. All information that is publicly available about the tests can be found in this chapter.

In the first section, all experiments used for the rating are listed in tables. These tables contain 8 columns. Below you can find the description of the column headers:
ID = unique testnumber
#F = number of loading signals (forces and moments/torques) measured
#P = number of positional signals (displacements and rotations) measured
#V = number of velocities measured
#A = number of acceleration signals measured
#I = number of injury values rated

In the second section of this chapter, more detailed descriptions are presented in order to give the reader more insight into the exact validation-set. For tests that originally were conducted by clients, this detailed description is not printed because of confidentiality reasons; no extra information with respect to what is offered in this report can be supplied.

### 2.1     Tests overview

All experiments that have been used, are listed in the tables below. The total experimental validation-set is divided into different categories. Each table represents a different category. The ID of the test include a reference to the category:
H = head component test,
S = spine component test,
P = pelvis component test,
F = full dummy test,
R = rigid seat (full dummy) test.

Table 2.1      head tests

| ID | Description | Conditions | #F | #P | #V | #A | #I |
|----|-------------|------------|----|----|----|----|----|
| H1 | Head drop certification test | Standard | | | | 1 | |

Table 2.2      spine tests

| ID | Description | Conditions | #F | #P | #V | #A | #I |
|----|-------------|------------|----|----|----|----|----|
| S1 | Calibration sled test, lower/mid-spine locked | 4.25m/s | | 3 | | 3 | |
| S2 | Calibration sled test, lower/mid-spine locked | 4.25m/s | | 3 | | 3 | |
| S3 | Calibration sled test, lower/mid-spine locked | 4.25m/s | | 3 | | 3 | |
| S4 | Calibration sled test, lower/mid-spine locked with muscle substitutes | 4.25m/s | | 3 | | 3 | |
| S5 | Calibration sled test, lower/mid-spine locked with muscle substitutes | 4.25m/s | | 3 | | 3 | |
| S6 | Calibration sled test, lower/mid-spine locked with muscle substitutes | 4.25m/s | | 3 | | 3 | |
| S7 | Calibration sled test, lower/mid-spine locked, damper and muscle substitutes | 4.25m/s | | 3 | | 3 | |
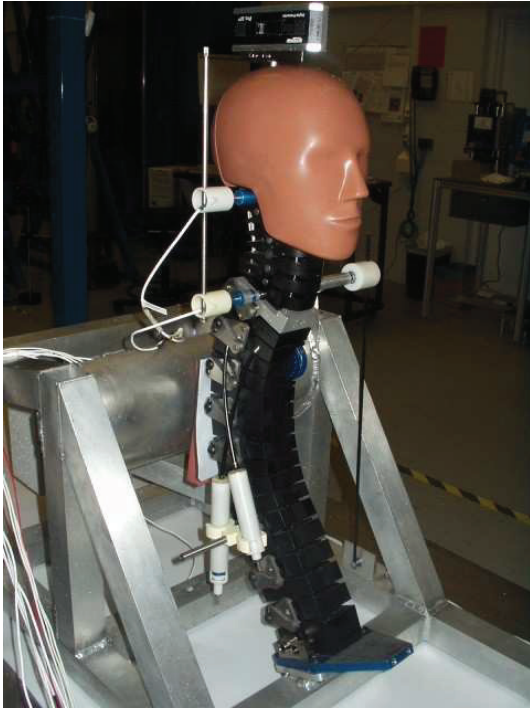
Figure 2.2      Dummy sub-assembly without jacket mounted on rig before testing.

**S14** Modified BioRID-II calibration test. The head and spine and torso are attached to a standard Denton calibration rig. The jacket is not included in the experiment. Due to the lack of support provided to the spine, the pendulum is dropped from a lower height than in the full test - 55" instead of 70". A sample of jacket rubber is placed between the spine and the spine support plate, to reduce experimental noise and protect the delicate components. The test is shown in Figure 2.2

**S15** Modified BioRID-II calibration test. The head and spine and torso are attached to a standard Denton calibration rig. The jacket is not included in the experiment. Due to the lack of support provided to the spine, the pendulum is dropped from a lower height than in the full test - 50" instead of 70". A sample of jacket rubber is placed between the spine and the spine support plate, to reduce experimental noise and protect the delicate components.

**S16** Standard BioRID-II calibration test. The head, spine and torso are attached to a specially-designed rig, shown in Figure 2.3. The base of the spine is held in place and the back rests against a curved steel plate. A 33.4kg pendulum strikes the back of the rig with an impact velocity of 4.76 m/s, accelerations and rotations are measured and compared to calibration corridors.

## 3        Rating of the validation set

All signals of all tests (40 experiments) have been numerically rated in the way as described in the appendix. The table below lists the combined values of all tests. Note that component scores include all tests, but only the signals that are measured in the component are included in the calculation of the score. Combined signals are also given.

### 3.1      Overall test 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 three give the score per rating criterion for the total dummy validation test set, followed by those for 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.

Table 3.1        Rating results for the model using the Peak criterion only

| Group | Weight | Model | M2 |
|---|---|---|---|
| Total | | 70.4% | 69.5% |
| head tests | 0.0250 | 93.5% | 93.5% |
| spine tests | 0.4750 | 65.3% | 63.5% |
| pelvis tests | 0.3000 | 86.9% | 86.9% |
| full tests | 0.0750 | 74.2% | 75.8% |
| rigid seat tests | 0.1250 | 59.6% | 59.7% |

Table 3.2        Rating results for the model using the Peaktime criterion only

| Group | Weight | Model | M2 |
|---|---|---|---|
| Total | | 81.2% | 79.2% |
| head tests | 0.0250 | 99.6% | 99.6% |
| spine tests | 0.4750 | 77.9% | 76.6% |
| pelvis tests | 0.3000 | 86.6% | 86.6% |
| full tests | 0.0750 | 89.6% | 87.0% |
| rigid seat tests | 0.1250 | 78.3% | 70.8% |

# 4     Comparison of results

This chapter shows the results that are obtained directly from the experiment and simulations. Direct signal output is listed in an Appendix. Range plots and Trend plots are shown in the next paragraphs. The next chapter shows rating results that are obtained from numerical comparisons between signals.

## 4.1     Range plots

The range plots show the results of a particular signal over different tests. The peak value of the signal during a particular simulation, is represented by a dot in the graph. The horizontal location of the dot 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 corresponds with the experiment, the dot is on the 45 degree line.
If the dot is below this line, the simulation had a lower peak than the experiment. Next to the 45 degree line, two lines have been drawn. Within these lines the peak score is above 0.8.
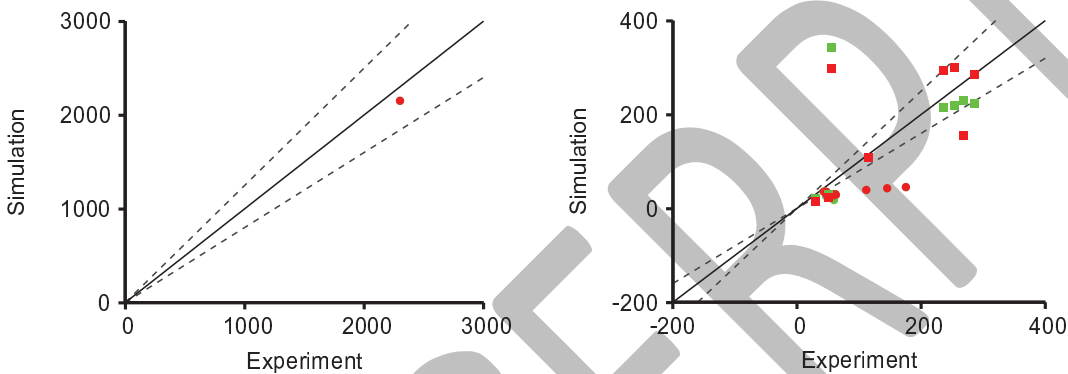


Figure 4.1     Rangeplot of signal Head_AccR (left); Rangeplot of signal Head_AccX (right)
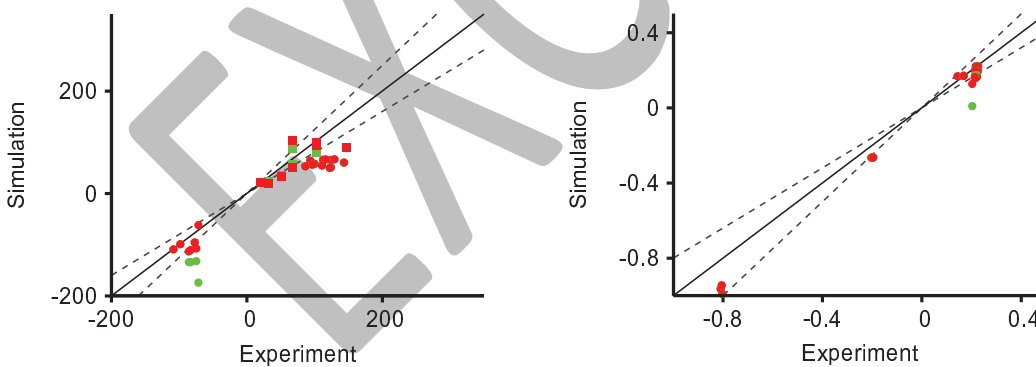


Figure 4.2     Rangeplot of signal Head_AccZ (left); Rangeplot of signal Head_AdisY (right)

# B    Signal results

In this Appendix the signals of all the tests are presented. Signals that are missing have been removed for reasons of confidentiality.
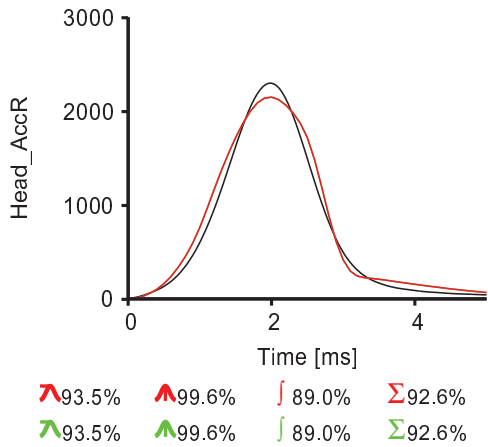
## B.1    Signals of Head tests



↗93.5%    ▲99.6%    ∫ 89.0%    Σ92.6%
↗93.5%    ▲99.6%    ∫ 89.0%    Σ92.6%

Figure B.1    Test H1 signal Head_AccR

## B.2    Signals of Spine tests



↗35.1%    ▲97.0%    ∫ 37.5%    Σ48.0%        ↗52.6%    ▲61.2%    ∫ 28.7%    Σ45.7%
↗35.1%    ▲97.0%    ∫ 37.5%    Σ48.0%        ↗52.6%    ▲61.2%    ∫ 28.7%    Σ45.7%
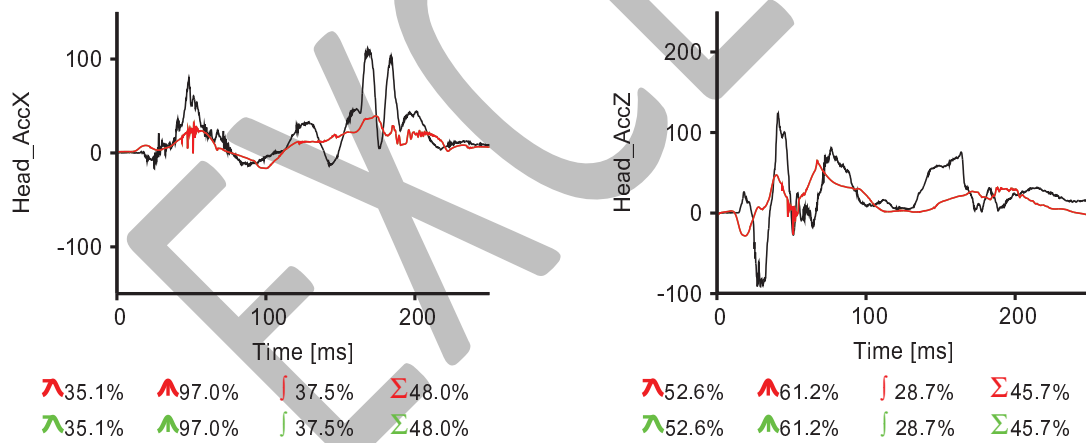
Figure B.2    Test S1 signal Head_AccX (l); Test S1 signal Head_AccZ (r)
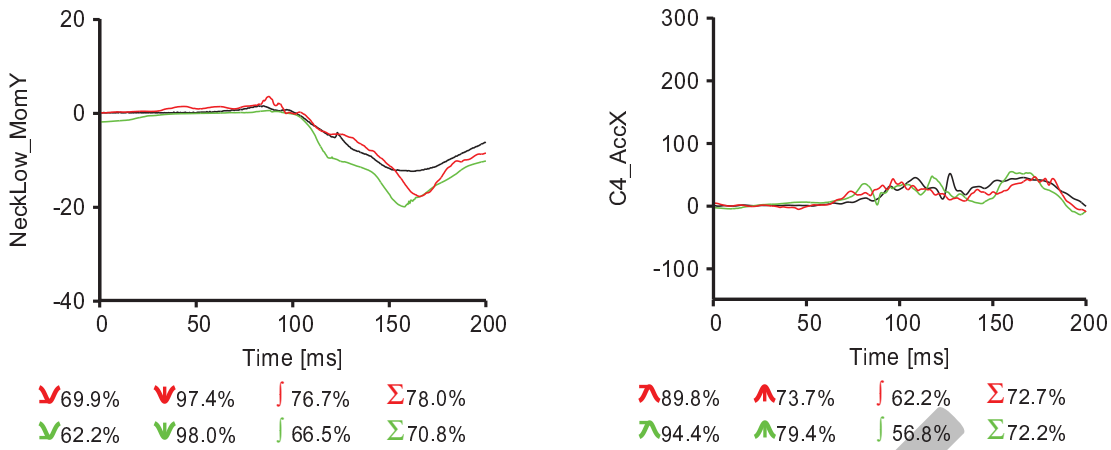
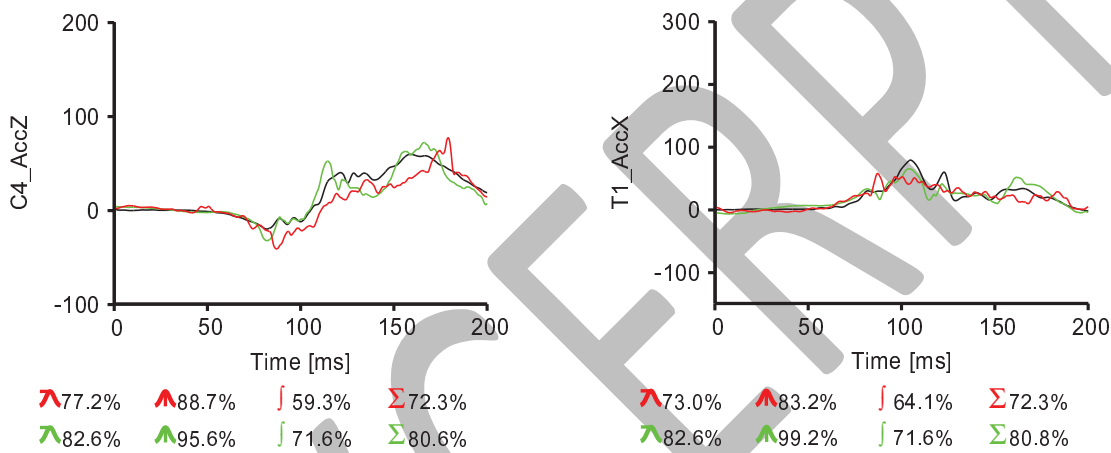Figure B.120  Test R4 signal NeckLow_MomY (l); Test R4 signal C4_AccX (r)



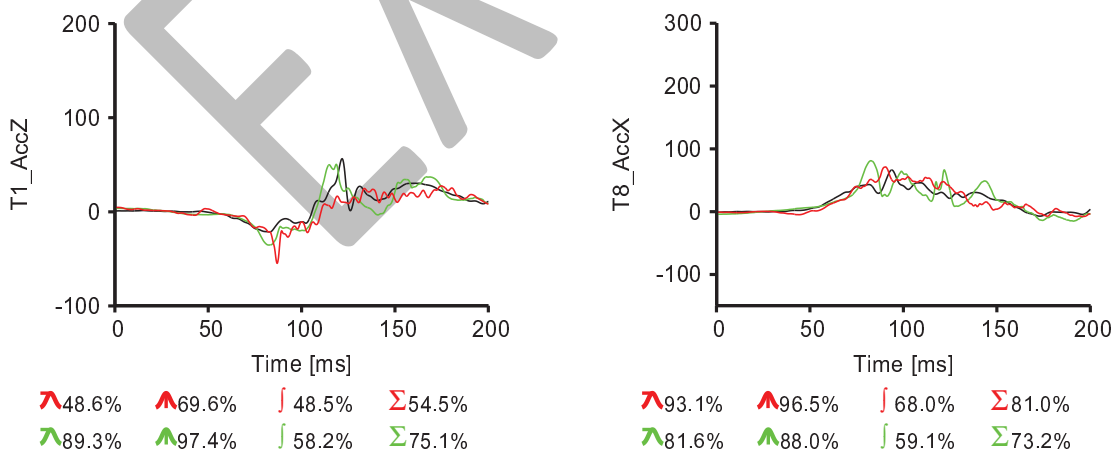Figure B.121  Test R4 signal C4_AccZ (l); Test R4 signal T1_AccX (r)



Figure B.122  Test R4 signal T1_AccZ (l); Test R4 signal T8_AccX (r)