



# **VISUAL3D™**

## Tutorial #1: Building a Model

Revision 3.30

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## How to Use the Visual3D™ Tutorials

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There are four tutorials, covering:

- (1) *Building a Model*
- (2) *Data Visualization*
- (3) *The Command Processing Pipeline*
- (4) *Signal and Event Processing*
- (5) *Analysis and Reporting.*

Each tutorial starts where the previous one ends. The results of each tutorial are saved as a .cmo file. So you can skip parts or try different features.

### *To locate sample input files*

The sample input file needed for this tutorial can be downloaded from the C-Motion website:

<http://www.c-motion.com/support/tutorials.htm>

## Objectives of Tutorial #1

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Tutorial #1 describes a lower-body gait model, but it uses techniques consistent with all Visual3D models. We will create a model by loading a standing trial, and creating segments.

During this tutorial, you will

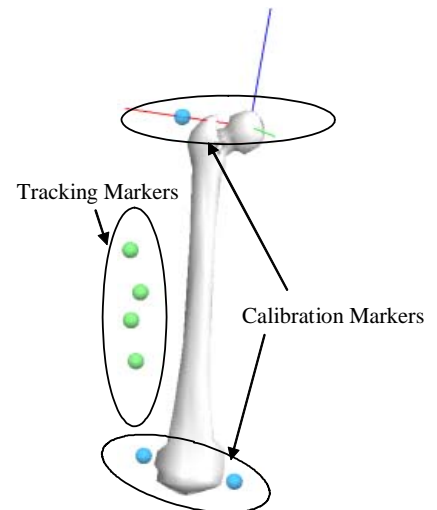
1. create a *model* that exists conceptually within the Workspace.
2. define segments within the model using *calibration markers* and *tracking markers*.

### Key Concepts

A *calibration file* is a short motion capture of the subject standing stationary in the anatomical position.

In this example, *Calibration markers* were placed at anatomically relevant locations. Marker positions are averaged automatically over all frames to compensate for *noise* in the data.

**NOTE:** If the subject moved during the standing trial, a subset of frames, in which the subject is stationary, can be selected for computing the average locations of the markers. The command **Modify Frame Range For Static Calibration** is located in the Model Menu items.



## Preparing for Tutorial #1

1. Ensure that version 3.0 or later of Visual3D has been downloaded and installed.
2. Download the standing calibration file from the website:  
<http://www.c-motion.com/support/tutorials.htm>
3. Locate the file “Lower Body Static Trial.c3d” in the list and download it.
4. Save this file in the folder where you plan to save your motion capture files.

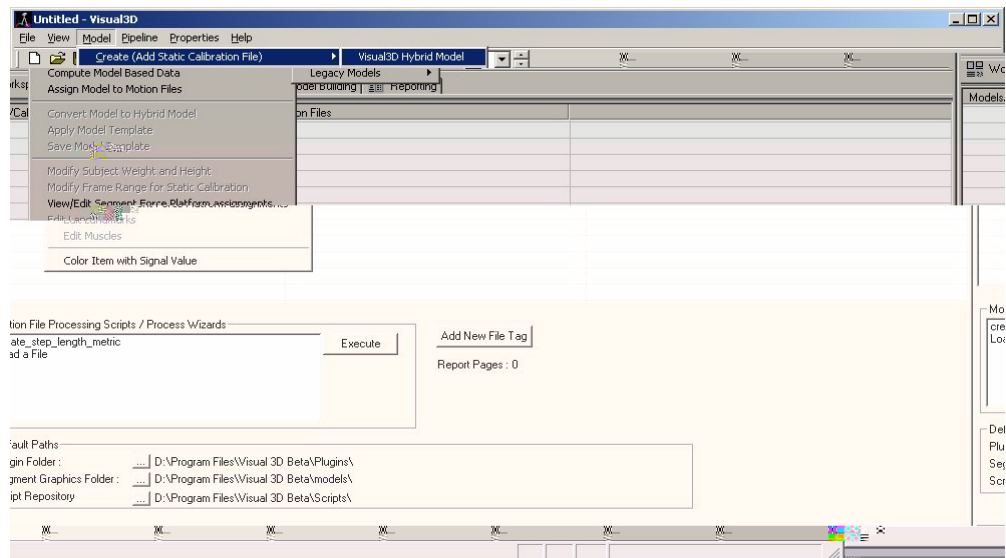
NOTE: The file “Tutorial1.cmo” contains the *end results* of this tutorial. It may be useful as a secondary resource for verifying your progress.

5. Launch the Visual3D program from the **Start** menu. The program will open to the main workspace.

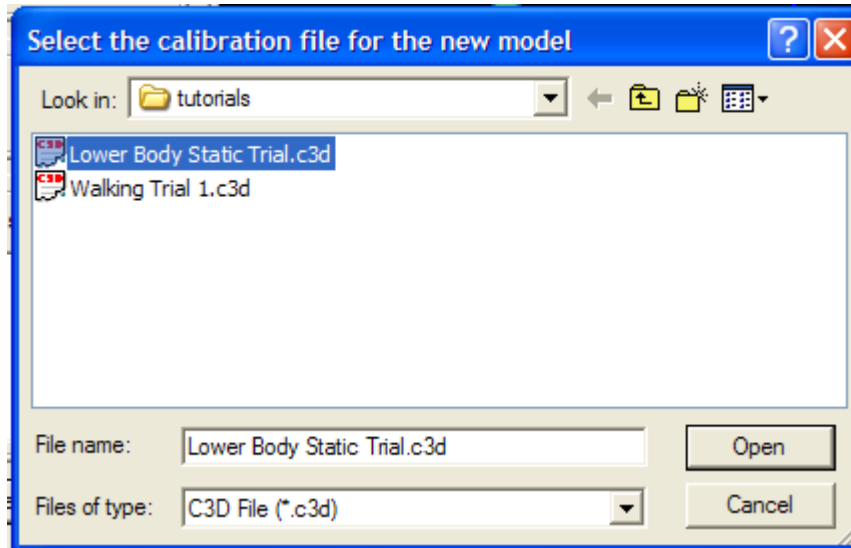
*Start -> Programs -> C-Motion -> Visual3D*

### **Crete a new model with the calibration file**

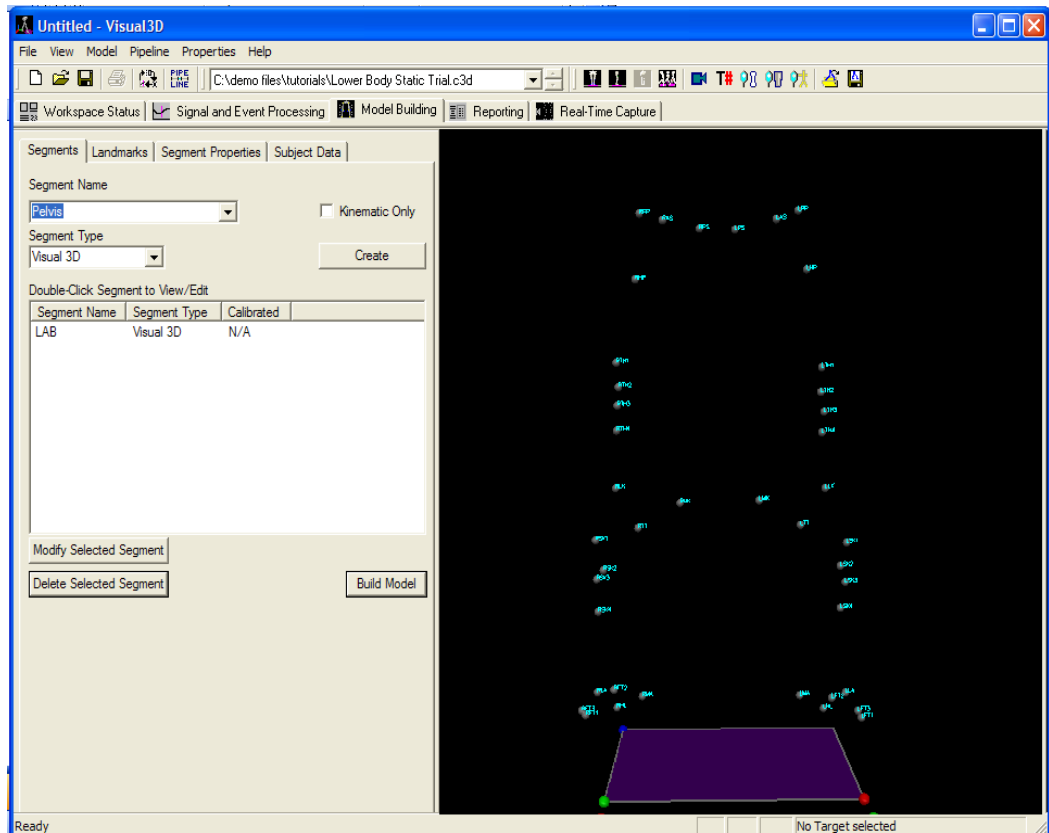
1. From the **Model** menu, select **Create (add Static Calibration file)**.



2. Select **Visual3D Hybrid Model**.
3. A dialog titled “Select the calibration file for the new model” will appear; select “Lower Body Static Trial.c3d.” Click **Open**.



Visual3D will switch to **Model Building** mode automatically. The 3D viewer will display the average value of the marker locations from the standing file. The dialog bar to the left of the screen will contain a list of segments, which by default will contain only a segment representing the Laboratory (e.g. Motion Capture Volume).



### 3D Viewer Controls

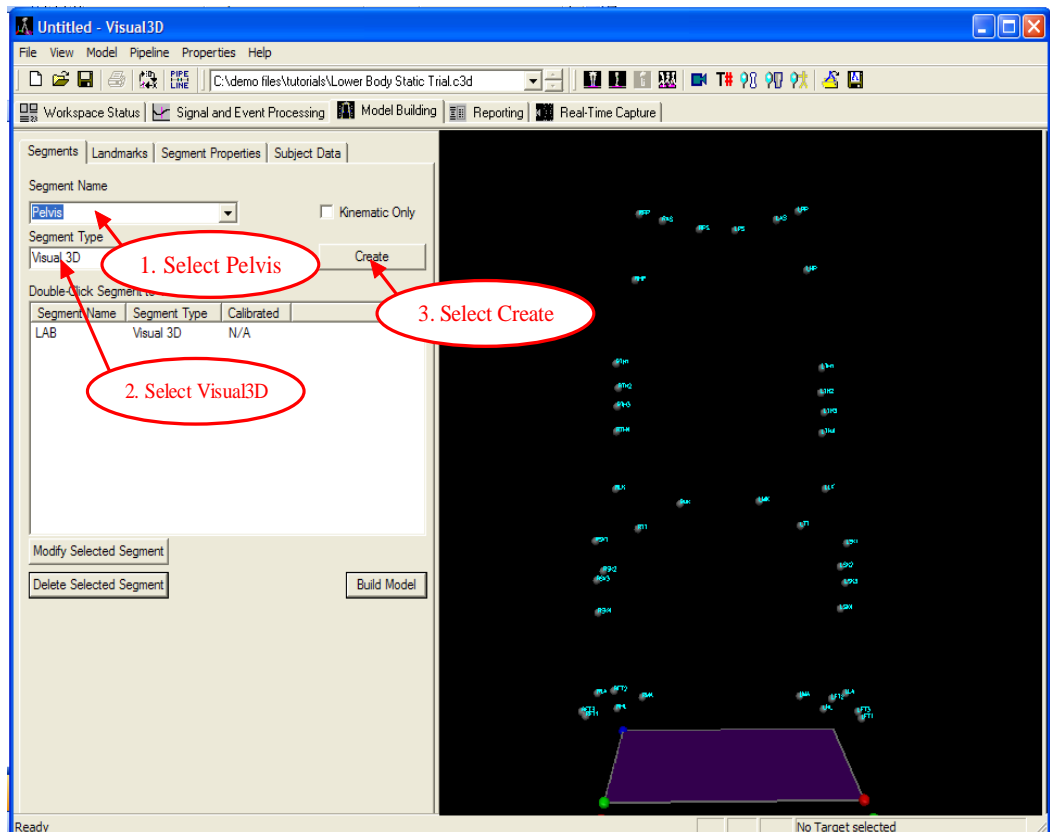
The screen is a 3D display (using the OpenGL libraries). The **T#** button toggles between marker numbers, marker names, and no annotation.

The mouse buttons control the view for panning and zooming using the same mouse controls as the 3D animation viewer in the Signal and Event Processing mode.

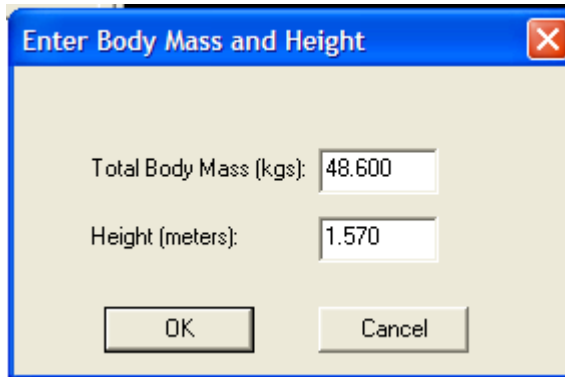
The **left mouse button** is used to modify the orientation of the 3D view of the scene. Holding down the left mouse button and moving the mouse vertically rotates the scene about the horizontal axis of the scene view, moving the mouse horizontally rotates the scene about an axis parallel to gravity. The **right mouse button** is used to modify the scaling of the scene. Holding down the right mouse button and moving the mouse outward moves the camera closer to the center of the scene (increases the size of the image displayed). Holding down the **center mouse button** (on a three-button mouse), or **both the left mouse button and right mouse buttons together**, allows the user to shift (translate) the scene from side to side and up or down.

## Creating the Pelvis Segment

### Create a Pelvis segment



1. From the **Segment Name** box, select **Pelvis**. Note: if your config folder is defined incorrectly, you may see a segment named RPV (an internal acronym), instead of Pelvis. If so, switch to Workspace Mode and modify the config folder.
2. From the **Segment Type** box, select **Visual3D**.
3. Click **Create**. A dialogue box **Enter Body Mass and Height** will open because Visual3D insists that the subject be assigned a mass and a height. For example, enter 48.6 kg and 1.57 m, and click **OK**.



4. In the **Pelvis** tab, enter these values:

Define Proximal Joint and Radius:

Lateral: **RPP** Medial: **LPP** (*Right and Left Iliac Crest Markers*)

Define Distal Joint and Radius

Lateral: **RHP** Medial: **LHP** (*Right and Left Greater Trochanter Markers*)

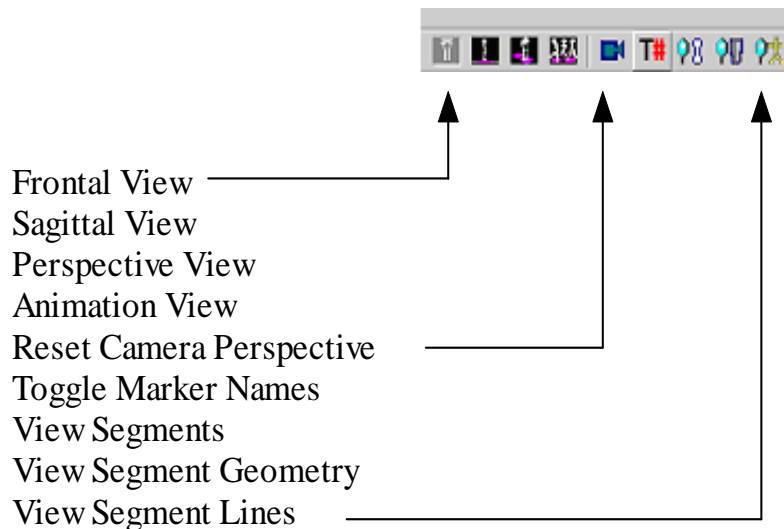
Select Tracking Targets: **LAS, RAS, LPP, RPP**

Depth: 0.14000 (**Physical depth of the pelvis; Mid ASIS to Mid PSIS**)

5. Click **Build Model** to build the segment.

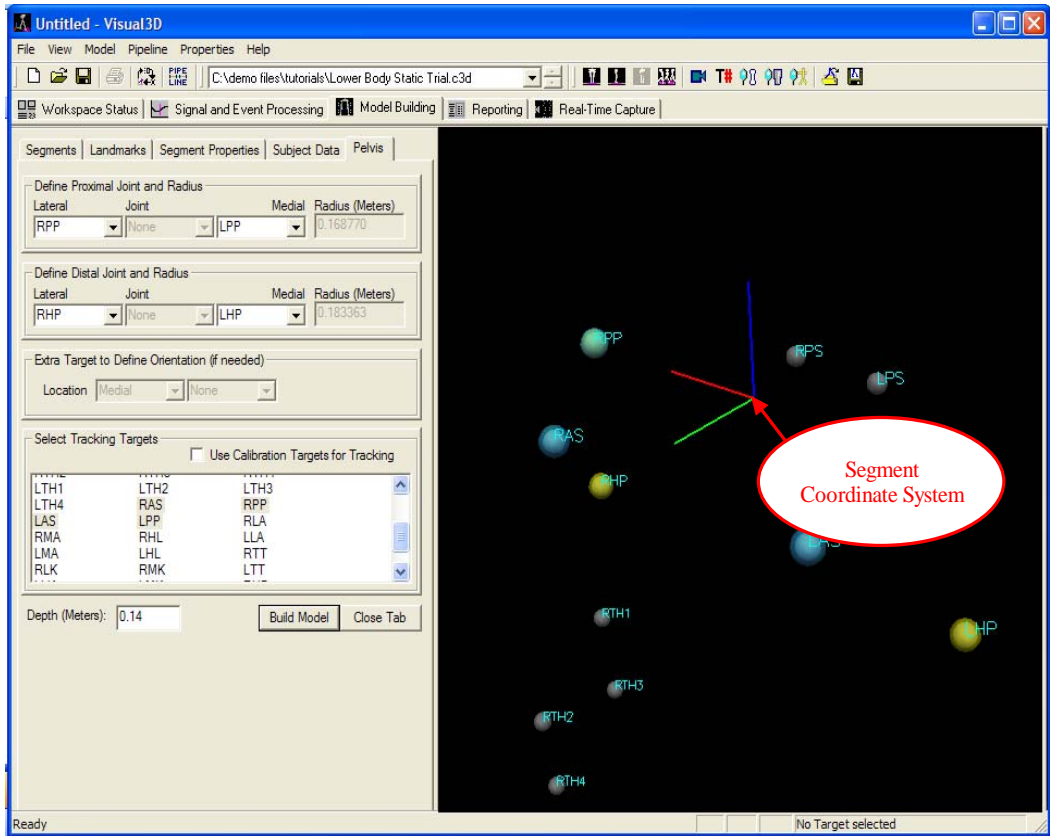
### **Modify the Viewer Settings**

The image of the segment in the 3D viewer depends on the **viewing options**

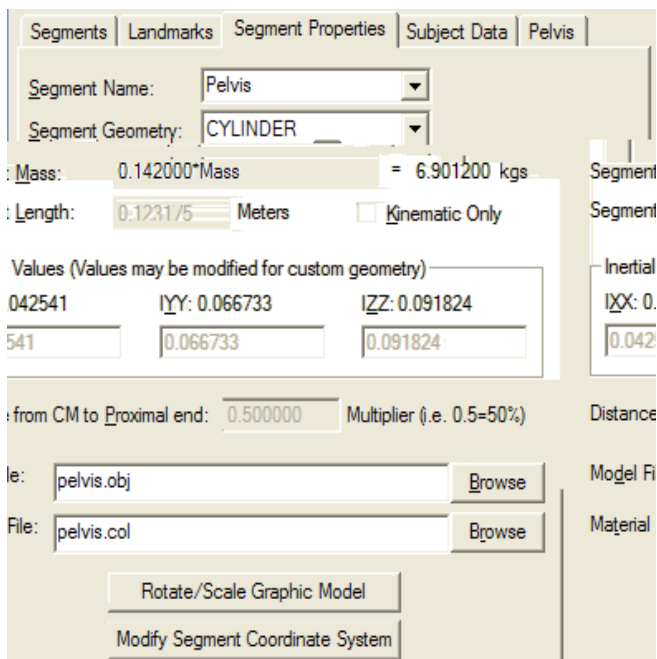


## View the Pelvis Segment Coordinate System

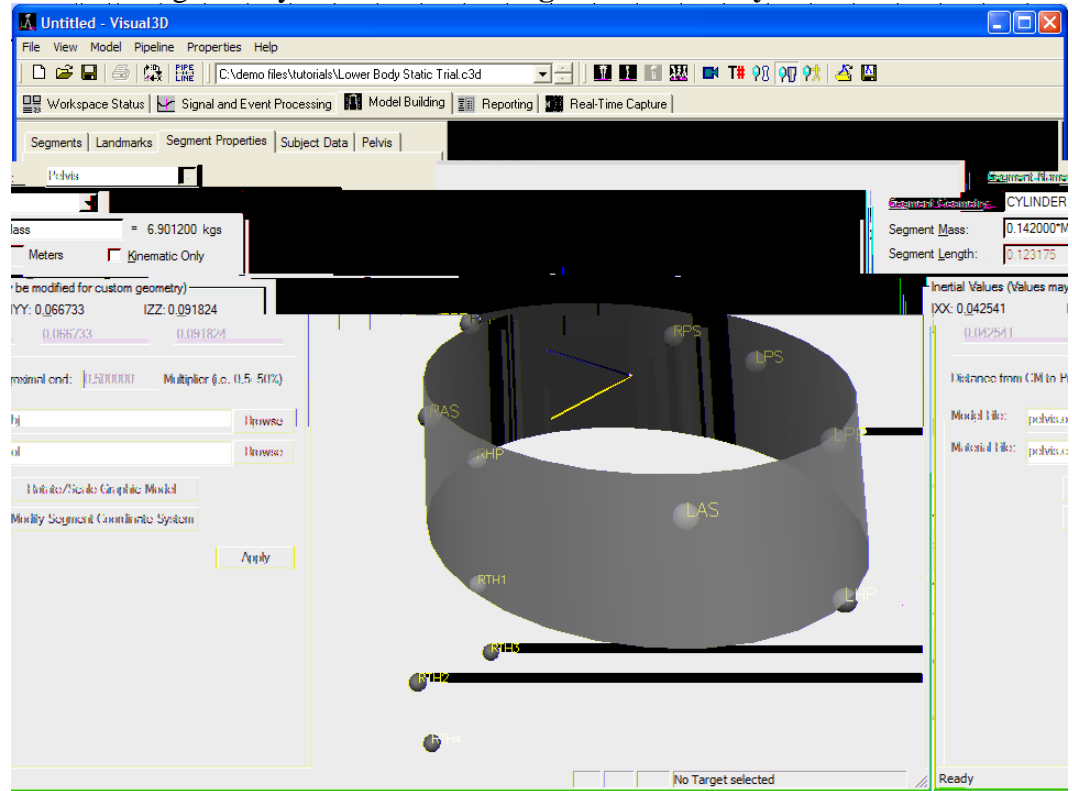
If the 3 toolbar segment views are off, and **View Segment Coordinate System Axes** is on, the Segment Coordinate System is represented as a Red Line (x-axis), and Green Line (y-axis) and a Blue Line (z-axis).



## The Pelvis Segment Properties

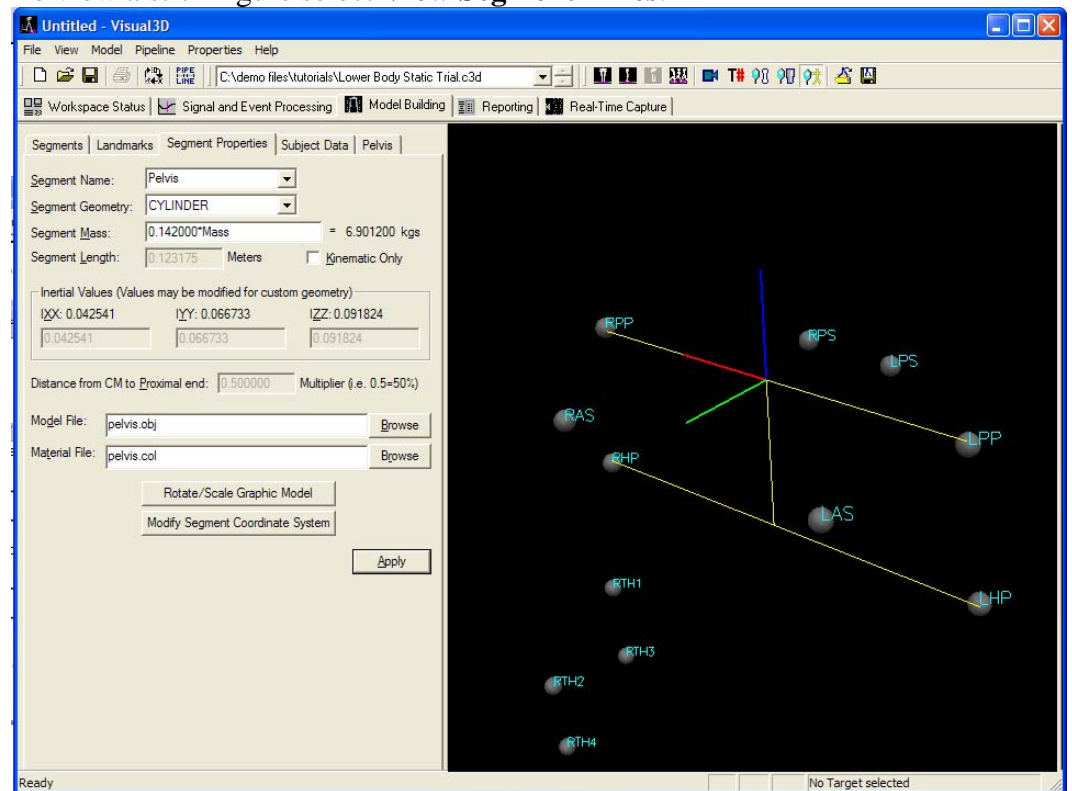


To view the geometry select the **View Segment Geometry** button on the toolbar.



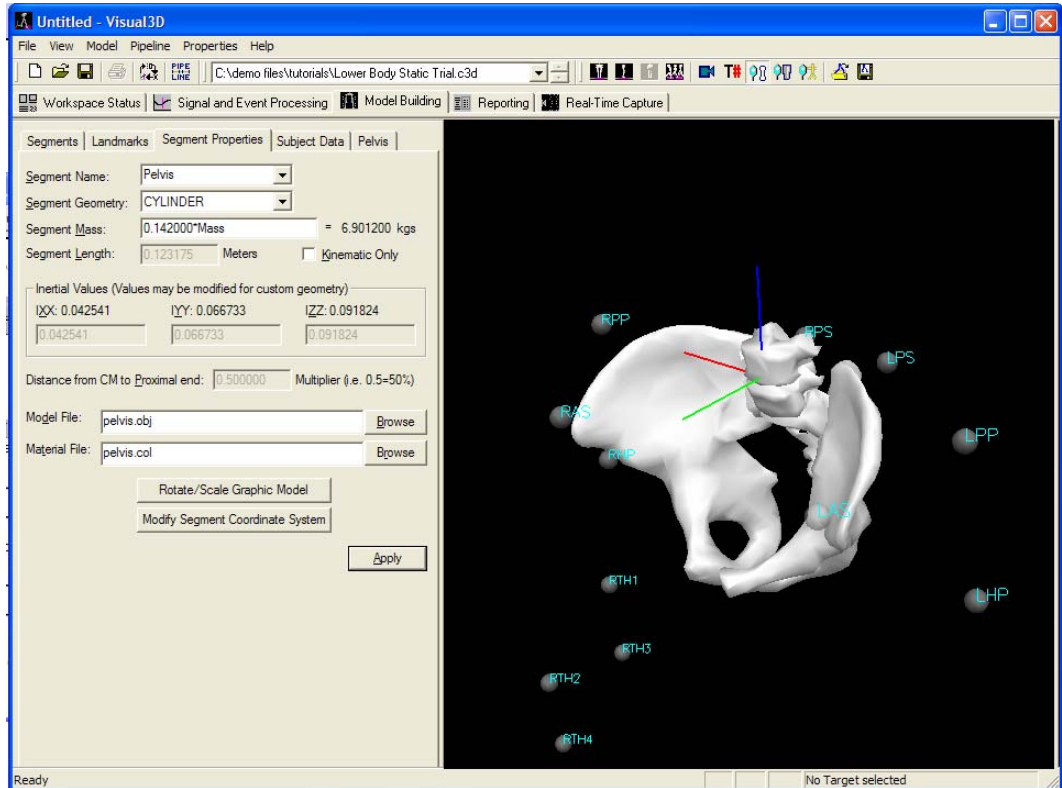
The width of the cylinder is defined by the endpoint radii of the segment.  
The depth of the cylinder is defined by the depth of the pelvis.

To view a stick figure select **View Segment Lines**.



The segment lines display is a vertical line between the segment endpoints, and horizontal lines between the medial and lateral radii of the segment (e.g. from the segment endpoint to the medial and lateral borders of the segment, which are one radius away).

Selecting **View Segments** will display the Model File assigned to the segment. The Model file is a wireframe object formatted as either a Wavefront obj file or a VRML wrl file. The Model File is usually a representation of the bone(s) used for the 3D Animation.



**NOTE: The 3D animation object is purely for visualization. It does not affect the analysis. You can rotate, scale or move the bones relative to the Segment Coordinate System. You can not, however, modify the Segment Coordinate System without affecting the analysis.**

This is an extremely important point because the animated bone can be extremely compelling to view and some users are distracted by the image, thinking if the image doesn't look correct, the data must be wrong or the segment must be defined incorrectly.

There are two main reasons why the “bones” don't seem to fit correctly.

1. The definition of the segment is incorrect, so it is important to check this first.
2. The graphical object is defined with respect to a segment coordinate system that may be inconsistent with the segment coordinate system that

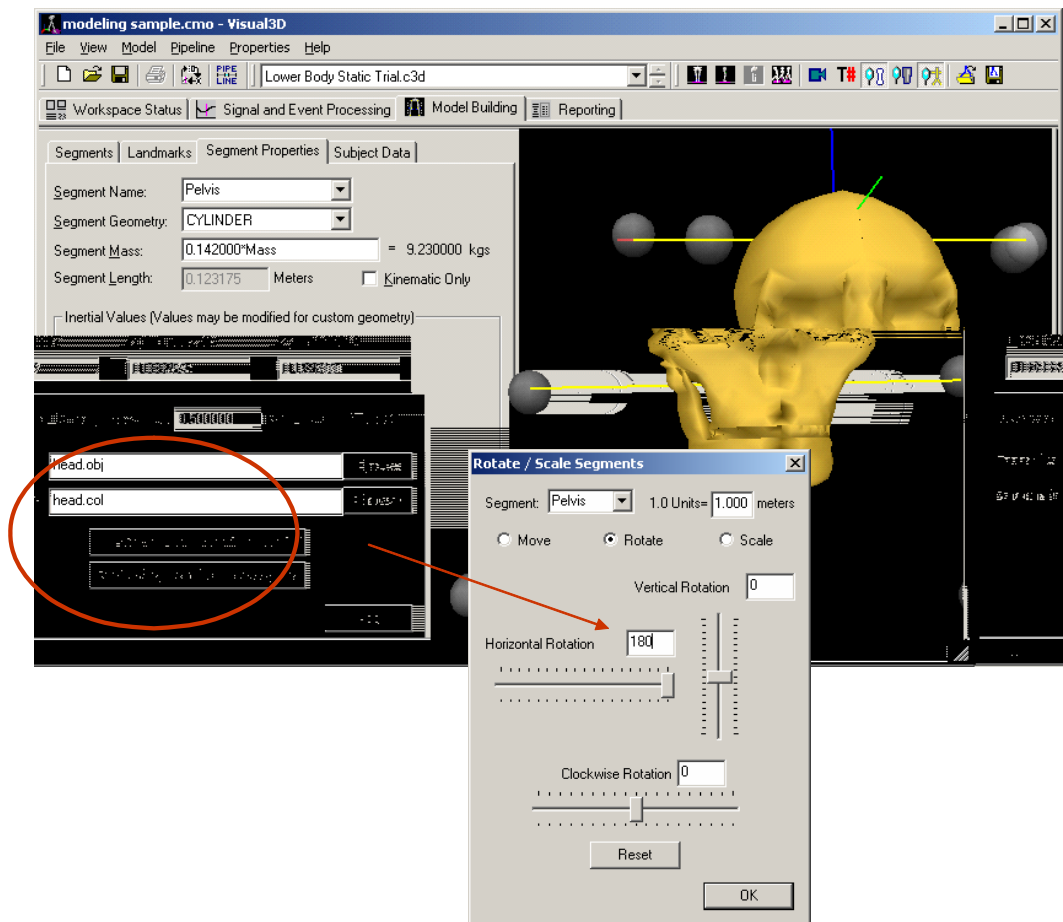
you have defined (i.e. there are many ways to build a segment coordinate system). If you are uncertain about the default (e.g. assumed) segment coordinate system, feel free to contact C-Motion.

It is possible to replace the “bones” with another bone or object file. As a ridiculous example, you can change the pelvis model to display a skull rather than the pelvis bones.

Click on the **Browse** button beside the **Mode File** edit box and open the *head.obj* file.

The head will appear upside down because the default segment coordinate system for the head is defined with the top of the head as the distal segment (see point 2 above concerning why a model may look incorrect).

To re-orient the bone click on the **Rotate/Scale Graphic Model** button to adjust the view. Set the **Horizontal Rotation** to 180 and click **OK** and then **Apply**. A 3D image of a head will appear in place of the pelvis.



Restore the pelvis image before proceeding: Change **Model File** back to *pelvis.obj* and, in **Rotate/Scale Graphic Model**, change the Horizontal Rotation back to 0.

## Save the Workspace to a .cmo file

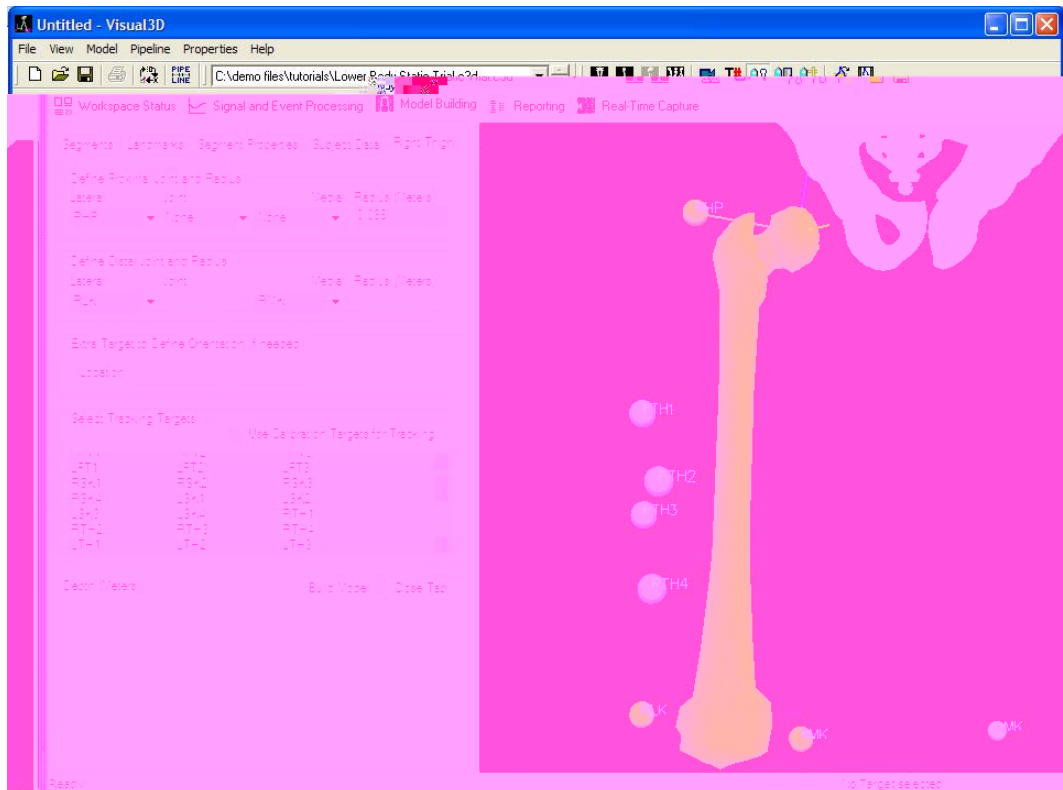
**NOTE:** Save often to prevent loss of files due to power outages or Windows errors. Maintain a series of .cmo files as you work so that you can revert to a previous step.

1. In the **File** menu, click on **Save**. MyTutorial1.cmo.

**TIP:** Save the segment definitions as a template (**mdh**) file to allow you to re-create models using the same marker set. To create a template, select **Save Model Template** under the **model** menu item.

## Creating the Legs

### Create the Right Thigh segment



1. In the **Segments** tab, select **Right Thigh** in the **Segment Name** box. Then click on **Create**. A new thigh image and a new set of tabs will open.

Note that there is no medial marker on the proximal end. Only three markers are needed to create the plane. In this situation Visual3D requires the distance from the marker to the hip joint center (proximal radius).

2. In the **Right Thigh** tab, enter these values:

Define Proximal Joint and Radius:

Lateral: RHP Joint: None Medial: None Radius: .089

Define Distal Joint and Radius:

Lateral: RLK Medial: RMK

Select Tracking Targets:

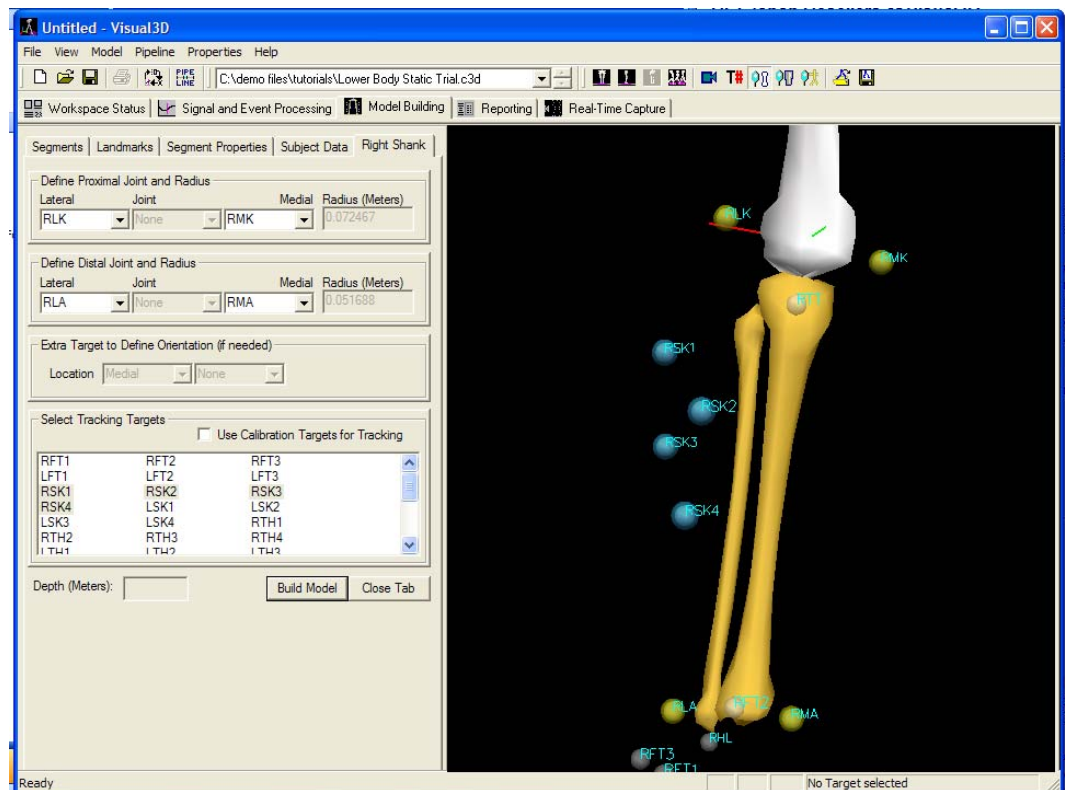
RTH1, RTH2, RTH3, RTH4

3. Click on **Build Model**. A 3D image of a thigh will appear.

**Warning:** If you receive an error message about inertial properties and custom segments, you may have entered an incorrect number for the proximal radius.

4. Click on **Close Tab** before proceeding.

### **Create the Right Shank segment**



1. Click on the **Segments** tab, and in the **Segment Name** box, select **Right Shank**.

2. Click the **Create Segment** button.

3. In the **Right Shank** tab, enter these values:

Define Proximal Joint and Radius:

Lateral: RLK

Radius: RMK

Define Distal Joint and Radius:

Lateral: RLA

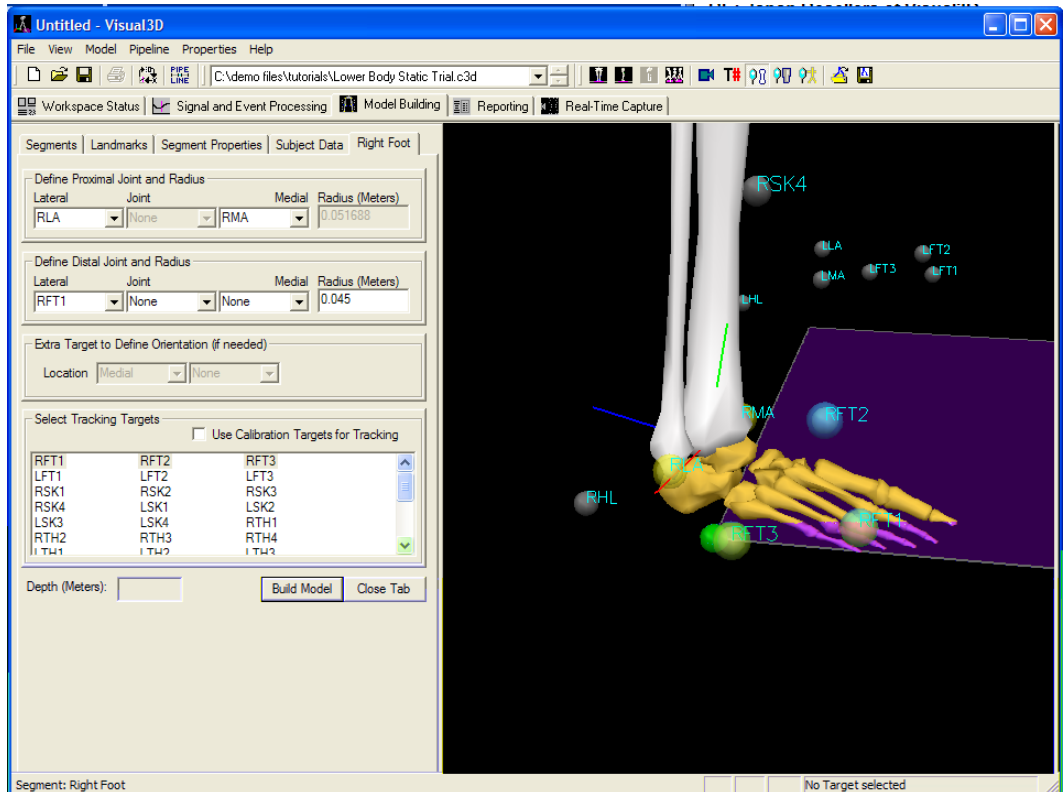
Medial: RMA

Select Tracking Targets:

RSK2, RSK2, RSK3, RSK4

4. Click **Build Model**. The right shank should appear attached to the right thigh.

## Create the Right Foot segment



The RFT1 marker was not on a post, so it has a radius of .010 m.

1. Click on the **Segments** tab, and in the **Segment Name** box, select **Right Foot**.
2. Click the **Create Segment** button.
3. In the Right Foot tab, enter these values:

Define Proximal Joint and Radius:

Lateral: RLA

Medial: RMA

Define Distal Joint and Radius:

Lateral: RFT1

Radius: 0.06

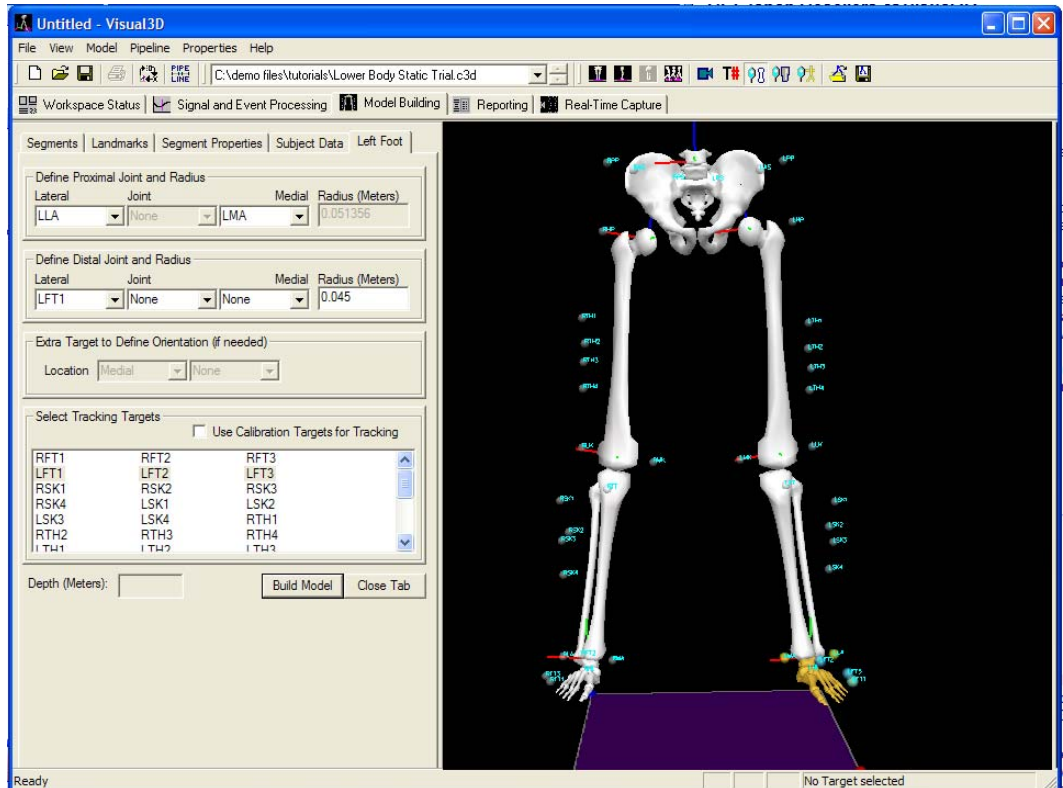
Select Tracking Targets:

RFT1, RFT2, RFT3

4. Click on Build Model. The right foot should appear.

This is a simple representation of the foot that is adequate for many of the Kinematic and Kinetics calculations in Visual3D. It is not, however, adequate for the calculation of the ankle joint angle, as you will see in Tutorial 5.

## Create the Left Leg



1. Click on the **Segments** tab, and in the **Segment Name** box, select **Left Thigh**.

2. Click the **Create Segment** button.

3. In the **Left Thigh** tab, enter these values:

Define Proximal Joint and Radius:

Lateral: LHP                      Radius: 0.089

Define Distal Joint and Radius:

Lateral: LLK                      Medial: LMK

Select Tracking Targets:

LTH1, LTH2, LTH3, LTH4

3. Click **Build Model**. The right thigh should appear distal to the pelvis.

1. Click on the **Segments** tab, and in the **Segment Name** box, select **Left Shank**.

2. Click the **Create Segment** button.

3. In the **Left Shank** tab, Enter these values:

Define Proximal Joint and Radius:

Lateral: LLK                      Radius: LMK

Define Distal Joint and Radius:

Lateral: LLA                      Medial: LMA

Select Tracking Targets:

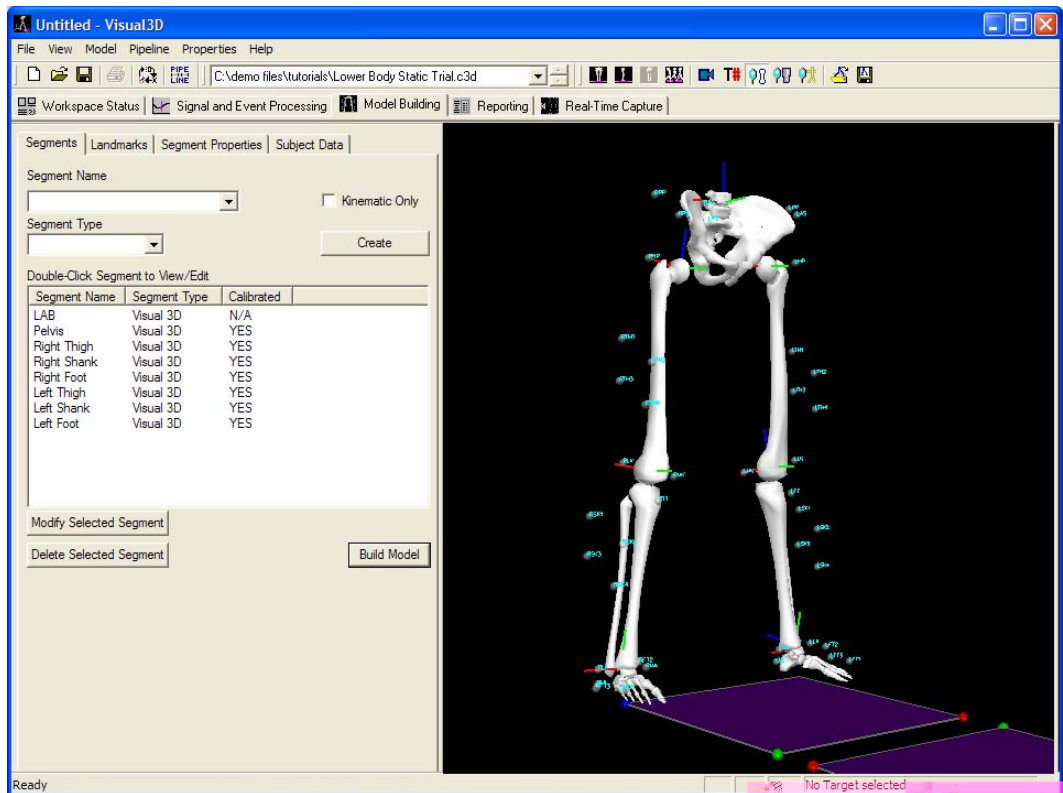
LSK1, LSK2, LSK3, LSK4

4. Click on **Build Model**.

1. Click on the **Segments** tab, and in the **Segment Name** box, select **Left Foot**.
2. Click the **Create Segment** button.
3. In the **Left Foot** tab, enter these values:  
 Define Proximal Joint and Radius:  
     Lateral: LLA                      Medial: LMA  
 Define Distal Joint and Radius:  
     Lateral: LFT1                    Radius: 0.06  
 Select Tracking Targets: LFT1, LFT2, LFT3
4. Click on **Build Model**.

## Completing the Model

1. When all segments have been defined, click on **Build Model**.



2. In the **File** menu, click on **Save** to save the file for use in Tutorial #2. Save the file as MyTutorial1.cmo.

NOTE: You can also save the model as a Model Template. Subject data must be changed in every case where templates are used.

\*\*\*\*\*

You have now successfully created a model. **Tutorial #2** will map this model to actual motion capture trials. It will also create analytical components for quantifying results.

## ADDENDUM: Key Concepts in Model Building

The program automatically switches to the **Model Building Tab** when being used to create a model. The complete model only exists while Visual3D is running. It can be saved in a .cmo file, or the model template can be saved to disk. The saved cmo file is a complete digital report containing the data, model and report.

A complete model is created by

1. Creating a Model in Visual3D.
2. Assigning a Static Calibration file to the Model.
3. Defining segments.

### Marker Sets

Visual3D supports almost any marker set, including *6 Degree of Freedom*, *Helen Hayes/Newinton* (e.g. "Conventional Gait Model"), *CODA*, and many laboratory in-house systems.

Place tracking markers on the segments in strategic and geometrically relevant positions that move only minimally with skin movement. Random placement of markers may result in unusable data

You will need two types of markers: calibration markers (for defining the segments) and tracking markers (for computing the movements). Calibration markers can be used for tracking, **but be aware that markers placed near the ends of segments (e.g. the lateral knee) are especially susceptible to skin movement artifacts.**

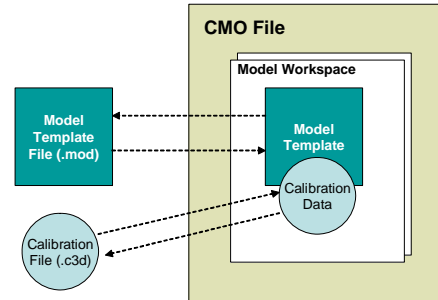
### Segments

Biomechanical models are composed of linked segments. A segment is typically a skeletal bone (e.g. the femur) or set of bones (e.g. the foot).

Each segment has

- defined end points and a defined orientation
- a geometrical shape (cylinder, cone, sphere, ellipsoid, or custom variation)
- mass (based on textbook averages unless overridden)
- length (calculated from the end points)
- associated visual object to aid visualization (in Alias Wavefront object format or VRML)

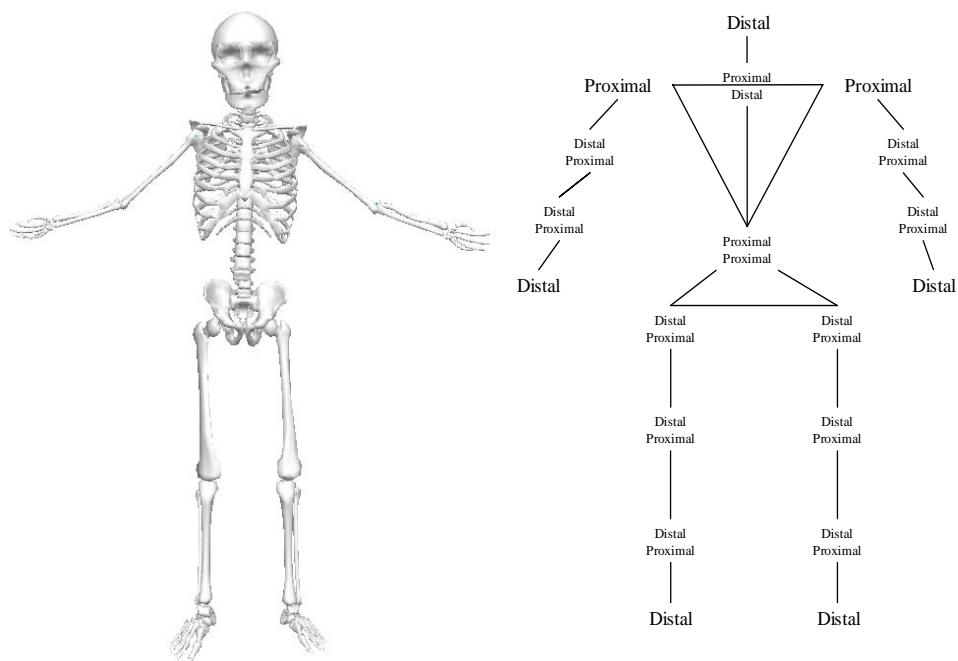
The program considers any two segments in proximity to be "linked" and calculates a Joint Center between them. These calculated centers can be used as markers for defining other segments.



## Standard Modeling Conventions

The Visual3D model-building tool uses standard medical terminology to define the locations and configurations of segments.

NOTE: *Right* and *left* are always the **subject's right** and *left*.



The “**Origin of the Pelvis**” is usually (but not always) the basis for determining “proximal” and “distal.”

**Proximal** means closest to the Center of Mass.

**Distal** is farther away.

Each segment is defined with a proximal and distal end.

**Joint Centers** are assumed to exist between the distal end of a segment and an extremely close proximal end of another segment.

The pelvis is normally defined in the same way: with the proximal end on the top and the distal end on the bottom.

The **Median** is an imaginary line dividing the subject into right and left hand sides. The median line is the standard from which “lateral” and “medial” are defined. **Medial** markers are closest to the median, and **lateral** ones are farthest away on the same segment. Any segment that straddles or is centered on the median, i.e. the pelvis or spine, are considered right-hand segments, thus by convention we have a right pelvis.

Note that medial and lateral are defined with respect to the subject in the **Anatomical Position**, which is important to remember when defining the forearm and hand segments.