# INFORMATION SOCIETIES TECHNOLOGY (IST) PROGRAMME


**Project Number**

IST-1999-10954

**Project Title:**

Virtual Animation of the Kinematics of the Human for Industrial, Educational and Research Purposes

**Title of deliverable**

Internal Document to Support Writing and Reading of PGD files

## PART I

**Project Number:** 10954

**Project Title** : Virtual Animation of the Kinematics of the Human for Industrial, Educational and Research Purposes

**Deliverable Type:** RP

**Deliverable Number:**

**Contractual date of delivery to the Commission:** M5

**Actual date of delivery to the Commission:** M11

**Second Revision:** M26

**Title of deliverable:**

**Work package contributing to the deliverable:** WP3

**Nature of the deliverable:** REPORT

**Authors:**

*Aurelio CAPPOZZO, Ugo DELLA CROCE, Valentina CAMOMILLA, Alberto LEARDINI*

**CONTENTS**

# GENERAL STRUCTURE

## File Header and Sections

A DST file consists of a File Header, which contains information concerning the DST lexicon and other general parameters, and a set of sections which are of the following type:

| | |
|---|---|
| Text sections | Contain general information concerning the patient, the experiment, and the experimental set up |
| Numeric sections | Contain numeric data |

Each section consists of

- Section header with the following general structure:

  #ABC{item1}{item2}{item3}-d1-d2,n1,n2,n3

  where:

  | | |
  |---|---|
  | # | section type identifier - one character |
  | ABC | section name - three characters |
  | {item1} | first specifier - two to five characters (when relevant) |
  | {item2} | second specifier - two to five characters (when relevant) |
  | {item3} | third specifier - two characters (when relevant) |
  | d1 | data vector dimensions (in numeric sections only and when greater than one) |
  | d2 | number of data vectors per line (in numeric sections only and when greater than one) |
  | n1 | number of data lines (in numeric sections and for time variant data only) |
  | n2 | sampling interval (in numeric sections and for time variant data only) |
  | n3 | time origin offset - see below for details (in numeric sections and for time variant data only) |

- Lines containing data

## Identifiers and Delimiters

File Header and Section identifiers:

| | |
|---|---|
| #! | File Header |
| $ | Text Section |
| ! | Numeric Section |

Parameter and data type identifiers:

| | |
|---|---|
| [] | optional item/s |
| {} | text section parameter/data which can only assume one of the values in a list |
| () | text section parameter/data which can assume any value |
| - | in a numeric section precedes vector dimensions |
| no identifier | is required for numeric section parameter/data |

Parameter and data delimiters:

| | |
|---|---|
| , | is the delimiter of parameters in the file header and in the section headers |
| ; | is the delimiter of data in text sections; this is mandatory also when delimiting a non-reported optional data |
| TAB or SPACE | delimits data in numeric sections. |

## NOTES

- Avoid using SPACE or TAB when not required as a delimiter
- Lower-case or capital letters are equivalent
- Line length in the file must not exceed 80 characters

## HEADER

**#!DST....MAD**

Mandatory

This section has the following format:

| |
|---|
| #!DST-dst_ver_#,MAD-mad_ver_#,day,month,year,{creator_code},[(creator)] |

where:

| | |
|---|---|
| dst_ver_# | identifies a DST version |
| mad_ver_# | identifies a MAD version |
| day | indicates day of original creation date of file |
| month | indicates month of original creation date of file |
| year | indicates year of original creation date of file |
| {creator_code} | indicates the creator code (see Table 1 in the Appendix for permissible codes) |
| (creator) | indicates the creator name. |

Example:

#!DST-1.1,MAD-1.1,1,3,97,UR, Istituti Ortopedici Rizzoli - Bologna

## COMMENT

**$COM**ment

Optional

This text section contains any comment the creator may consider useful to the remote user for a better appreciation of the data.

In addition it may contain information concerning variables the actual value of which is not reported in a standardised selection list and indicated in this list as "other".

The format of this section is:

| |
|---|
| $COM<br>(comment) |

where:

| | |
|---|---|
| (comment) | is an alphanumeric string of any length. |

## TRIAL AND PATIENT CHARACTERISTICS

*Task parameters: These relate to the type of the motor task involved and the subjectively assessed speed of the motor task. When step or seat is used tread and rise can be stored.*

*Subject parameters: These provide an identification for the subject and his/her pathology in addition to basic anthropometric measures and age and sex.*

**$ MO**tor **T**ask

Mandatory

This text section describes the type of exercise performed by the subject.

The format of this section is:

| |
|---|
| $MOT{motortask}<br>{speed},{footwear}[,rise, tread] |

where:

| | |
|---|---|
| {motortask} | is an alphanumeric variable which identifies the exercise and can assume one of the values in Table 2. |
| {speed} | identifies the subjective assessment of the speed with which the motor task is performed and can assume one of the values listed in Table 3. |
| {footwear} | identifies weather shod or barefoot and the type of footwear and can assume one of the values given in Table 4 (if not in this list see $COM) . |
| rise | the height of each step or seat, when relevant |
| tread | the depth of each step or seat, when relevant. |

(see below for units of measurement)

Example:

```
$MOTLW
nr,bf
```

**$PAT**ient

Mandatory

The format of this section is:

| |
|---|
| $PAT<br>(ref_code),{pathology},age,{sex},stature,body_mass,{aid} |

where:

| | |
|---|---|
| (ref_code) | is an alphanumeric string uniquely identifying the patient within the institution of the creator of the file (no commas permitted) |
| {pathology} | identifies a patient pathology (see Table 5 for standard selection list) |
| age | is the patient's age (in years) at the date of the experiment |
| {sex} | is the patient's gender (see selection list in Table 6) |

| | |
|---|---|
| stature | is the patient's stature |
| body_mass | is the patient's body mass |
| {aid} | indicates the use of a motor task aid and can assume one of the values in Table 7. |

If the patient wears a prosthesis or an orthosis, then relevant details must be included in the section $COM.

(see below for units of measurement)

Example:

```
$PAT
354-232-RX4-W,cp,12,m,1540,41,no
```

## MEASUREMENT UNITS

*In these sections the unit of measurement used to report data, and different from SI units, are specified. However, the use, whenever applicable, of SI units (default) is strongly recommended.*

**$TI**me**U**nit

Mandatory (default value possible)

This text section indicates the unit of measurement used for time.

The format of this section is:

```
$TIU
{unit}
```

where:

| | |
|---|---|
| {unit} | is the time unit of measurement (see Table 8) |

Default: if this section is not included in the file, the time unit is assumed to be given in the SI system (seconds).

Example:

```
$TIU
ms
```

**$KI**nematic**U**nit

Mandatory (default value possible)

This text section indicates the unit of measurement used for linear kinematic and geometric data.

The format is:

```
$KIU{kquantity}
```

| |
|---|
| {kunit} |

where:

{kquantity} indicates the quantity and can assume one of the values in Table 9

{kunit} is the measurement unit among those indicated in the relevant list:

if {kquantity} = L then see Table 10

if {kquantity} = A then see Table 11

Default: If this section is not included in the file, these units are assumed to be given in the SI system (meter and radian).

Example:

```
$KIUL
mm
$KIUA
deg
```

(The linear and angular units used in the examples showed below are millimeters and degrees respectively)

**$DY**namic**U**nits

Mandatory (if ground reaction data are provided - default values possible)

This section indicates the unit of measurement used for forces and moments of force.

The format is:

| |
|---|
| $DYU{dquantity}<br>{dunit} |

where:

{dquantity} indicates the quantity and can assume one of the values in Table 12.

{dunit} is the measurement unit among those indicated in this relevant list:

if {dquantity} = F then see Table 13

if {dquantity} = M then see Table 14

Default: if this section is not included in the file, dynamic units are assumed to be given in the SI system (N, Nm respectively).

Example:

```
$DYUF
kN
$DYUM
```

kN.m

(In the examples given below the default units are used)

**$IN**ertia**U**nits

Mandatory (if ground reaction data are provided - default values possible)

This text section indicates the unit of measurement used for masses and moments of inertia.

The format is:

| $INU{iquantity}<br>{iunit} |
|---|

where:

{iquantity} indicates the mass or the moment of inertia and can assume one of the values listed in Table 15.

{iunit} is the measurement unit among those indicated in the relevant list:

if {quantity} = M then see Table 16

if {quantity} = I then see Table 17

Default: if these variables are not included in the file, these units are assumed to be given in the SI system (kg, kg $m^2$ respectively).

Example:

$INUM

g

$INUI

gcm^2

(In the examples given below the default units are used)

**$EM**g**U**nits

Mandatory if EMG data is provided

This text section indicates the unit of measurement used for EMG data processed using the indicated method.

The format is:

| $EMU{processing}<br>{emgunit} |
|---|

where:

{processing} denotes the data processing method used and can assume one of the values listed in the Appendix (Table 18).

{emgunit} is the relevant measurement unit and can assume one of the values indicated in the Appendix (Table 19).

Example:

```
$EMUR
mV
```

## MEASUREMENT ERROR PARAMETERS

**!OP**tometric**E**rrors

*These parameters result from an experiment which must be carried out at the beginning of each experimental session. This is a test aimed at the assessment of the accuracy and precision which affect the reconstruction of the 3-D position of a target point with respect to the motor task frame. Details concerning this experiment, which is alluded to as M.A.L. test (Motion Analysis Laboratory test), and the calculation of relevant parameters are provided in Della Croce et al. (2000).*

Optional

This numeric section contains the bias error and the normalized standard error high and low frequency components of the stereometric set-up.

The format is:

| |
|---|
| !OPE-w-v<br>$b_x$ $b_y$ $b_z$ $sl_x$ $sl_y$ $sl_z$ $sh_x$ $sh_y$ $sh_z$ |

where:

| | |
|---|---|
| w | is the number of components of each vector |
| v | is the number of vectors |
| $b_x$ $b_y$ $b_z$ | are the bias errors for each motor task axis frame coordinate (TAB or SPACE delimited). |
| $sl_x$ $sl_y$ $sl_z$ | are the normalized low frequency standard errors for each coordinate (TAB or SPACE delimited). |
| $sh_x$ $sh_y$ $sh_z$ | are the normalized high frequency standard errors for each coordinate (TAB or SPACE delimited). |

Example:

```
!OPE-3-3
3     10    8     1.3   0.4   0.1   0.2   0.5   0.8
```

**!F**orce**P**late**E**rrors

*These parameters result from an experiment which must be carried out periodically. This is a test aimed at the assessment of the accuracy which affects the ground reaction force application point coordinates. Selected points, having known*

*coordinates on the top plate, are loaded using a pin point bar with a force in the order of 300 N. The root mean square of the errors reported in each point is thereafter calculated for each coordinate.*

Optional

This numeric section contains the root mean square error affecting the force application point coordinates.

The format is:

| |
|---|
| !FPE-w-v |
| $s_X$ $s_Y$ $s_Z$ |

where:

| | |
|---|---|
| w | is the number of components of each vector |
| v | is the number of vectors |
| $s_X$ $s_Y$ $s_Z$ | are the root mean square errors of the ground reaction force application point coordinates (TAB or SPACE delimited). |

Example:

```
!FPE-3-1
1.3     0.4     0.1
```

## GLOBAL SYSTEMS OF AXES

***Laboratory axes:*** *this is the frame with respect to which all positional data are given; it is arbitrarily chosen. No information needed.*

***Motor task axes:*** *this is a frame which provides an overall description of the motor task assigned to the subject. In locomotion tests, for instance, it may indicate the direction of progression and position and orientation of the floor with respect to the laboratory axes.*

*Normally*

- *X coincides with the motor task direction assigned to the subject and points anteriorly,*
- *Y is orthogonal to the floor and points up-wards,*
- *Z goes from left to right,*
- *O the origin must lie on the floor and on the midsagittal plane assigned to the subject.*

*Information on these axes needs to be provided.*

***Plumb line:*** *this is the gravity line and points upwards. If the Y axis of the motor task frame is not vertical, then relevant information is mandatory.*

***Force plate (or other dynamometer) axes:*** *this is the frame embedded in the force plate and with respect to which the relevant calibration matrix is provided. Relevant information is mandatory when reaction loads are reported. During locomotion, the positional relationship of these axes with respect to the motor task axes provides information on what foot hits what force plate.*

**!M**otor-**T**ask **A**xes

Optional

This numeric section contains orientation and position of the motor task-related axes with respect to the laboratory frame.

The format is:

| |
|---|
| !MTA-w-v<br>$\theta_x$ $\theta_y$ $\theta_z$ $p_x$ $p_y$ $p_z$ |

where:

| | |
|---|---|
| w | is the number of components of each of the vectors $\underline{\theta}$ and $\underline{p}$ |
| v | is the number of vectors |
| $\theta_x$ $\theta_y$ $\theta_z$ | are the components in the laboratory frame of the orientation vector of the motor task frame (TAB or SPACE delimited) |
| $p_x$ $p_y$ $p_z$ | are the components in laboratory frame of the position vector of the motor task frame origin (TAB or SPACE delimited). |

Example:

```
!MTA-3-2
15.1  2.9  39.91       20.0  10.3  400.4
```

**!PL**umb**L**ine

Mandatory (default value possible)

This is a section containing the three direction cosines of the plumb line in the laboratory frame.

The format is:

| |
|---|
| !PLL-w<br>$c_x$ $c_y$ $c_z$ |

where:

| | |
|---|---|
| w | is the number of direction cosines |
| $c_x$ $c_y$ $c_z$ | are the direction cosines in laboratory frame of the plumb line (TAB or SPACE delimited). |

Default values are: 0 1 0 (plumb line coincides with the Y axis of the laboratory frame)

Example:

```
!PLL-3
0.5  0.86  0
```

**!F**orce**P**late**A**xes

Mandatory if reaction force data are provided.

This numeric section contains the orientation and position vectors of the $m^{th}$ force plate axes with respect to the laboratory frame.

The format is:

| |
|---|
| !FPA{m}-w-v<br>$\theta_X$ $\theta_Y$ $\theta_Z$ $p_X$ $p_Y$ $p_Z$ |

where:

| | |
|---|---|
| {m} | indicates the $m^{th}$ force plate using the correspondent cardinal number |
| w | is the number of components of each of vectors $\underline{\theta}$ and $\underline{p}$ |
| v | is the number of vectors |
| $\theta_X$ $\theta_Y$ $\theta_Z$ | are the components in laboratory frame of the orientation vector of the frame embedded in the $m^{th}$ force plate (TAB or SPACE delimited) |
| $p_X$ $p_Y$ $p_Z$ | are the components in laboratory frame of the position vector of the frame embedded in the $m^{th}$ force plate (TAB or SPACE delimited). |

Example:

```
!FPA1-3-2
60  30  0      293.0  1264.3  1523.4
```

## ANTHROPOMETRIC AND INERTIA PARAMETERS

*These sections contain the inertia parameters of the relevant body segments.*

**!LE**ngthof**S**egment

Optional

This numeric section contains length of the anatomical segment of interest.

The format is:

| |
|---|
| !LES{side}{segment}<br>length |

where:

| | |
|---|---|
| {side} | indicates the body side and can assume one of the values listed in |

Table 20.

{segment} indicates the body segment and can assume one of the values listed in Table 21.

length is the length of the anatomical segment of interest.

Example:

!LESRTH

201.2

**!MAS**s

Optional

This numeric section contains the mass of the specified body segment.

The format of this variable is:

| |
|---|
| !MAS{side}{segment} |
| mass |

where:

{side} indicates the body side and can assume one of the values listed in Table 21.

{segment} indicates the body segment and can assume one of the values listed in Table 22.

mass indicates the body segment mass.

Example:

!MASLSH

2.2

**!C**entreof**MA**ss

Optional

This numeric section contains the three coordinates of the position vector of centre of mass with respect to the segment anatomical frame.

The format is:

| |
|---|
| !CMA{side}{segment}-w |
| $c_x$ $c_y$ $c_z$ |

where:

{side} indicates the body side and can assume one of the values listed in Table 21.

{segment} indicates the body segment and can assume one of the values listed in Table 22.

w is the number of components of this vector

$c_x$ $c_y$ $c_z$ are the three coordinates of the position vector of centre of mass with respect to the segment anatomical frame.

Example:

```
!CMARTH-3
201.2  102.2  64.9
```

**!M**omentsof**IN**ertia

Optional

This numeric section contains three moments of inertia with respect to the segment principal axes of inertia and the orientation vector ($\underline{\theta}$) of the principal axes of inertia with respect to the segment anatomical frame.

The format is:

| |
|---|
| !MIN{side}{segment}-w-v<br>$mi_1$ $mi_2$ $mi_3$ $\theta_x$ $\theta_y$ $\theta_z$ |

where:

{side} indicates the body side and can assume one of the values listed in Table 21.

{segment} indicates the body segment and can assume one of the values listed in Table 22.

w is the number of components of each of vectors

v is the number of vectors

$mi_1$ $mi_2$ $mi_3$ are the three moments of inertia with respect to the segment principal axes of inertia (TAB or SPACE delimited)

$\theta_x$ $\theta_y$ $\theta_z$ are the components of the orientation vector $\underline{\theta}$ of the principal axes of inertia with respect to the segment anatomical frame (TAB or SPACE delimited).

Example:

```
!MINLSH-3-2
0.030      0.010      0.030      1.1      0.1      10.4
```

# SUBJECT CALIBRATIONS

*These sections report the results of the anatomical landmark calibration and upright standing recording. The former calibration parameters may be obtained in a number of ways which are specific of the experimental protocol used.*

## ANATOMICAL LANDMARK CALIBRATION

**!CAL**ibration

Mandatory

This numeric section contains the coordinates of the specified anatomical landmark of a segment in the relevant technical frame. The list of the landmarks is showed below. This data is time invariant.

The format is:

| |
|---|
| !CAL{side}{anat_lndmk}-w<br>$a_X$ $a_Y$ $a_Z$ |

where:

{side} indicates the body side and can assume one of the values listed in Table 20.

{anat_lndmk} indicates the calibrated landmark. This parameter can assume one of the values listed in Table 24.

w is the number of coordinates for each landmark

$a_X$ $a_Y$ $a_Z$ are the coordinates (TAB or SPACE delimited) in the specified kinematic units.

Example:

```
!CALRAS-3
123.3    12.5    142.2
```

## REFERENCE POSTURE PARAMETERS

**!PO**sture **P**arameters

Mandatory

This numeric section contains the orientation vector $\underline{\theta}$ and position vector $\underline{p}$ of the origin of the segmental technical frame indicated, during the specified posture. This data is time invariant.

The format is:

| |
|---|
| !POP{posture}{side}{segment}-w-v<br>$\theta_X$ $\theta_Y$ $\theta_Z$ $p_X$ $p_Y$ $p_Z$ |

where:

{posture} indicates the specified posture and can assume one of the values listed in Table 2

0.

{side} indicates the body side and can assume one of the values listed in Table 21.

{segment} indicates the body segment and can assume one of the values listed in Table 22.

w is the number of components of each of vectors

v is the number of vectors

$\theta_X$ $\theta_Y$ $\theta_Z$ are the mean components in the laboratory frame of the orientation vector of the segmental technical frame (TAB or SPACE delimited).

$p_X$ $p_Y$ $p_Z$ are the mean components in the laboratory frame of the position vector of the segmental technical frame origin (TAB or SPACE delimited).

Example:

```
!POPURPMPE-6-2
15.1  2.9  39.9        1293.0  1264.3  1523.48
```

## TEMPORAL DISTANCE FACTORS

*Note: an arbitrary experiment time origin must be defined with respect to which temporal parameters and the time offsets of the individual time variables are given.*

**!TE**mporal **F**actors

Mandatory.

This numeric section contains the temporal factors values within the time interval of observation.

The format is:

| |
|---|
| !TEF{event}{side}-w<br>$ict_1$ $ict_2$ .. $ict_w$ |

where:

{event} indicates the temporal factor and can assume one of the values listed in Table 23.

{side} indicates the body side and can assume one of the values listed in Table 21.

w is the number of given values

$ict_i$ indicates the $i^{th}$ initial time value.

Example:

```
!TEFICTL-2
0.1     1.5
```

**!ST**ride**L**ength

Optional

This numeric section contains the stride length defined as the distance between the initial contact position of the indicated (side) foot and the successive initial contact position of the same foot.

The format is:

```
!STL{side}
sl
```

where:

| | |
|---|---|
| {side} | indicates the body side and can assume one of the values listed in Table 21. |
| sl | indicates the stride length. |

Example:

```
!STLR
1.4
```

**!S**te**PL**ength

Optional

This numeric section contains the step length defined as the distance between the initial contact position of the ipsilateral foot and the successive initial contact position of the indicated (side) foot.

The format of this variable is:

```
!SPL{side}
spl
```

where:

| | |
|---|---|
| {side} | indicates the body side and can assume one of the values listed in Table 21. |
| spl | indicates the step length |

Example:

```
!SPLR
0.6
```

## TIME VARIANT DATA

*Note: an arbitrary experiment time origin must be defined with respect to which*

*temporal parameters and the time offsets of the individual time variables are given.*

## KINEMATICS

**!D**egrees**O**f**F**reedom

This numeric section contains the six degrees of freedom (orientation vector $\underline{\theta}$ and position vector $\underline{p}$) of the segmental technical frame with respect to the laboratory frame, during the motor task (Cappozzo et al. 1995).

The format is:

| | | | | | |
|---|---|---|---|---|---|
| !DOF{side}{segment}-w-v,n,si,tos | | | | | |
| $\theta_{x1}$ | $\theta_{y1}$ | $\theta_{z1}$ | $p_{x1}$ | $p_{y1}$ | $p_{z1}$ |
| .. | .. | .. | .. | .. | .. |
| $\theta_{xi-1}$ | $\theta_{yi-1}$ | $\theta_{zi-1}$ | $p_{xi-1}$ | $p_{yi-1}$ | $p_{zi-1}$ |
| $\theta_{xi}$ | $\theta_{yi}$ | $\theta_{zi}$ | $p_{xi}$ | $p_{yi}$ | $p_{zi}$ |
| $\theta_{xi+1}$ | $\theta_{yi+1}$ | $\theta_{zi+1}$ | $p_{xi+1}$ | $p_{yi+1}$ | $p_{zi+1}$ |
| .. | .. | .. | .. | .. | .. |
| $\theta_{xn}$ | $\theta_{yn}$ | $\theta_{zn}$ | $p_{xn}$ | $p_{yn}$ | $p_{zn}$ |

where:

| | |
|---|---|
| {side} | indicates the body side and can assume one of the values listed in Table 21. |
| {segment} | indicates the body segment and can assume one of the values listed in Table 22. |
| w | is the number of components of each vector quantity |
| v | is the number of vectors |
| n | is the number of samples |
| si | is the sample interval |
| tos | is the time offset between the experiment time origin and the start of DOF data. |
| $\theta_{xi}$ $\theta_{yi}$ $\theta_{zi}$ | are the instantaneous components in the laboratory frame of the orientation vector of the segmental technical frame (TAB or SPACE delimited). |
| $p_{xi}$ $p_{yi}$ $p_{zi}$ | are the instantaneous components in the laboratory frame of the position vector of the segmental technical frame origin (TAB or SPACE delimited). |

Example:

```
!DOFMPE-3-2,250,0.01,0.5
15.1  2.9  39.9        1293.0  1264.3  1523.4
15.2  2.8  39.8        1293.2  1264.5  1523.4
15.3  2.7  39.7        1293.4  1264.5  1523.4
.................
.................
15.4  2.6  39.4        1986.0  1769.3  1125.8
```

# DYNAMICS

**!GR**ound**R**eaction

This numeric section contains the ground reaction force data for force plate m. This variable comprises 3 components of force, and 3 components of moment relative to the force plate embedded system of axes (see above).

The format is:

| | | | | | |
|---|---|---|---|---|---|
| !GRR{side}{m}-w-v,n,si,tos | | | | | |
| $Fx_1$ | $Fy_1$ | $Fz_1$ | $Mx_1$ | $My_1$ | $Mz_1$ |
| ... | ... | ... | ... | ... | ... |
| $Fx_{i-1}$ | $Fy_{i-1}$ | $Fz_{i-1}$ | $Mx_{i-1}$ | $My_{i-1}$ | $Mz_{i-1}$ |
| $Fx_i$ | $Fy_i$ | $Fz_i$ | $Mx_i$ | $My_i$ | $Mz_i$ |
| $Fx_{i+1}$ | $Fy_{i+1}$ | $Fz_{i+1}$ | $Mx_{i+1}$ | $My_{i+1}$ | $Mz_{i+1}$ |
| ... | ... | ... | ... | ... | ... |
| $Fx_n$ | $Fy_n$ | $Fz_n$ | $Mx_n$ | $My_n$ | $Mz_n$ |

where:

| | |
|---|---|
| {side} | indicates the body side and can assume one of the values listed in Table 21. |
| {m} | indicates the $m^{th}$ force plate using the correspondent cardinal number |
| w | is the number of components |
| v | is the number of vectors |
| n | is the number of samples |
| si | is the sample interval |
| tos | is the time offset between the experiment time origin and the start |

of ground reaction data

$F_{x_i}$ $F_{y_i}$ $F_{z_i}$ are the instantaneous components of the force vector in the frame embedded in the m-th force plate (TAB or SPACE delimited)

$M_{x_i}$ $M_{y_i}$ $M_{z_i}$ are the instantaneous components of the moment vector in the frame embedded in the m-th force plate (TAB or SPACE delimited).

Example:

```
!GRR1-3-2,800,0.01,0.02
112    50    880    42    173    23
113    51    881    41    171    21
..     ..    ..     ..    ..     ..
..     ..    ..     ..    ..     ..
112    50    880    42    173    23
```

## EMG

**!EMG**

This numeric section contains EMG data of the specified muscle processed using the method identified by the parameter {processing}.

The format is:

!EMG{processing}{muscle},n,si,tos
$emg_1$
...
$emg_{i-1}$
$emg_i$
$emg_{i+1}$
...
$emg_n$

where:

{processing} denotes the data processing method used and can assume one of the values listed in Table 18.

{muscle} indicates the muscle (see selection list in Table 25)

n is the number of samples

si is the sample interval

| | |
|---|---|
| tos | is the time offset between the arbitrary time origin and the start of the EMG data |
| $emg_i$ | are the instantaneous values of the relevant EMG data (TAB or SPACE delimited). |

Example:

```
!EMGIRF,800,0.01,0.02
67
80
..
15
```

**REFERENCES**

Benedetti M.G., Cappozzo A., Catani F., and Leardini A. (1994), Anatomical Landmark Definition and Identification. CAMARC II Internal Report; March 15, 1994

Cappozzo A., Della Croce U. (1994), The PGD Lexicon. CAMARC II internal Report, May 27, 1994.

Cappozzo, A., Catani, F., Della Croce, U. and Leardini, A. (1995) Position and orientation of bones during movement: anatomical frame definition and determination. *Clin. Biomech.* **10**, 171-178.

Della Croce U. Cappozzo A. (2000) A spot check for estimating stereophotogrammetric errors. Medical & Biological Engineering & Computing 38, 260-266

Paul, J.P. and Morris, J.R.W. (1992), CAMARC II - Data exchange. What? Why? How?, In: Proceedings of the Workshop "CAMARC II: Problems and Perspectives", Rome February 29- March 1, 1992. Deliverable N.2.

Spoor, C.W. and Veldpaus F.E. (1980), Rigid body motion calculated from spatial co-ordinates of markers, J. Biomechanics, 13: 391-393.

## APPENDIX

### Code lists

Table 1 - {creator_code}

| | |
|---|---|
| *Istituti Ortopedici Rizzoli - Bologna* | IOR |
| *University of Brussels, Department of Anatomy* | ULB |
| *Università degli Studi di Sassari, Scienze Biomediche* | UNISS |
| *Istituto Universitario di Scienze Motorie, Roma* | IUSM |

Table 2 - {motortask}

| | |
|---|---|
| *sit to stand:* | DU |
| *stand to sit:* | UD |
| *gait initiation:* | GI |
| *level walking:* | LW |
| *walking upstairs:* | US |
| *walking down stairs:* | DS |
| *up-right posture:* | UR |
| *chair rising and sitting:* | RS |
| *step up & down:* | ST |
| *walk – stop - walk:* | WW |
| *cycling:* | CY |
| *squatting:* | SQ |
| *high jumping:* | ST |

Table 3 - {speed}

| | |
|---|---|
| *very slow:* | VS |
| *slow:* | SL |
| *normal:* | NR |
| *fast:* | FA |
| *very fast:* | VF |

Table 4 - {footwear}

| | |
|---|---|
| *barefoot:* | BF |
| *training shoes:* | TS |
| *low heel:* | LH |
| *high heel:* | HH |
| *other:* | OT |

Table 5 - {pathology}

| | |
|---|---|
| *able body* | AB |

Table 6 - {gender}

| | |
|---|---|
| *male:* | M |
| *female:* | F |

Table 7 - {aid}

| | |
|---|---|
| *none:* | NO |
| *crutches:* | CR |
| *right walking stick:* | RS |
| *left walking stick:* | LS |
| *walking frame:* | WF |
| *prosthesis:* | PR |

| | |
|---|---|
| *orthosis:* | OR |
| *other:* | OT |

Table 8 - {tunit}

| | |
|---|---|
| *milliseconds:* | ms |
| *seconds:* | s |

Table 9 - {kquantity}

| | |
|---|---|
| *length:* | L |
| *angle:* | A |

Table 10 - {kunit}

| | |
|---|---|
| *meter:* | m |
| *centimeter:* | cm |
| *millimeter:* | mm |

Table 11 - {kunit}

| | |
|---|---|
| *degree:* | deg |
| *radian:* | rad |

Table 12 - {dquantity}

| | |
|---|---|
| *force:* | F |
| *moment of force:* | M |

Table 13 - {dunit}

| | |
|---|---|
| *newton:* | N |
| *kilonewton:* | kN |

Table 14 - {dunit}

| | |
|---|---|
| *newtonmeter:* | N.m |
| *kilonewtonmeter:* | kN.m |

Table 15 - {iquantity}

| | |
|---|---|
| *mass:* | M |
| *mass moment of inertia:* | I |

Table 16 - {iunit}

| | |
|---|---|
| *kilogram:* | kg |
| *gram:* | g |

Table 17 - {iunit}

| | |
|---|---|
| *kilogram square meter:* | kg.m^2 |
| *gram square centimeter* | g.cm^2 |

Table 18 - {processing}

| | |
|---|---|
| *raw:* | R |
| *rectification:* | P |
| *linear envelope:* | E |
| *integration:* | I |
| *differentiation:* | D |
| *root mean square:* | M |
| *on/off:* | B |

Table 19 - {emgunit}

| | |
|---|---|
| *millivolt:* | mV |
| *% maximal voluntary contraction:* | % |
| *adimensional:* | A |

Table 20 - {posture}

| | |
|---|---|
| *Up Right Posture:* | URP |
| *Sitting Posture:* | SP |

Table 21 - {side}

| | |
|---|---|
| *left:* | L |
| *irrelevant (meaning that laterality, right or left, is irrelevant):* | I |
| *right:* | R |

Table 22 - {segment}

| | |
|---|---|
| *pelvis:* | PE |
| *thigh:* | TH |
| *shank:* | SH |
| *foot:* | FO |

Table 23 - {event}

| | |
|---|---|
| *initial contact time* | ICT |
| *last contact time* | LCT |
| *seat off time* | SOT |
| *reach time* | RT |

Table 24 - {anatomical landmarks}

| | |
|---|---|
| **Pelvis** | |
| *sacral crest:* | *S2* |
| *pubic spine:* | *PP* |
| *pubic symphysis:* | *PY* |
| *ischial tuberosity:* | *IT* |
| *tubercule of iliac crest:* | *IC* |
| *anterior superior iliac spine:* | *AS* |
| *posterior superior iliac spine:* | *PS* |
| *posterior inferior iliac spine:* | *PI* |
| *centre of the ipsilateral acetabulum:* | *AC* |
| **Femur** | |
| *centre of the femoral head:* | *FH* |
| *greater trochanter external surface:* | *GT* |
| *medial epicondyle:* | *ME* |
| *lateral epicondyle:* | *LE* |
| *antero-lateral apex of the patellar surface ridge:* | *LP* |
| *antero-medial apex of the patellar surface ridge:* | *MP* |
| *adductor tubercle:* | *AT* |
| *most distal point of the lateral condyle:* | *LC* |
| *most distal point of the medial condyle:* | *MC* |
| **Tibia/Fibula** | |
| *prominence of the tibial tuberosity:* | *TT* |
| *apex of head of the fibula:* | *HF* |

| | |
|---|---|
| *most medial ridge of the medial tibial plateau:* | *MR* |
| *most lateral ridge of the medial lateral plateau:* | *LR* |
| *Gerdy's tubercle:* | *YT* |
| *distal apex of the medial malleolus:* | *MM* |
| *distal apex of the lateral malleolus:* | *LM* |
| **Foot** | |
| *upper ridge of the calcaneus posterior surface:* | *CA* |
| *sustentaculum tali:* | *ST* |
| *tuberosity of navicular bone:* | *TN* |
| *dorsal aspect of first metatarsal head:* | *FM* |
| *dorsal aspect of second metatarsal head:* | *SM* |
| *dorsal aspect of fifth metatarsal head:* | *VM* |
| *tuberosity of fifth metatarsal bone:* | *VT* |
| *peroneal trochlea* | *PT* |

Table 25 - {muscles}

| | |
|---|---|
| *psoas maior:* | PM |
| *iliacus:* | IC |
| *gemellus superior:* | GMS |
| *gemellus inferior:* | GMI |
| *obturator externus:* | OBE |
| *obturator internus:* | OBI |
| *piriformis:* | PIR |
| *quadratus femoris:* | QF |
| *pectineus:* | PEC |
| *adductor longus:* | AL |
| *adductor magnus:* | AM |
| *adductor magnus (anterior):* | AMA |
| *adductor magnus (middle):* | AMM |
| *adductor magnus (posterior):* | AMP |
| *adductor brevis:* | AB |
| *adductor brevis (superior):* | ABS |
| *adductor brevis (inferior):* | ABI |
| *gluteus minimus:* | GMIN |
| *gluteus minimus (anterior):* | GMINA |
| *gluteus minimus (middle):* | GMINM |
| *gluteus minimus (posterior):* | GMINP |
| *gluteus medius:* | GMED |
| *gluteus medius (anterior):* | GMEDA |
| *gluteus medius (middle):* | GMEDM |
| *gluteus medius (posterior):* | GMEDP |
| *gluteus maximus:* | GMAX |
| *gluteus maximus (deep):* | GMAXD |
| *gluteus maximus (superfial):* | GMAXS |
| *tensor fascia latae:* | TFL |
| *semimembranosus:* | SM |
| *semitendinosus:* | ST |
| *gracilis:* | GR |
| *sartorius:* | SAR |
| *rectus femoris:* | RF |
| *biceps femoris:* | BF |
| *biceps femoris (long):* | BFL |
| *biceps femoris (short):* | BFS |
| *vastus lateralis:* | VL |
| *vastus intermedius:* | VI |

| | |
|---|---|
| *vastus medialis:* | VM |
| *popliteus:* | POP |
| *gastrocnemius:* | G |
| *gastrocnemius (lateral):* | GL |
| *gastrocnemius (medial):* | GM |
| *plantaris:* | PLT |
| *soleus:* | SOL |
| *tibialis anterior:* | TA |
| *tibialis posterior:* | TP |
| *peroneus longus:* | PL |
| *peroneus brevis:* | PB |
| *peroneus tertius:* | PT |
| *extensor digitorum longus:* | EDL |
| *extensor hallucis longus:* | EHL |
| *flexor digitorum longus:* | FDL |
| *flexor hallucis longus:* | FHL |