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MADYMO 3D Simulations of Hybrid III Dummy Sled Tests

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MADYMO 3D Simulations of Hybrid III Dummy Sled Tests

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ABSTRACT

This paper presents a three-dimensional 15-segment model of the Hybrid III dummy for the MADYMO 3D Crash Victim Simulation program. The model is based on measurements conducted on two Hybrid III dummies by Wright Patterson Air Force Base. Results of MADYMO 3D simulations will be compared with Hybrid III sled tests conducted by Ford Motor Co. These tests were conducted at three different impact severity levels. For the three test conditions good agreement between model and experimental results could be observed for most of the output parameters. Recommendations for further model improvements will be made.

MADYMO is a computer program particularly developed for Crash Victim Simulations (1)*. The program predicts the kinematics and the dynamical behaviour of a crash victim or any other structure which can be represented by a number of connected rigid bodies, based on data of the victim, the environment, the safety devices and the crash conditions. The package differs from most of the existing CVS programs by its flexibility in choice of number of linkages and number of elements in each linkage. Great flexibility in the modelling of force interactions between elements and environment is assured by the fact that user-defined submodels can readily be incorporated.

There are two versions of MADYMO: MADYMO 2D and MADYMO 3D for two- and three-dimensional simulations, respectively. Both versions have been used extensively in the past for the simulation of frontal crashes, pedestrian and cyclist accidents, side impacts, sport accidents, etc....

This paper is related to the application of MADYMO 3D in a frontal crash environment. A mathematical model (= input data set) of the Hybrid III dummy will be presented. This dummy is generally considered to be one of the most advanced crash test dummies available at the moment. The MADYMO 3D Hybrid III database presented here is mainly based on measurements conducted by the Biodynamics & Bioengineering Division of the Harry G. Armstrong Aerospace Medical Research Laboratory, Wright Patterson Air Force Base in Ohio, USA. (Further refered to as WPAFB). These measurements were carried out on two dummies: one standing dummy and one sitting dummy (2). The work presented here is part of the activities conducted by the Analytical Human Simulation Taskforce of the SAE Human Biomechanics and Simulation Subcommittee. As part of the work of this Taskforce also a series of Hybrid III sled tests have been carried out by Ford Motor Co. (3). These tests will be used here for validation of the proposed MADYMO 3D Hybrid III model.

Simular model validation studies have been carried out by Prasad (4) for the MADYMO 2D model, by Obergefell et al. (5) for the ATB-CVS program and by Khatua (6) for the CALSPAN CVS program.

In the next section the Hybrid III dummy model will be formulated followed by a section describing the model of the environment of the Hybrid III dummy, i.e. the sled and the restraint system. In the subsequent section model predictions will be presented together with experimental results. A final discussion concludes this paper.

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* Numbers in parentheses designate references at end of paper

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HYBRID III DUMMY MODEL

SEGMENT SELECTION - Fifteen segments have been selected in this study to define the Hybrid III dummy in MADYMO 3D. Segment numbers and segment names are summarized in Table 1. In the measurement program conducted by WPAFB a similar segment division was used except for the hands which were measured separately. In the model proposed here the hands have been included in the lower arm segments. A reprint of the computer output of MADYMO 3D explaining the selected MADYMO input data is given in Annex A. For an explanation of this input description see the MADYMO 3D User's Manual (7). In the following sections the most important input parameters will be discussed briefly and the most important model assumptions will be summarized.

TABLE 1 - ELEMENT NAMES OF MODEL OF HYBRID III DUMMY

Element number	Element name
1	Lower Torso
2	Spine
3	Upper Torso
4	Neck
5	Head
6	Upper Arm Left
7	Lower Arm Left
8	Upper Arm Right
9	Lower Arm Right
10	Upper Leg Left
11	Lower Leg Left
12	Foot Left
13	Upper Leg Right
14	Lower Leg Right
15	Foot Right

LOCAL COORDINATE SELECTION - For each segment a local right-handed coordinate system (x,y,z) has been defined. For the sitting position illustrated in Fig. 1 all local z-axes are directed upward, all x-axes are forward and all y-axes to the left. Table 2 specifies in more detail the location of these local coordinate systems. The origins of the coordinate system of the limbs and the lower torso have been selected in the joint centers of rotation. For the other segments the coordinate system origins were chosen in the centers of the end planes of the rubber cylinders representing neck and lumbar spine.

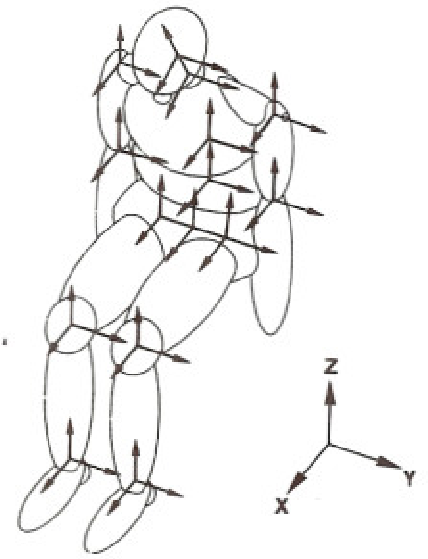

Fig. 1 Location of local coordinate systems.

MASS DISTRIBUTION - Segment masses, centers of gravity and principal moments of inertia are based on rough data obtained from WPAFB in the beginning of 1987. In certain cases these rough data will differ from the data to be presented in the final report of WPAFB which is planned to be published in 1988 (8). In the input dataset principal moments of inertia of less than 0.01 kg.m^2 have been set at 0.01 kg.m^2 in order to reduce the computer time (cpu) required for a simulation. The influence of this on the simulation results is negligible. WPAFB measurements show that for most segments the deviation in orientation between principal moments of inertia axes and local coordinate system axes is small. Only the head principal axes appear to deviate significantly. Consequently it was decided to introduce a separate principal moment of inertia coordinate system only for the head. In the other segments the orientation of this coordinate system is taken identical to the segment local coordinate system orientation.

JOINT PROPERTIES - In MADYMO 3D two types of joint models can be distinguished (1). The cardan joint model was used to simulate shoulder, elbow, hip, knee and ankle joints. The flexion-torsion joint model was chosen to approximate the neck and lumbar spine flexibility. For each segment member of a joint, a local joint coordinate system has to be defined. The orientation of these coordinate systems has been selected such that for the sitting position of the dummy which is illustrated in Fig. 1 both joint coordination systems of a joint coincide. Fig. 2 presents the location of the joint local coordinate systems for which the orientation differs from the orientation of the local coordinate system.

TABLE 2 - SPECIFICATION OF LOCAL COORDINATE SYSTEMS*

Lower Torso	origin:	H-point.
	y-axis:	Along centerline through left and right hip center.
	x-axis:	Pointing forwards parallel to pelvis top plane.
Spine	origin:	The center of the plate on the lumbar spine which attaches the pelvis and the spine.
	y-axis:	Parallel to centerline through left and right hip center.
	x-axis:	Parallel to x-axis of the lower torso local coordinate system.
Upper Torso	origin:	The center of the plate on the lumbar spine which attaches the spine and the upper torso.
	y-axis:	Parallel to centerline throug left and right hip center.
	x-axis:	Parallel to x-axis of the lower torso local coordinate system.
Neck	origin:	Center of the lower aluminium neck spacer.
	z-axis:	Along centerline neck.
Head	origin:	Center of the neck/head pivot.
	z-axis:	Along centerline neck.
Upper Arm	origin:	Center of shoulder pivot for abduction/adduction motion.
	x-axis:	Along centerline of shoulder pivot for abduction/adduction motion.
	z-axis:	Along the line between center of shoulder and elbow pivot.
Lower Arm	origin:	Center of elbow pivot.
	y-axis:	Along centerline of elbow pivot.
Upper Leg	origin:	Center of hip.
	y-axis:	Along centerline through left and right hip center.
	x-axis:	Intersects the knee centerline
Lower Leg	origin:	Center of the knee.
	y-axis:	Along centerline of knee pivot.
	z-axis:	Along the line between center of knee and ankle pivot.
Foot	origin:	Center of the ankle.
	z-axis:	Along the line through center of knee and center of ankle.

* Note: if not specified in other way, all positive x-axis are forward, all positive y-axis are to the left and all positive z-axis are upward (in sitting position)

Both the cardan joint model and the flexion-torsion model allow three degrees of freedom. Joint motions in MADYMO 3D can be suppressed by defining relatively stiff elastic joint characteristics. The number of degrees of freedom allowed in the various joints of the present model is summarized in Table 3. The Hybrid III shoulder assembly allows motion in four pin joints: two joints for rotation of the shoulder assembly relative to the thorax and two joints for rotation of the upper arms relative to the shoulder assembly. Both rotations of the shoulder assembly have been neglected in the model.

Most of the elastic joint properties in the model have been derived from the rough data provided by WPAFB. Values for the neck and lumbar spine were based on additional data obtained from Ford Motor Co. (4). Due to the limited information available no separate bending properties for rearward and lateral bending in the neck and lumbar spine could be defined in the present model. Properties in these

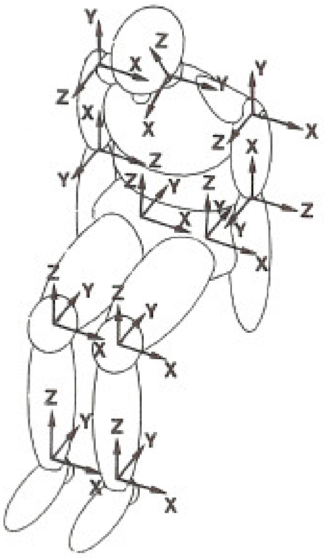

Fig. 2. Orientation of joint coordinate systems in dummy reference position for which the orientation differs from the orientation of the local coordinate systems.

directions have been chosen identical to frontal flexion data. For the validation studies presented here the effect of this is expected to be small. Most of the damping coefficients have been estimated assuming that the joints are less than critically damped. First a rough estimate was made of a critical damping coefficient; the actual values in the model were selected below this critical damping depending on the type of joint. Friction torques have been calculated assuming that the dummy joints are preset to hold the segment in a static equilibrium position (1G setting). The upper and lower arm are both kept horizontally. For the hip joint both lower leg and upper leg are placed in a horizontal position.

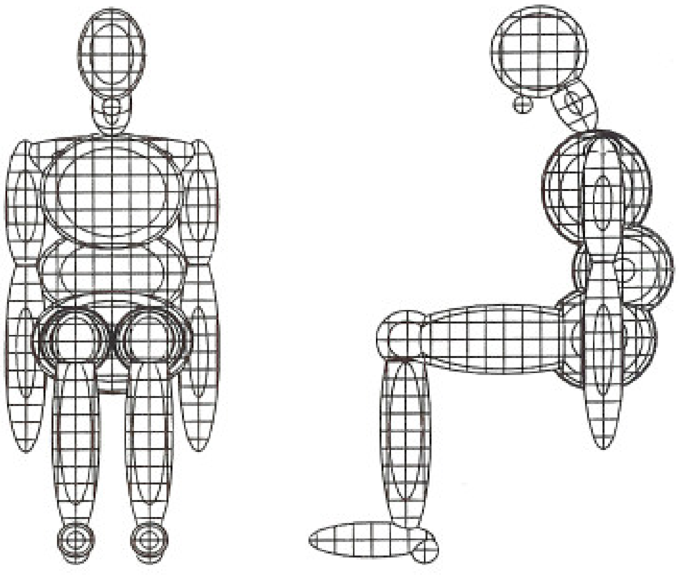

Fig. 3 Contact ellipsoids in Hybrid III model.

CONTACT ELLIPSOIDS - Results of the WPAFB measurements include dimensions and locations of dummy segment contact ellipsoids. The contact ellipsoids in the MADYMO 3D have been specified based on this information and additional data contained in technical drawings of the Hybrid III dummy. Fig. 3 illustrates the resulting Hybrid III surface description.

MODEL OF SLED AND RESTRAINT SYSTEM

A series of sled tests with the Hybrid III dummy in a three-point harness system have been carried out by Ford Motor Co. (3). Dummy responses for three levels of impact severity are available. The peak

TABLE 3. DEGREES OF FREEDOM IN JOINTS OF HYBRID III MODEL.

joint	degrees of freedom	type of motion
neck (upper and lower)	3	bending (x/y)* and torsion (z)*
spine (upper and lower)	3	bending (x/y and torsion (z)
shoulders	2	flexion-extension (x) and adduction abduction (z)
elbow	2	flexion-extension (z) and twist (x)
hip	3	flexion-extension (x), twist (z) and adduction-abduction (y)
knee	1	flexion-extension (x)
ankle	1	flexion-extension (x)

* for explanation of rotation axes; see MADYMO User's Manual (7)

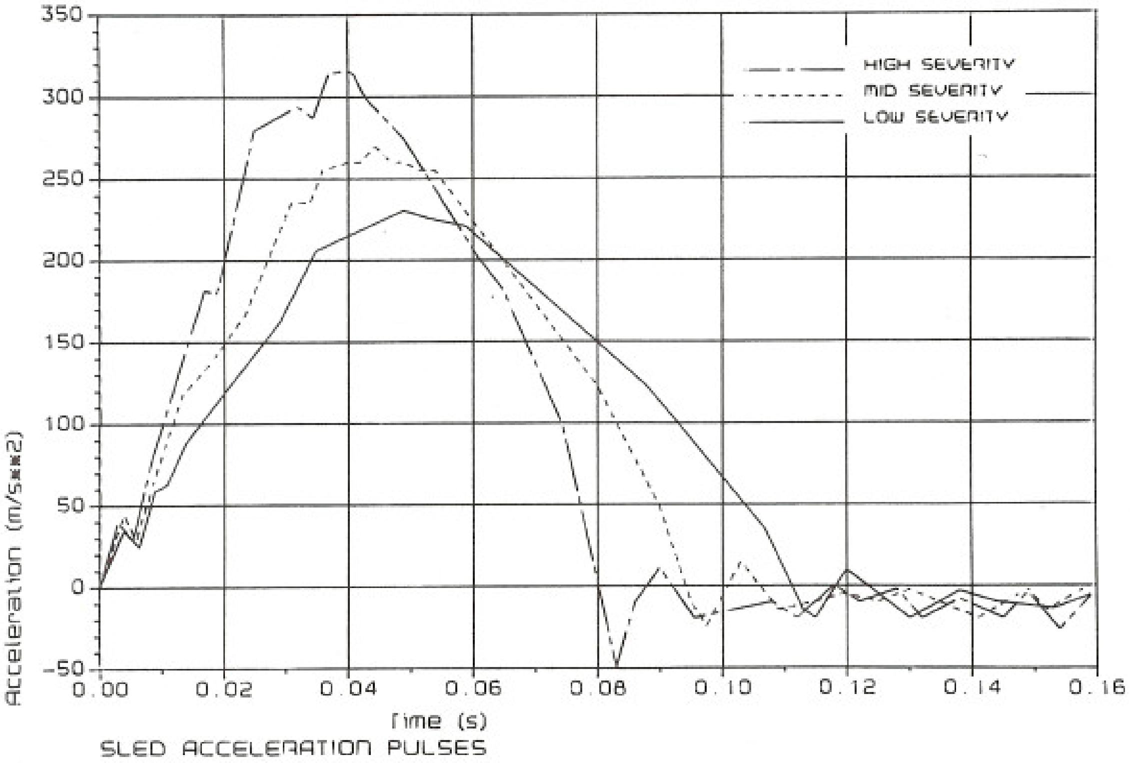

Fig. 4 Sled acceleration-time histories used as input in MADYMO.

values for the sled acceleration of the low, mid and high severity tests were 23.5, 27.5 and 32.2 G, respectively. The sled velocity in these tests was 15.3 m/s. MADYMO 3D simulations have been carried out for all three impact severities. Fig. 4 shows the sled acceleration-time histories used in the simulations. The initial position of the dummy and the locations of the various belt parts are shown in Fig. 5.

SEAT - A hard seat pan without foam was used in these tests. This seat is modeled in MADYMO 3D by planes attached to the inertial space. The contact stiffnesses for the interaction between pelvis and seat were measured by Ford Motor Co. Additional planes were defined in MADYMO for the contact between feet and floor (see Fig. 5). Stiffness data for this contact were also obtained from Ford Motor Co.

RESTRAINT SYSTEM - The anchor locations for the restraint system were exactly as in the tests. The inboard strap used in the test was not simulated. In the model the part of the shoulder belt leading from chest to inboard buckle was assumed to extend from the chest to the inboard floor tunnel-anchor point. Similarly, the inboard portion of the lap belt was assumed to extent from the pelvis to the same inboard anchor point. These simplifications of the belt geometry are expected to have a minor effect on the

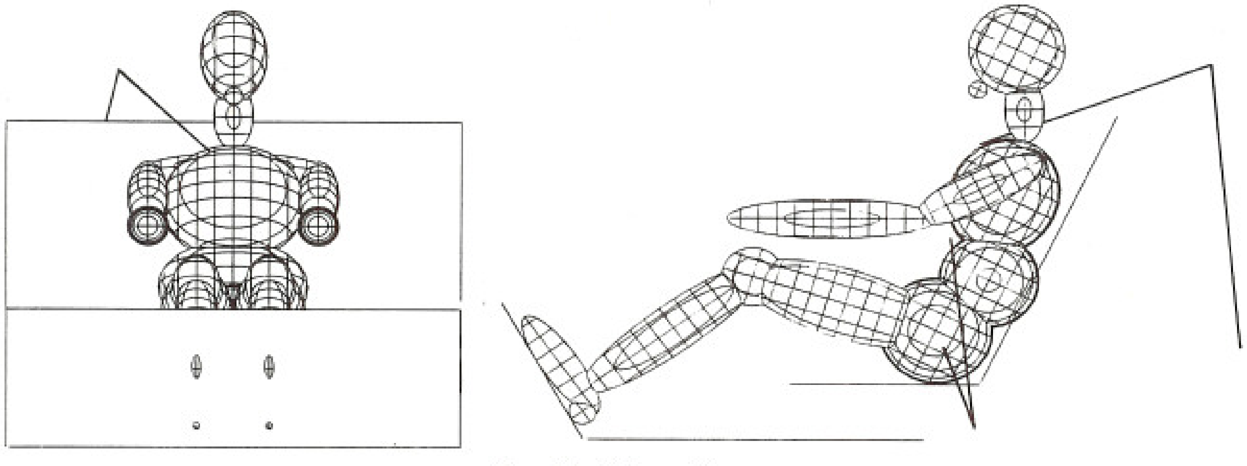

Fig. 5 Initial position.

model results since the inboard strap is also made of webbing material.

Five belt segments are used in the model to represent this restraint system: retractor part, shoulder belt, lower torso part, inboard lap and outboard lap. The retractor outlet function used in the model ('film spool effect') and belt properties were measured by Ford Motor Co. Lap belt stiffness data were corrected for compression of the dummy flesh based on static tests conducted by Ford Motor Co.

RESULTS

Mathematical simulations have been conducted with MADYMO 3D for the three impact severity levels discussed in the preceding section. Fig. 6 illustrates the resulting motion (gross kinematics) of the Hybrid III dummy model in the mid-severity test (27.5 G). These plots were obtained using the MADYMO Graphics Program. The predicted gross kinematics appeared to agree very well with the observations from the high speed films.

ACCELERATIONS - Fig. 7 shows a comparison between the model and experimental acceleration-time histories. Results are given for the resultant accelerations of the head, thorax (upper torso) and pelvis (lower torso) for the three impact severity levels. Model predictions for the head and thorax accelerations appear to be very realistic for all impact severity levels. Both the peak values and the shapes of the acceleration-time curves are close to the experimental findings. For the pelvis accelerations peak values predicted by the model appear to exceed the experimental peak values for all impact severity levels. The most likely explanation for this deviation is the compliance of the pelvis/abdomen flesh (submarining!) which was only partly taken into account in our simulations. Parameter variations of the lap belt stiffness showed indeed that improvements in the model response can be obtained easily by adjusting the lap belt stiffness.

BELT LOADS - Fig. 8 presents the belt force-time histories in the retractor belt part, the shoulder belt part and the outboard lap belt. Results are presented for all three impact severity levels. A quite good agreement between model and experimental results can be observed.

DISCUSSION

The 15-segment database developed in this study should be considered as a first attempt to develop a computer simulation model of the Hybrid III dummy for MADYMO 3D. In spite of a number of limitations in the present study the resulting model predictions appear to be very promising, particularly in view of the fact that reliable model results have been obtained here for **three** different impact severity levels. In the past most validation studies presented in the literature concerned only **one** test condition. In such a case quite often acceptable model results can be obtained simply by tuning some of the model input parameters. However, using such a 'tuned' database under different test conditions sometimes results in rather unreliable and disappointing model predictions.

The database presented here is based on rough data obtained from Wright Patterson Airforce Base (WPAFB) in Dayton, Ohio. When the final WPAFB data becomes available parameters in the present database probably have to be adjusted slightly. Further it should be noted here that WPAFB measurements have been conducted on earlier Hybrid III dummy types. Recently some design changes have been introduced in the thorax and neck segments. Such changes will also influence the selected model input parameters. For these dummy segments additional measurements are therefore recommended.

Another area of concern is the representation of the neck and lumbar spine in the model. Additional static and dynamic tests are needed, particularly for lateral and rearward impact directions. Further it should be realized that both the neck and lumbar spine are represented by 2 ball and socket joints in the model while in reality these (rubber) elements are much more complicated. Flexible model elements should be developed to simulate this type of structures.

The presented model consists of 15 segments. Further model improvements can be obtained if separate shoulder segments are included in order to represent the shoulder assembly motion. Also one or more separate sternum elements, as introduced by Prasad (4) in de MADYMO 2D Hybrid III database, would improve the model. Due to such database extensions the shoulder belt-thorax interaction would become more realistic. In addition separate sternum elements will allow the determination of the chest deflection which is one of the most important Hybrid III injury parameters.

In the lower torso area a further model improvement could be realized by simulating sliding of the lap belt relative to the pelvis and the corresponding submarining response. MADYMO allows this type of simulations by defining a separate segment while this segment can slide and penetrate relative to the lower and middle torso using adequate contact surfaces.

In the present validation study the complete dummy response predicted by the model has been compared with test results. Additional validation studies are proposed here to evaluate the response of specific dummy components, for instance in well-controlled calibration (impactor) tests.

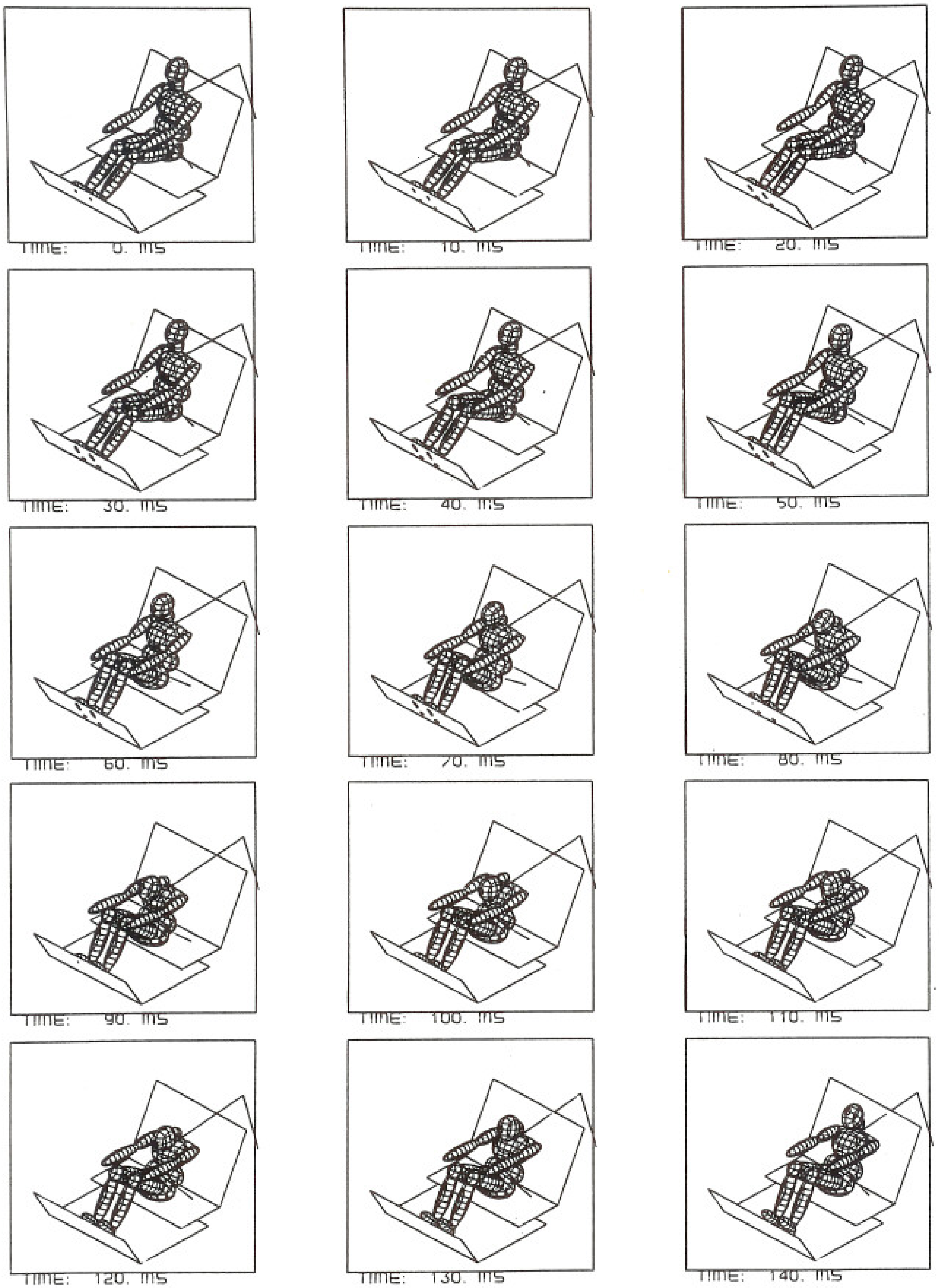

Fig. 6 Resulting motion (gross kinematics) of the Hybrid III dummy model in the mid-severity test (27.5 G).

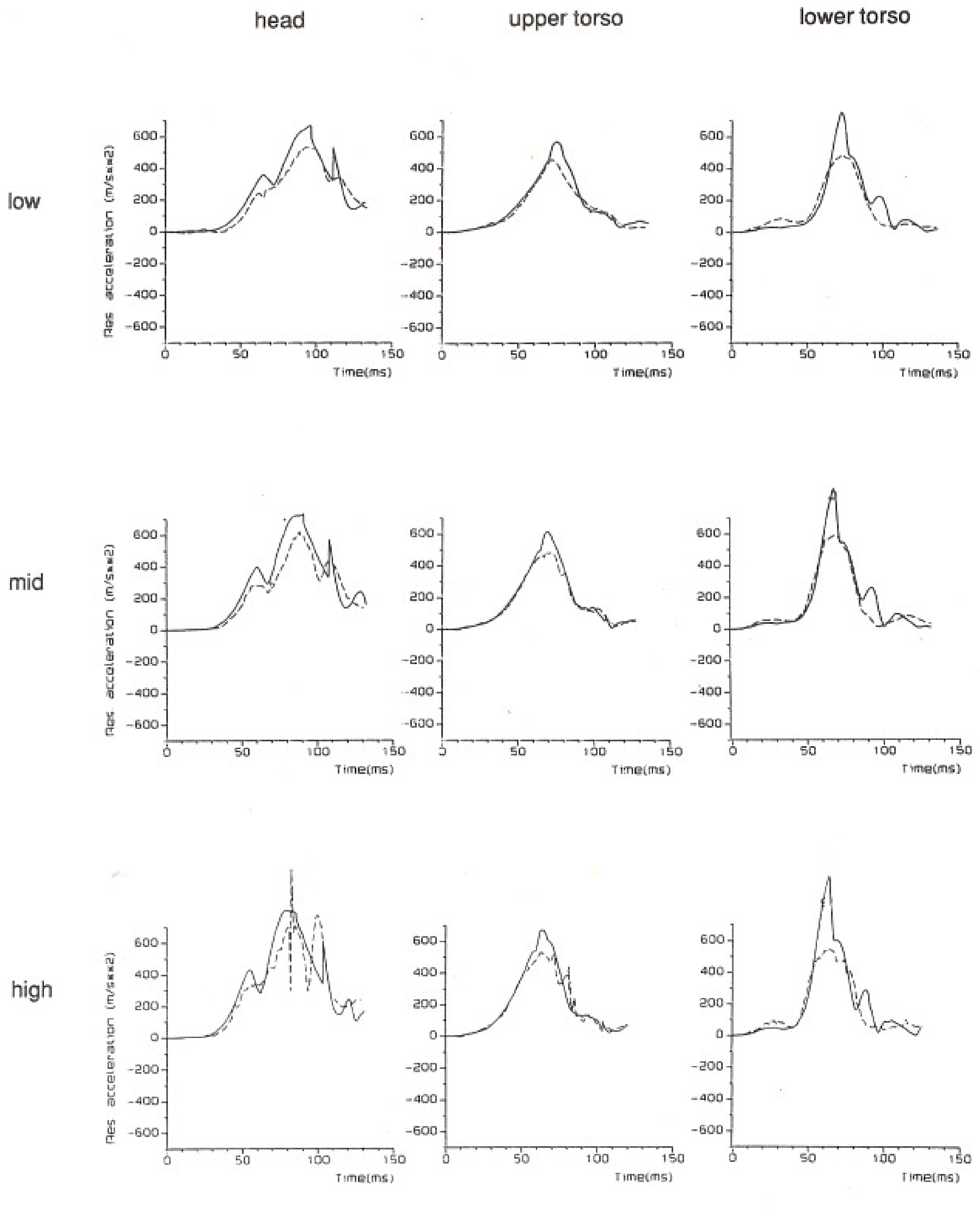

Fig. 7 Model and experimental acceleration-time histories for the three impact severity levels.
——— *model*
---------- *test*

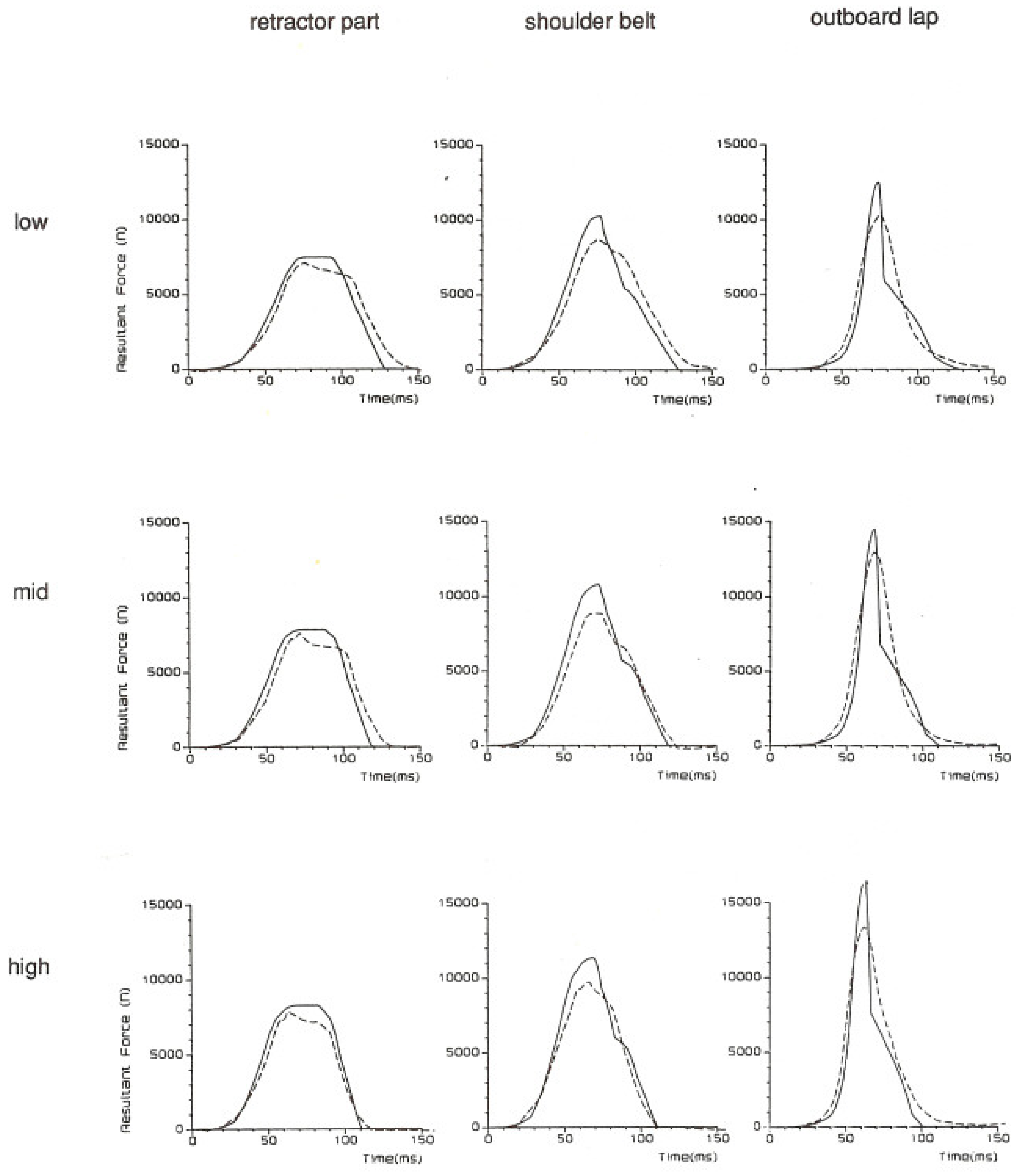

Fig. 8 Model and experimental belt load-time histories for the three impact severity levels.

——— *model*
---------- *test*

CONCLUSIONS

- A 15-segment MADYMO 3D-model has been developed based on data obtained from Wright-Patterson Air Force Base.
- Model predictions have been compared with well controlled slecd tests under various impact severity levels conducted by Ford Motor Co.
- Model results show good agreement with experimental results.
- Areas for future model improvements have been identified and additional Hybrid III measurements are proposed.
- In addition to full scale or sled test also local impact tests on certain dummy parts should be carried out for model validation purposes.

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APPENDIX A:
MADYMO reprint of input dataset for Hybrid III sled test simulation (mid severity impact level)

```
                    ---------------------------------------------------------------------
                    |                     F I L E   :   R E P R I N T                   |
                    ---------------------------------------------------------------------


                    ---------------------------------------------------------------------
                    | M A D Y M O   3 D    V E R S I O N   4 . 1                        |
                    ---------------------------------------------------------------------
                    | Release date : 870922                                             |
                    | (c) 1987 TNO Road Vehicles Research Institute                     |
                    | P.O. Box 237, 2600 AE Delft, The Netherlands                      |
                    | Licensed to : TNO-IW                                              |
                    | Host ID     :                                                     |
                    ---------------------------------------------------------------------


                    ---------------------------------------------------------------------
                    |  M A D Y M O  3 D :   I N P U T   D E S C R I P T I O N           |
                    ---------------------------------------------------------------------
                    |  RUN NR. :     1                                                  |
                    |  NAME    : HYBRID III SITTING MID SEVERITY                        |
                    |  DATE    : FEBRUARI 1988                                          |
                    ---------------------------------------------------------------------

******************************************************************************************************************************
GENERAL MODEL PARAMETERS
******************************************************************************************************************************

STARTING TIME           =  0.0000
END TIME                =  0.1500
TIME STEP RESTART DATA  =  0.1000
RESTART TIME            =  0.0000

5TH ORDER RUNGE-KUTTA MERSON WITH VARIABLE TIME STEP :
INITIAL TIME STEP = 0.00050
TOLERANCE         = 0.00100

LINEAR RAMP FUNCTION FOR JOINTS   : RAMP1 = 0.000 RAMP2 = 0.500

LINEAR RAMP FUNCTION FOR CONTACTS : RAMP1 = 0.010 RAMP2 = 4.000

******************************************************************************************************************************
INERTIAL SPACE : RIGID SEAT
******************************************************************************************************************************


** PLANES **

PLA|  EL |                       COORDINATES EDGES [M]                         |  ELASTIC CHARAC.  |
   |     |   X1     Y1     Z1     X2     Y2     Z2     X3     Y3     Z3      | LO  UNL    HYS    |
 1 |   0 |  0.770  0.500 -0.254  0.770 -0.500 -0.254  0.952 -0.500  0.065   |  1   3   1500000. | FOOT PLANE
 2 |   0 |  0.024  0.500 -0.254  0.024 -0.500 -0.254  0.770 -0.500 -0.254   |  1   3   1500000. | FLOOR PLANE
 3 |   0 | -0.096  0.500 -0.125 -0.096 -0.500 -0.125  0.327 -0.500 -0.125   |  2   4    825000. | SEATCUSH
 4 |   0 | -0.393  0.500  0.500 -0.393 -0.500  0.500 -0.096 -0.500 -0.125   |  2   4    825000. | SEATBACK

** FORCE-PENETRATION CHARACTERISTICS PLANES **


FORCE [N] AS FUNCTION OF PENETRATION [M]

       NR  1          |        NR  2          |        NR  3          |        NR  4          |
                      |                       |                       |                       |
   0.000       0.0    |   0.000       0.0     |  -0.100       0.0     |   0.000       0.0     |
   0.050   10000.0    |   0.008     490.0     |   0.000       0.0     |   0.013     135.0     |
                      |   0.013    1113.0     |   0.050    8000.0     |   0.023     450.0     |
                      |   0.018    2225.0     |                       |   0.028     900.0     |
                      |   0.020    4005.0     |                       |                       |
******************************************************************************************************************************
SYSTEM  1 : SITTING HYBRID III
******************************************************************************************************************************


** SYSTEM CONFIGURATION **

ELEMENT SEQUENCE IN BRANCH  1 =  5  4  3  2  1
ELEMENT SEQUENCE IN BRANCH  2 =  7  6  3  2  1
ELEMENT SEQUENCE IN BRANCH  3 =  9  8  3  2  1
ELEMENT SEQUENCE IN BRANCH  4 = 12 11 10  1
ELEMENT SEQUENCE IN BRANCH  5 = 15 14 13  1

** GEOMETRICAL DATA EXPRESSED IN ELEMENT COORDINATE SYSTEM **

EL |   REFERENCE JOINT [M]     |    CENTER OF GRAVITY [M]   |
   |     X       Y       Z     |     X       Y       Z      |
 1 |   0.000   0.000   0.000   |  -0.001   0.000   0.041    | LOWER TORSO
 2 |  -0.075   0.000   0.090   |   0.025   0.000   0.065    | SPINE
 3 |   0.006   0.000   0.130   |   0.056   0.000   0.125    | UPPER TORSO
 4 |   0.104   0.000   0.285   |   0.027   0.000   0.043    | NECK
 5 |   0.000   0.000   0.133   |   0.014   0.000   0.050    | HEAD
 6 |   0.061   0.188   0.205   |   0.000   0.000  -0.138    | UPPER ARM LEFT
 7 |   0.000   0.000  -0.263   |  -0.002   0.000  -0.146    | LOWER ARM LEFT
 8 |   0.061  -0.188   0.205   |   0.000   0.000  -0.138    | UPPER ARM RIGHT
 9 |   0.000   0.000  -0.263   |  -0.002   0.000  -0.146    | LOWER ARM RIGHT
10 |   0.000   0.080   0.000   |   0.253   0.000   0.000    | UPPER LEG LEFT
11 |   0.420   0.000   0.000   |   0.005   0.000  -0.171    | LOWER LEG LEFT
12 |   0.000   0.000  -0.414   |   0.045   0.000  -0.032    | FOOT LEFT
13 |   0.000  -0.080   0.000   |   0.253   0.000   0.000    | UPPER LEG RIGHT
14 |   0.420   0.000   0.000   |   0.005   0.000  -0.171    | LOWER LEG RIGHT
15 |   0.000   0.000  -0.414   |   0.045   0.000  -0.032    | FOOT RIGHT
```

```
** MASSES AND PRINCIPAL MOMENTS OF INERTIA **

EL |    MASS [KG] |         MOMENT OF INERTIA [KGM2]           |
   |              |      IXX           IYY          IZZ        |
 1 |    2.017E+01 |   2.393E-01     8.230E-02    1.647E-01 | LOWER TORSO
 2 |    2.667E+00 |   1.000E-02     1.000E-02    1.000E-02 | SPINE
 3 |    1.609E+01 |   2.961E-01     2.319E-01    1.959E-01 | UPPER TORSO
 4 |    1.480E+00 |   1.000E-02     1.000E-02    1.000E-02 | NECK
 5 |    4.535E+00 |   1.590E-02     2.400E-02    2.210E-02 | HEAD
 6 |    2.085E+00 |   1.160E-02     1.130E-02    1.000E-02 | UPPER ARM LEFT
 7 |    2.318E+00 |   3.390E-02     3.370E-02    1.000E-02 | LOWER ARM LEFT
 8 |    2.085E+00 |   1.160E-02     1.130E-02    1.000E-02 | UPPER ARM RIGHT
 9 |    2.318E+00 |   3.390E-02     3.370E-02    1.000E-02 | LOWER ARM RIGHT
10 |    6.220E+00 |   6.880E-02     6.740E-02    1.210E-02 | UPPER LEG LEFT
11 |    3.283E+00 |   7.580E-02     7.620E-02    1.000E-02 | LOWER LEG LEFT
12 |    1.250E+00 |   1.000E-02     1.000E-02    1.000E-02 | FOOT LEFT
13 |    6.220E+00 |   6.880E-02     6.740E-02    1.210E-02 | UPPER LEG RIGHT
14 |    3.283E+00 |   7.580E-02     7.620E-02    1.000E-02 | LOWER LEG RIGHT
15 |    1.250E+00 |   1.000E-02     1.000E-02    1.000E-02 | FOOT RIGHT


ORIENTATION OF MOMENTS OF INERTIA COORDINATE SYSTEM RELATIVE TO ELEMENT COORDINATE SYSTEM

EL |                                                                                             |
 5 | COSINE MATRIX |  0.8943  0.0002  0.4475 -0.0001 -1.0000  0.0006  0.4475 -0.0006 -0.8943 |

** CARDAN JOINTS **

NO |          IDENTIFIER                 |
   |                                     |
 1 | LOWER TORSO     - UPPER LEG LEFT    |
 2 | LOWER TORSO     - UPPER LEG RIGHT   |
 3 | UPPER LEG LEFT  - LOWER LEG LEFT    |
 4 | UPPER LEG RIGHT - LOWER LEG RIGHT   |
 5 | LOWER LEG LEFT  - FOOT LEFT         |
 6 | LOWER LEG RIGHT - FOOT RIGHT        |
 7 | UPPER TORSO     - UPPER ARM LEFT    |
 8 | UPPER TORSO     - UPPER ARM RIGHT   |
 9 | UPPER ARM LEFT  - LOWER ARM LEFT    |
10 | UPPER ARM RIGHT - LOWER ARM RIGHT   |

NO |         |    ELASTIC CHAR. PHI     |   ELASTIC CHAR. THETA    |    ELASTIC CHAR. PSI     |   DAMPING [NMS/RAD]    |     FRICTION [NM]      |
   | ELI ELJ | LO  UNL     HYS      XEL | LO  UNL     HYS      XEL | LO  UNL     HYS      XEL | PHI    THETA    PSI    |  PHI    THETA    PSI   |
 1 |   1  10 |  1   0       0. 0.000 |  2   0       0. 0.000 |  3   0       0. 0.000 | 6.00   6.00    5.00 | 45.00  45.00  14.00 |
 2 |   1  13 |  1   0       0. 0.000 |  4   0       0. 0.000 |  3   0       0. 0.000 | 6.00   6.00    5.00 | 45.00  45.00  14.00 |
 3 |  10  11 |  5   0       0. 0.000 |  6   0       0. 0.000 |  6   0       0. 0.000 | 5.00   7.50    4.00 | 11.00   0.00   0.00 |
 4 |  13  14 |  5   0       0. 0.000 |  6   0       0. 0.000 |  6   0       0. 0.000 | 5.00   7.50    4.00 | 11.00   0.00   0.00 |
 5 |  11  12 |  7   0       0. 0.000 |  6   0       0. 0.000 |  6   0       0. 0.000 | 1.00   1.00    1.00 |  1.00   0.00   0.00 |
 6 |  14  15 |  7   0       0. 0.000 |  6   0       0. 0.000 |  6   0       0. 0.000 | 1.00   1.00    1.00 |  1.00   0.00   0.00 |
 7 |   3   6 |  8   0       0. 0.000 |  6   0       0. 0.000 |  9   0       0. 0.000 | 2.00   4.00    4.00 | 11.40   0.00  11.40 |
 8 |   3   8 |  8   0       0. 0.000 |  6   0       0. 0.000 | 10   0       0. 0.000 | 2.00   4.00    4.00 | 11.40   0.00  11.40 |
 9 |   6   7 | 11   0       0. 0.000 |  6   0       0. 0.000 | 12   0       0. 0.000 | 2.00   4.00    2.00 |  3.20   0.00   3.20 |
10 |   8   9 | 11   0       0. 0.000 |  6   0       0. 0.000 | 12   0       0. 0.000 | 2.00   4.00    2.00 |  3.20   0.00   3.20 |

ORIENTATION OF CARDAN JOINT COORDINATE SYSTEM RELATIVE TO ELEMENT COORDINATE SYSTEM
(JOINT DENOTED BY ITS HIGHER NUMBERED ELEMENT ELJ,ELEMENT DENOTED BY ELEM)

ELJ| ELEM|                                                                          |
10 |   1 |   ROTATIONS    |     3.  1.5708     0.  0.0000     0.  0.0000         |
10 |  10 |   ROTATIONS    |     3.  1.5708     0.  0.0000     0.  0.0000         |
13 |   1 |   ROTATIONS    |     3.  1.5708     0.  0.0000     0.  0.0000         |
13 |  13 |   ROTATIONS    |     3.  1.5708     0.  0.0000     0.  0.0000         |
11 |  10 |   ROTATIONS    |     3.  1.5708     0.  0.0000     0.  0.0000         |
11 |  11 |   ROTATIONS    |     3.  1.5708     0.  0.0000     0.  0.0000         |
14 |  13 |   ROTATIONS    |     3.  1.5708     0.  0.0000     0.  0.0000         |
14 |  14 |   ROTATIONS    |     3.  1.5708     0.  0.0000     0.  0.0000         |
12 |  11 |   ROTATIONS    |     3.  1.5708     0.  0.0000     0.  0.0000         |
12 |  12 |   ROTATIONS    |     3.  1.5708     0.  0.0000     0.  0.0000         |
15 |  14 |   ROTATIONS    |     3.  1.5708     0.  0.0000     0.  0.0000         |
15 |  15 |   ROTATIONS    |     3.  1.5708     0.  0.0000     0.  0.0000         |
 6 |   3 |   ROTATIONS    |     1.  1.5708     2.  1.5708     0.  0.0000         |
 6 |   6 |   ROTATIONS    |     1.  1.5708     2.  1.5708     0.  0.0000         |
 8 |   3 |   ROTATIONS    |     1.  1.5708     2.  1.5708     0.  0.0000         |
 8 |   8 |   ROTATIONS    |     1.  1.5708     2.  1.5708     0.  0.0000         |
 7 |   6 |   ROTATIONS    |     2. -1.5708     1. -1.5708     0.  0.0000         |
 7 |   7 |   ROTATIONS    |     2. -1.5708     1. -1.5708     0.  0.0000         |
 9 |   8 |   ROTATIONS    |     2. -1.5708     1. -1.5708     0.  0.0000         |
 9 |   9 |   ROTATIONS    |     2. -1.5708     1. -1.5708     0.  0.0000         |

** TORQUE CHARACTERISTICS CARDAN JOINTS **

TORQUE [NM] AS FUNCTION OF ANGLE [RAD] :

        NR  1            |        NR  2            |        NR  3            |        NR  4            |        NR  5            |        NR  6            |
                         |                         |                         |                         |                         |                         |
  -1.600       -552.0    |  -1.800       -587.0    |  -2.000       -500.0    |  -1.650       -546.0    |  -2.570       -500.0    |  -1.000       -500.0    |
  -0.600        -52.0    |  -0.800        -87.0    |  -1.000          0.0    |  -0.650         46.0    |  -1.570          0.0    |   1.000        500.0    |
   0.000          0.0    |   0.000          0.0    |   1.000          0.0    |   0.000          0.0    |   0.000          0.0    |                         |
   0.900         68.0    |   0.650         46.0    |   2.000        500.0    |   0.800         87.0    |   0.260          0.0    |                         |
   1.000         96.0    |   1.650        546.0    |                         |   1.800        587.0    |   0.710         31.0    |                         |
   2.000        596.0    |                         |                         |                         |   0.890         81.0    |                         |
                         |                         |                         |                         |   1.890        581.0    |                         |

TORQUE [NM] AS FUNCTION OF ANGLE [RAD] :

        NR  7            |        NR  8            |        NR  9            |        NR 10            |        NR 11            |        NR 12            |
                         |                         |                         |                         |                         |                         |
  -1.900       -537.0    |  -3.500       -500.0    |   0.000          0.0    |  -3.500       -526.0    |  -1.880       -500.0    |  -3.000       -544.0    |
  -0.900        -37.0    |  -2.500          0.0    |   2.500         26.0    |  -2.500        -26.0    |  -0.880          0.0    |  -2.000        -44.0    |
  -0.800          0.0    |   0.000          0.0    |   3.500        526.0    |   0.000          0.0    |   0.880          0.0    |  -1.800        -11.0    |
   0.000          0.0    |   1.300          0.0    |                         |                         |   1.880        500.0    |  -1.570          0.0    |
   0.700          0.0    |   2.300        500.0    |                         |                         |                         |   0.000          0.0    |
   0.800         41.0    |                         |                         |                         |                         |   1.000        500.0    |
   1.800        541.0    |                         |                         |                         |                         |                         |
```

```
** FLEXION-TORSION JOINTS **

NO |            IDENTIFIER                           |
   |                                                 |
 1 | LOWER TORSO       - SPINE                       |
 2 | SPINE             - UPPER TORSO                 |
 3 | UPPER TORSO       - NECK                        |
 4 | NECK              - HEAD                        |

NO |          |  ELASTIC   CHAR. FLEXION   |  ELASTIC CHAR.   TORSION   |  DAMPING   | FRICTION  | NFAC |
   | ELI ELJ  |  LO  UNL     HYS       XEL |  LO  UNL     HYS       XEL | [NMS/RAD]  |   [NM]    |      |
 1 |   1   2  |   1   0       0.    0.000  |   2   0       0.    0.000  |  30.50     |   0.00    |    0 |
 2 |   2   3  |   1   0       0.    0.000  |   2   0       0.    0.000  |  30.50     |   0.00    |    0 |
 3 |   3   4  |   3   0       0.    0.000  |   4   0       0.    0.000  |   2.30     |   2.00    |    0 |
 4 |   4   5  |   3   0       0.    0.000  |   4   0       0.    0.000  |   2.30     |   2.00    |    0 |

ORIENTATION OF FLEXION-TORSION JOINT COORDINATE SYSTEM RELATIVE TO ELEMENT COORDINATE SYSTEM
(JOINT DENOTED BY ITS HIGHER NUMBERED ELEMENT ELJ, ELEMENT DENOTED BY ELEM)

ELJ| ELEM|                                                                                        |
 4 |   3 |   ROTATIONS    |        2.   0.4768        0.   0.0000        0.   0.0000            |

** TORQUE CHARACTERISTICS FLEXION-TORSION JOINTS **

TORQUE [NM] AS FUNCTION OF ANGLE [RAD] OR FUNCTION FOR FACTOR :

        NR  1            |          NR  2          |          NR  3          |          NR  4          |
                         |                         |                         |                         |
   0.000          0.0    |  -1.000        -126.0   |   0.000           0.0   |  -1.000        -103.0   |
   1.000       2978.0    |  -0.175         -40.0   |   0.021           4.7   |  -0.175         -28.0   |
                         |   0.175          40.0   |   0.390          30.0   |   0.175          28.0   |
                         |   1.000         126.0   |   0.500          40.6   |   1.000         103.0   |
                         |                         |   0.590          53.7   |                         |
                         |                         |   0.660          71.1   |                         |
                         |                         |   0.680          77.7   |                         |
                         |                         |   0.710          84.8   |                         |
                         |                         |   1.710         538.0   |                         |


** ELLIPSOIDS **

NO |  EL |       SEMI-AXES [M]      |         CENTER [M]        | DEG |   ELASTIC CHARAC.        |
   |     |    EX      EY      EZ    |    X       Y        Z     |     |  LO  UNL       HYS       |

 1 |   1 |  0.125   0.183   0.122   |  0.000   0.000   0.000    |  2. |  0    0              0.  | LOWER TORSO
 2 |   2 |  0.110   0.165   0.110   |  0.024   0.000   0.066    |  2. |  0    0              0.  | ABDOMEN
 3 |   3 |  0.120   0.158   0.138   |  0.075   0.000   0.124    |  2. |  1    0              0.  | UPPER TORSO
 4 |   3 |  0.050   0.220   0.050   |  0.061   0.000   0.205    |  2. |  0    0              0.  | SHOULDERS
 5 |   4 |  0.043   0.043   0.076   |  0.000   0.000   0.044    |  2. |  0    0              0.  | NECK
 6 |   5 |  0.105   0.073   0.105   |  0.014   0.000   0.050    |  2. |  0    0              0.  | HEAD
 7 |   6 |  0.048   0.044   0.153   |  0.000   0.000  -0.113    |  2. |  0    0              0.  | UPPER ARM LEFT
 8 |   7 |  0.045   0.045   0.230   |  0.000   0.000  -0.188    |  2. |  0    0              0.  | LOWER ARM LEFT
 9 |   8 |  0.048   0.044   0.153   |  0.000   0.000  -0.113    |  2. |  0    0              0.  | UPPER ARM RIGHT
10 |   9 |  0.045   0.045   0.230   |  0.000   0.000  -0.188    |  2. |  0    0              0.  | LOWER ARM RIGHT
11 |  10 |  0.234   0.078   0.080   |  0.208   0.000   0.000    |  2. |  0    0              0.  | UPPER LEG LEFT
12 |  10 |  0.068   0.052   0.068   |  0.420   0.000   0.000    |  2. |  0    0              0.  | KNEE LEFT
13 |  11 |  0.055   0.052   0.248   |  0.005   0.000  -0.210    |  2. |  0    0              0.  | LOWER LEG LEFT
14 |  12 |  0.137   0.040   0.040   |  0.080   0.000  -0.046    |  2. |  0    0              0.  | FOOT LEFT
15 |  13 |  0.234   0.078   0.080   |  0.208   0.000   0.000    |  2. |  0    0              0.  | UPPER LEG RIGHT
16 |  13 |  0.068   0.052   0.068   |  0.420   0.000   0.000    |  2. |  0    0              0.  | KNEE RIGHT
17 |  14 |  0.055   0.052   0.248   |  0.005   0.000  -0.210    |  2. |  0    0              0.  | LOWER LEG RIGHT
18 |  15 |  0.137   0.040   0.040   |  0.080   0.000  -0.046    |  2. |  0    0              0.  | FOOT RIGHT
19 |   5 |  0.020   0.020   0.020   |  0.100   0.000  -0.041    |  2. |  0    0              0.  | CHIN
20 |  12 |  0.030   0.030   0.030   | -0.035   0.000  -0.070    |  2. |  0    0              0.  | HEEL LEFT
21 |  15 |  0.030   0.030   0.030   | -0.035   0.000  -0.070    |  2. |  0    0              0.  | HEEL RIGHT
** FORCE-PENETRATION CHARACTERISTICS ELLIPSOIDS **

FORCE [N] AS FUNCTION OF PENETRATION [M]

        NR  1            |
                         |
   0.000          0.0    |
   0.051       2250.0    |

** INITIAL POSITION [M] AND LINEAR VELOCITY [M/S] OF TREE STRUCTURE ORIGIN IN INERTIAL COORDINATE SYSTEM **

 X =     0.0000      Y =     0.0000      Z =     0.0000
VX =     0.0000     VY =     0.0000     VZ =     0.0000

** INITIAL ORIENTATION OF ELEMENT COORDINATE SYSTEM RELATIVE TO INERTIAL OR PRECEDING ELEMENT COORDINATE SYSTEM **

EL |                                                                                                   |
 1 | INERTIAL |   ROTATIONS    |      2. -0.4538      0.   0.0000      0.   0.0000                   |
 2 | INERTIAL |   ROTATIONS    |      2. -0.4538      0.   0.0000      0.   0.0000                   |
 3 | INERTIAL |   ROTATIONS    |      2. -0.4538      0.   0.0000      0.   0.0000                   |
 4 | INERTIAL |   ROTATIONS    |      2.  0.0230      0.   0.0000      0.   0.0000                   |
 5 | INERTIAL |   ROTATIONS    |      2.  0.0230      0.   0.0000      0.   0.0000                   |
 6 | INERTIAL |   ROTATIONS    |      2. -1.1000      0.   0.0000      0.   0.0000                   |
 7 | INERTIAL |   ROTATIONS    |      2. -1.5708      0.   0.0000      0.   0.0000                   |
 8 | INERTIAL |   ROTATIONS    |      2. -1.1000      0.   0.0000      0.   0.0000                   |
 9 | INERTIAL |   ROTATIONS    |      2. -1.5708      0.   0.0000      0.   0.0000                   |
10 | INERTIAL |   ROTATIONS    |      2. -0.2990      0.   0.0000      0.   0.0000                   |
11 | INERTIAL |   ROTATIONS    |      2. -0.9400      0.   0.0000      0.   0.0000                   |
12 | INERTIAL |   ROTATIONS    |      2. -0.9465      0.   0.0000      0.   0.0000                   |
13 | INERTIAL |   ROTATIONS    |      2. -0.2990      0.   0.0000      0.   0.0000                   |
14 | INERTIAL |   ROTATIONS    |      2. -0.9400      0.   0.0000      0.   0.0000                   |
15 | INERTIAL |   ROTATIONS    |      2. -0.9465      0.   0.0000      0.   0.0000                   |

*******************************************************************************************************************
FORCE INTERACTIONS
*******************************************************************************************************************

** BELT SYSTEM  1 **

BELT| SYS1| EL1 |     CONNECTION 1        | SYS2| EL2 |      CONNECTION 2        |
    |     |     |    X1      Y1      Z1   |     |     |    X2      Y2      Z2    |
  1 |  -1 |   0 | -0.665   0.406  -0.039  |  -1 |   0 | -0.599   0.252   0.620   |

  2 |  -1 |   0 | -0.599   0.252   0.620  |   1 |   3 |  0.175   0.055   0.212   |
  3 |   1 |   3 |  0.135  -0.075  -0.013  |  -1 |   0 | -0.086  -0.229  -0.229   |

BELT| ELASTIC CHARACTERISTIC   | FRIC |  SLACK  | ADD LEN|  COR |
    | LO  UNL    HYS      XEL  |      |         |   [M]  |      |
  1 |  1    3 1170000.  0.000  | 0.00 |  0.000  | -0.167 |  1.0 | RETRACTOR PART
  2 |  2    3 1170000.  0.000  | 0.18 |  0.000  |  0.057 |  1.0 | SHOULDER BELT
  3 |  2    3 1170000.  0.000  | 0.16 |  0.000  |  0.000 |  1.0 | LOWER TORSO

INITIAL BELT LENGTHS =  0.513  0.630  0.473
```

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** RETRACTOR PARAMETERS **

    SPLINE PARAMETER           =   1
    LOCK TIME RETRACTOR        =   0.001
    LOCK VELOCITY RETRACTOR =   0.00

    ** RETRACTOR CHARACTERISTIC **

    FORCE [N] AS FUNCTION OF BELT OUTLET [M] :

            NR  1            |
                             |
       -1.000          0.0 |
        0.000          0.0 |
        0.025       2000.0 |
        0.051       4561.0 |
        0.064       6341.0 |
        0.076       7342.0 |
        0.089       7676.0 |

    ** FORCE-RELATIVE ELONGATION CHARACTERISTICS BELT ELEMENTS **

    FORCE [N] AS FUNCTION OF RELATIVE ELONGATION [M] :

            NR  1            |          NR  2            |          NR  3            |
                             |                           |                           |
       -0.100          0.0 |  -0.100          0.0 |   0.000          0.0 |
        0.000          0.0 |   0.000          0.0 |   0.017          0.0 |
        0.075      11200.0 |   0.020        670.5 |   0.029       2000.0 |
                             |   0.095      11792.5 |   0.042       3500.0 |
                             |                           |   0.054       5000.0 |

    ** BELT SYSTEM  2 **

    BELT| SYS1| EL1 |       CONNECTION 1        | SYS2| EL2 |       CONNECTION 2        |
        |     |     |    X1      Y1      Z1     |     |     |    X2      Y2      Z2     |
      1 |  -1 |   0 | -0.086 -0.229 -0.229 |   1 |   1 |  0.050 -0.140  0.050 |
      2 |   1 |   1 |  0.050  0.170  0.050 |  -1 |   0 | -0.086  0.305 -0.196 |

    BELT| ELASTIC CHARACTERISTIC | FRIC |  SLACK | ADD LEN|  COR |
        | LO  UNL     HYS     XEL |      |        |  [M]   |      |
      1 |  1    2 1170000.  0.000 | 0.00 |  0.000 |  0.101 |  1.3 | INBOARD LAP
      2 |  1    2 1170000.  0.000 | 0.00 |  0.000 |  0.101 |  1.3 | OUTBOARD LAP

    INITIAL BELT LENGTHS =  0.429  0.416

    ** FORCE-RELATIVE ELONGATION CHARACTERISTICS BELT ELEMENTS **

    FORCE [N] AS FUNCTION OF RELATIVE ELONGATION [M] :

            NR  1            |          NR  2            |
                             |                           |
        0.000          0.0 |   0.000          0.0 |

        0.077        605.0 |   0.105          0.0 |
        0.102        970.0 |   0.150        675.0 |
        0.128       1660.0 |   0.230       4500.0 |
        0.154       2465.0 |                           |
        0.179       3805.0 |                           |
        0.192       4695.0 |                           |
        0.200       5563.0 |                           |
        0.250      11125.0 |                           |

    ** ACCELERATION FIELD **

    ALL SYSTEMS :

        |  FUNCTION |
        |  AX AY AZ |
        |   1  0  2 |


    ** TIME-ACCELERATION CHARACTERISTICS **

    ACCELERATION [M/S**2] AS FUNCTION OF TIME [S] :

            NR  1            |          NR  2            |
                             |                           |
        0.000          0.0 |   0.000         -9.8 |
        0.004         44.2 |   0.100         -9.8 |
        0.006         29.4 |                           |
        0.010         78.5 |                           |
        0.013        117.7 |                           |
        0.018        137.3 \                           \
        0.023        166.8 |                           |
        0.031        235.4 |                           |
        0.034        235.4 |                           |
        0.036        255.1 |                           |
        0.040        260.0 |                           |
        0.042        260.0 |                           |
        0.045        269.8 |                           |
        0.047        260.0 |                           |
        0.049        260.0 |                           |
        0.052        255.1 |                           |
        0.054        255.1 |                           |
        0.080        122.6 |                           |
        0.090         49.0 |                           |
        0.095         -9.8 |                           |
        0.097        -24.5 |                           |
        0.103         14.7 |                           |
        0.109        -14.7 |                           |
        0.115         -9.8 |                           |
        0.120         -4.9 |                           |
        0.125         -9.8 |                           |
        0.130         -2.5 |                           |
        0.141        -19.6 |                           |
        0.149         -2.5 |                           |
        0.152        -14.7 |                           |
```

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** PLANE - ELLIPSOID CONTACT MODEL **

NO  | SY  | PL  | SY  | EL  |   ELASTIC  CHARACTERISTIC       |  DAMP   | FRIC |    FIN    | COR|
    |     |     |     |     |  CHO  LO  UNL     HYS      XEL  | [NS/M]  |      |    [M]    |    |
 1  | -1  |  3  |  1  |  1  |   2   0    0       0.   0.000  | 770.00  | 0.62 |   0.050   |  0 | SEATCUSH          - LOWER TORSO
 2  | -1  |  4  |  1  |  3  |   2   0    0       0.   0.000  |   0.00  | 0.62 |   0.050   |  0 | SEATBACK          - UPPER TORSO
 3  | -1  |  4  |  1  |  1  |   2   0    0       0.   0.000  |   0.00  | 0.62 |   0.050   |  0 | SEATBACK          - LOWER TORSO
 4  | -1  |  1  |  1  | 14  |   2   0    0       0.   0.000  |   0.00  | 1.00 |   0.050   |  0 | FOOT PLANE        - FOOT LEFT
 5  | -1  |  2  |  1  | 14  |   2   0    0       0.   0.000  |   0.00  | 1.00 |   0.050   |  0 | FLOOR PLANE       - FOOT LEFT

 6  | -1  |  1  |  1  | 18  |   2   0    0       0.   0.000  |   0.00  | 1.00 |   0.050   |  0 | FOOT PLANE        - FOOT RIGHT
 7  | -1  |  2  |  1  | 18  |   2   0    0       0.   0.000  |   0.00  | 1.00 |   0.050   |  0 | FLOOR PLANE       - FOOT RIGHT
 8  | -1  |  1  |  1  | 20  |   2   0    0       0.   0.000  |   0.00  | 1.00 |   0.050   |  0 | FOOT PLANE        - HEEL LEFT
 9  | -1  |  1  |  1  | 21  |   2   0    0       0.   0.000  |   0.00  | 1.00 |   0.050   |  0 | FOOT PLANE        - HEEL RIGHT
** ELLIPSOID - ELLIPSOID CONTACT MODEL **

NO  | SY  | EL1| SY  | EL2|   ELASTIC  CHARACTERISTIC       |  DAMP   | FRIC | COR|
    |     |    |     |    |  CHO  LO  UNL     HYS      XEL  | [NS/M]  |      |    |
 1  |  1  | 19 |  1  |  3 |   2   0    0       0.   0.000  |   0.00  | 0.50 |  0 | CHIN              - UPPER TORSO

*****************************************************************************************************************
OUTPUT CONTROL PARAMETERS
*****************************************************************************************************************

OUTPUT DEBUG FILE IS NOT STORED
KINEMATIC OUTPUT IS STORED EACH  0.0100 SEC

** COORDINATES OF POINTS FOR WHICH LINEAR ACCELERATIONS WILL BE CALCULATED **

SYS |  EL |    COORDINATES [M]     | CORR. FUNCTIONS | RELATIVE | IDENTIFIER
    |     |     X      Y      Z    |   X    Y    Z   |    TO    |
  1 |   1 | -0.044  0.000  0.005 |   1    0    1   |   LOCAL  | LOWER TORSO
  1 |   3 |  0.039  0.000  0.122 |   1    0    1   |   LOCAL  | UPPER TORSO
  1 |   5 |  0.014  0.000  0.050 |   1    0    1   |   LOCAL  | HEAD

** DATA FOR FORCE MODEL OUTPUT **

FOR  |  NR |         IDENTIFIER
     |     |
BELT |   1 | RETRACTOR PART
BELT |   2 | SHOULDER BELT
BELT |   5 | OUTBOARD LAP

*****************************************************************************************************************
CALCULATED INITIAL PENETRATIONS
*****************************************************************************************************************

** PLANE - ELLIPSOID CONTACT MODEL **

NO | INITIAL PEN. [M] |
 1 |        0.0000     | SEATCUSH         - LOWER TORSO
 2 |        0.0000     | SEATBACK         - UPPER TORSO
 3 |        0.0000     | SEATBACK         - LOWER TORSO
 4 |        0.0006     | FOOT PLANE       - FOOT LEFT
 5 |        0.0000     | FLOOR PLANE      - FOOT LEFT
 6 |        0.0006     | FOOT PLANE       - FOOT RIGHT

 7 |        0.0000     | FLOOR PLANE      - FOOT RIGHT
 8 |        0.0000     | FOOT PLANE       - HEEL LEFT
 9 |        0.0000     | FOOT PLANE       - HEEL RIGHT
** ELLIPSOID - ELLIPSOID CONTACT MODEL **

NO | INITIAL PEN. [M] |
 1 |        0.0000     | CHIN             - UPPER TORSO
```