

VICON iQ

TUTORIAL 2: MODELLING

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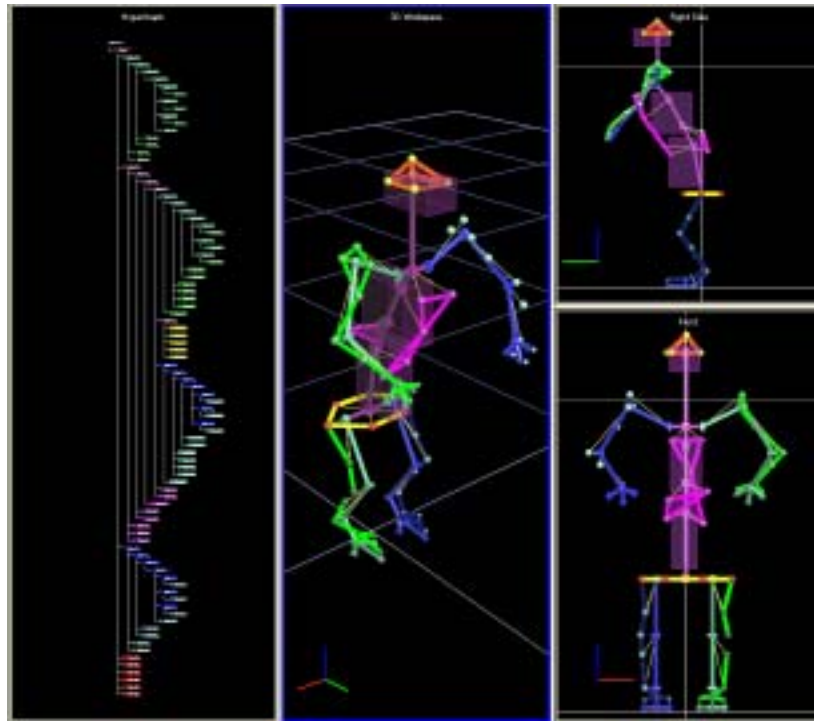
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Introduction to Modelling



Introduction

As you have already learned from Tutorial 1: Subject Calibration, kinematic subjects are one of the keystones for using Vicon iQ 1.5 efficiently. In that section, the VST, VSK, and subject calibration were introduced. In this section, the specific contents of the VST and VSK files will be explored in greater detail, and you will work through the process of creating your own VST and VSK files for different scenarios.

Some of the key concepts from Tutorial 1 are reviewed below; however, this Tutorial does assume that you have completed Tutorial 1 in its entirety, and are familiar with Subject Calibration principles and techniques.

Key Concepts *Modelling* in the context of Vicon iQ, encompasses the following concepts:

- **VST:** The construction of a Subject template. This serves as an un-calibrated and often generic model of the subject we are going to be capturing and processing. This is called a **VST** (Vicon Skeletal Template) and exists as a **VST** file on disk, with the file extension **“.vst.”** **VST** files can be created and edited using Vicon iQ 1.5 using the Modelling Mode. These are normally stored in the installation folder for Vicon iQ 1.5, in the “Models” directory
- **Subject Calibration:** In order for Vicon iQ 1.5 to accurately perform many of its high-level processing features, a subject-specific model file must be generated. This process consists of collecting a Range of Motion (ROM) trial for the subject, with a marked known pose, typically a T-Pose, and then specifying a VST file that has the same general marker locations. The process of subject calibration within Vicon iQ 1.5 takes these inputs, and optimises the marker and skeleton relationships in the VST file to best match the actual locations of markers on the subject. At the same time, Vicon iQ 1.5 attempts to scale change the proportions of the subject to match the exact physical dimensions of the captured subject.

The level to which this happens is completely controllable, with constraints and parameterisation (more on this later). The end result of this is a calibrated subject file, which exists as a .VSK file in disk.

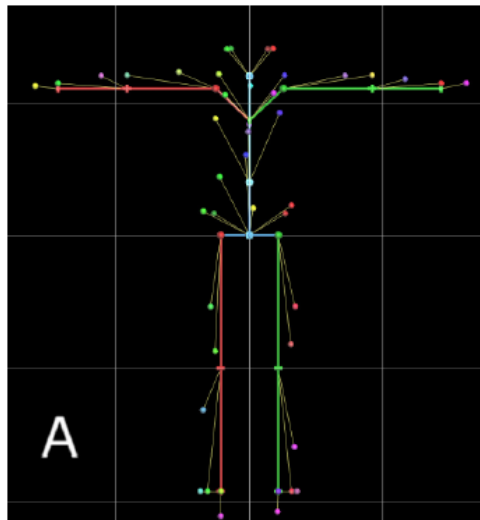
- **VSK:** Once a VSK has been produced for each captured subject, the process of using the calibrated subjects (VSKs) to perform tasks such as labelling, gap filling, and producing skeletal animation from captured and processed optical marker data can be achieved.

Important Notes: It is important to distinguish the differences between VST files and VSK files. In many ways, they are very similar, in that they reflect a defined kinematic model and marker relationships. However:

VST vs. VSK

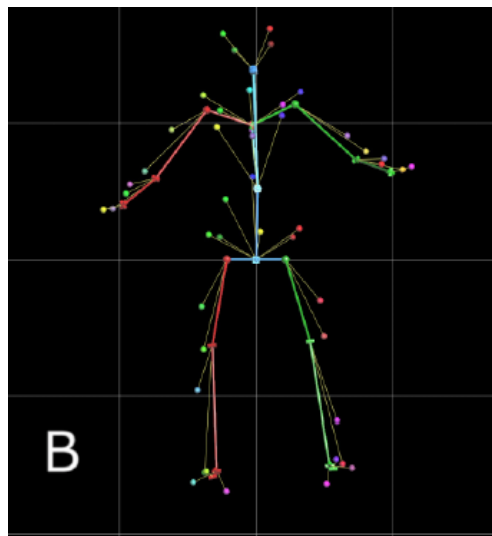
- VST files (Subject Templates) are **generic** models for a particular subject (typically actor). They are one of the inputs to the subject calibration process.

Figure 1: VST file, visualised in Vicon iQ 1.5



- VSK files (Calibrated Subjects) are **specific** to a particular subject (actor/prop). They are the output of *calibrating* a VST, given a captured Range of Motion (ROM). VSKs are used for processing data in Vicon iQ, both in Real Time and in Post Processing.

Figure 2: VSK file, visualised in Vicon iQ 1.5



-
- VST files are typically stored in the "Models" Directory in the installation location for Vicon iQ 1.5 on your hard drive.
 - VSK files, once generated by Vicon iQ 1.5, are typically saved in a Session folder alongside the actual captured trial data, which generally is within the active Eclipse Database that you are using.
 - Both VST and VSK files are XML based text files, and can easily be viewed in any standard text editor if you wish to do so.

Lesson 1 – The VST Explained.

Introduction

In this lesson, we will delve into the contents of a VST file. The various data contained within the file will be discussed in detail. Although you will not need to typically edit the VST outside of Vicon iQ 1.5, having a detailed look at the file contents will introduce some key concepts of Vicon iQ 1.5 Modelling.

The VST file format

The VST file format is an XML based hierarchical skeleton description format. It allows the user to specify segments hierarchically, the joints between the segments, the markers and to which segments of the skeleton they attach, and the parameters which the Subject Calibration routine is allowed to optimise.

The best way to understand a VST file is to look at an existing one and try to decipher it.

Here's an example of a simple VST file:

```
<?xml version="1.0" standalone="yes"?>
<KinematicModel>
  <Parameters>
    <Parameter NAME="MKR2x" VALUE="50"/>
    <Parameter NAME="MKR3x" VALUE="50"/>
    <Parameter NAME="MKR3y" VALUE="50"/>
    <Parameter NAME="MKR4x" VALUE="0"/>
    <Parameter NAME="MKR4y" VALUE="50"/>
    <Parameter NAME="MKR4z" VALUE="0"/>
  </Parameters>
  <Skeleton>
    <Segment NAME="Object" POSITION="0 0 0" BOUNDS="-50 -50 -50 50 50 50">
      <JointFree/>
    </Segment>
  </Skeleton>
  <MarkerSet NAME="Object">
    <Markers>
      <Marker NAME="MKR1" SEGMENT="Object" POSITION="0 0 0"/>
      <Marker NAME="MKR2" SEGMENT="Object" POSITION="MKR2x 0 0"/>
      <Marker NAME="MKR3" SEGMENT="Object" POSITION="MKR3x MKR3y 0"/>
      <Marker NAME="MKR4" SEGMENT="Object" POSITION="MKR4x MKR4y MKR4z"/>
    </Markers>
    <Sticks>
      <Stick MARKER1="MKR1" MARKER2="MKR2" RGB="255 0 0"/>
      <Stick MARKER1="MKR2" MARKER2="MKR3" RGB="0 255 0"/>
      <Stick MARKER1="MKR3" MARKER2="MKR4" RGB="255 255 0"/>
      <Stick MARKER1="MKR4" MARKER2="MKR1" RGB="255 255 0"/>
    </Sticks>
  </MarkerSet>
</KinematicModel>
```

The file is divided into several different sections, each section starting with a "<" and ending with a "/>".

The three main sections are called "Parameters", "Skeleton" and "MarkerSet". These three sections have to be present in every VST file, but the content of each section can vary widely.

Let's start by deciphering the VST file above. The first question to ask is: what does it describe? Well, this particular VST file describes a single segment to which 4 markers are attached. The labels for these four markers are "MKR1", "MKR2", "MKR3" and "MKR4".

Look first at the "MarkerSet" section. In this section, all the markers that form the template are specified, and all markers must be assigned to a segment. Furthermore, the marker's position with respect to that segment must be specified.

Note: At this point it is crucial to remember that the segment is defined by the markers, not the other way around. Ultimately, the only thing that will be known will be the marker positions and all segments must be defined with respect to the markers.

Specifying Constraints

To write a successful VST, you will have to decide how to *constrain* the model. More specifically, you will need to constrain the local coordinate systems of the segments with respect to the markers being tracked.

Why do we need to constraint the model? In order to produce the desired results in the finished work, it is often necessary to restrict the ability of the Subject Calibrator in certain ways. As an example, consider a simple model of a sword. If we are interested in obtaining the best representation of the sword, it makes logical sense that one of the principal axes of the sword's local coordinate system should lie along the axis of the blade. In building a VST file of the sword, it would be critical to constrain the model for this desired result. The subject calibrator has no intuitive sense to know that the local axis system of this object should lie along a desired result; given an under-constrained VST of the sword, the resulting VSK may have a totally unexpected result, and the end results of your work may not be satisfactory.

On the other hand, models can certainly be over-constrained as well. If we do not allow the subject calibrator any leeway in the optimization process, the resulting VSK may not match the actual marker positions of the subject. A poor-quality VSK will cause numerous quality problems in Vicon iQ 1.5, and the end results will suffer.

In the file above, look at the specification for the marker called MKR1:

```
<Marker NAME="MKR1" SEGMENT="Object" POSITION="0 0 0"/>
```

The keyword "POSITION" specifies this marker's position in the segment's local coordinate system. However, you have to define the segment's local coordinate system with respect to the markers, so in this case the author of the VST file has chosen to establish the local coordinate system's origin *exactly where MKR1 is*. In other words, MKR1 is *constrained* to be at position "0 0 0" in the segment's local coordinate system, which of course is the origin.

Moving on to MKR2:

```
<Marker NAME="MKR2" SEGMENT="Object" POSITION="MKR2x 0 0"/>
```

Again, the author of the VST file has chosen to constrain the local coordinate system with respect to the marker positions. In this case, the constraint is that the marker "MKR2" is situated on the X-axis of the local coordinate system.

Why? because the position of the marker has been constrained to be 0 both in the Y and Z directions.

However, given that the constraint is that the marker is "somewhere" on the X axis, the X position cannot be determined a priori. Because of this, the author has chosen to *parameterise* this position and allow the subject calibration procedure to *optimise* this.

Note:: This is a very important distinction when writing VSTs: parameterisation is the opposite of constraining. Anything with a parameter means that the subject calibration process can optimise and change the value of the parameter to optimise the model for a given range of motion. Anything without a parameter will not be changed by the process of subject calibration, and will be left exactly as defined in the VST.

Then we have MKR3:

```
<Marker NAME="MKR3" SEGMENT="Object" POSITION="MKR3x MKR3y 0"/>
```

Clearly, given that we've constrained MKR1 to be in the origin of the local coordinate system and MKR2 to be along the X axis, we need one more constraint to specify the local coordinate system of the segment with respect to the markers. This has been done with MKR3 - it has been constraint to be in the XY plane by specifying that its Z value is

zero. Its X and Y values, however, are parameterised and will be calculated by the subject calibration.

Finally, MKR4:

```
<Marker NAME="MKR4" SEGMENT="Object" POSITION="MKR4x MKR4y MKR4z"/>
```

This marker does not affect the location of the local coordinate system at all since it is fully parameterised in all three directions. The subject calibration will calculate its position in the local coordinate system which has been established by the other three markers.

The “Markers” section ties in closely with the “Parameters” section in that all the parameters used need to be explicitly specified here:

```
<Parameters>
  <Parameter NAME="MKR2x" VALUE="50"/>
  <Parameter NAME="MKR3x" VALUE="50"/>
  <Parameter NAME="MKR3y" VALUE="50"/>
  <Parameter NAME="MKR4x" VALUE="0"/>
  <Parameter NAME="MKR4y" VALUE="50"/>
  <Parameter NAME="MKR4z" VALUE="0"/>
</Parameters>
```

This should be quite self-explanatory apart from the “VALUE=” keyword. Why do we need to specify a value when the subject calibration can calculate it? The answer is that because the subject calibration is an iterative procedure, an initial guess is necessary. In the next lesson, we will begin to study VST files graphically, using Vicon iQ 1.5’s modelling mode. The approximate position of a segment or marker within the model will aid the visualization of the model, using the marker set defined by the VST. Also, for more complex VSTs, good initial guesses will help the calibrator to converge.

The final group of elements within the <MarkerSet> section of the VST file is the <STICKS> section. Sticks are colored lines that connect 2 individual markers. They are used for display purposes only. Their definition is fairly straightforward. The two markers to connect are specified, followed by an 8-bit RGB colour definition:

```
<Stick MARKER1="MKR1" MARKER2="MKR2" RGB="255 0 0"/>
```

The “Skeleton” section

The final important section in the VST file is the Skeleton section. In the example above, the Skeleton section looks like this:

```
<Skeleton>
  <Segment NAME="Object" POSITION="0 0 0" BOUNDS="-50 -50 -50 50 50 50">
    <JointFree/>
  </Segment>
</Skeleton>
```

For this particular model, the skeleton is simple: Only 1 segment exists named “Object”. This segment can be thought of as the “root” segment, as its parent segment is the world coordinate system.

The “JointFree” joint type is a 6 degree of freedom (DOF) joint, which means that it moves completely freely with respect to the parent segment. The parent segment in this case is the global coordinate system because the segment is the root segment. As the complexity VST files increases, this concept will always remain true; the root segment will always be assigned a <JointFree/> property. Several other joint types exist for kinematic model definition; these will be addressed in Lessons 2 & 5.

The “POSITION” keyword specifies the segment’s position *in the parent segment’s coordinate system*. Since this segment is the root segment, its parent segment is the world coordinate system. In this special case, the values of the position attribute of the segment are somewhat arbitrary, as the subject calibration routine will not take them into

consideration. This is important, because if the root segment should not be constrained to a particular location in the world coordinate system.

The "BOUNDS" keyword specifies a bounding box which is used for display purposes only. Software such as iQ or Polygon will read the bounding box values and display a box in the 3D environments accordingly. The bounding box is defined with respect to the segment's local coordinate system, the first three numbers defining one corner, the last three the opposite.

End of Lesson

You have just learned the structure and contents of the VST file. These concepts will prove invaluable as you begin constructing your own models within Vicon iQ. Key points to take away are:

- VST structure - XML based, hierarchical structure
- VST contents - `<Parameters>` , `<Skeleton>`, and `<MarkerSet>` sections
- VST element attributes - joint, position, constraints, colour, bounds, etc.

Chapter 2 – The Modelling Mode

Introduction

The Modelling mode of Vicon iQ 1.5, is one of the most complex modes, but also the most powerful. It allows you to create, edit, and define your kinematic models, (VST,VSK), constrain your kinematic models, and even set up character mapping for re-targeting.

Lesson 2 – Visualizing a VST file in the Modelling Mode

Introduction This lesson will introduce the Modelling mode within Vicon iQ 1.5. This interface allows you to create and edit all elements of a VST file. This lesson assumes that you have already completed Lesson 1, and are familiar with the contents and structure of VST files.

Step 1: Load a VST file into Vicon iQ Launch Vicon iQ 1.5, and choose File | Open.
Use the "Files of Type" filter to look for ".vst" files, and then browse to the Vicon iQ1.5 installation folder, and to the "Models" directory.

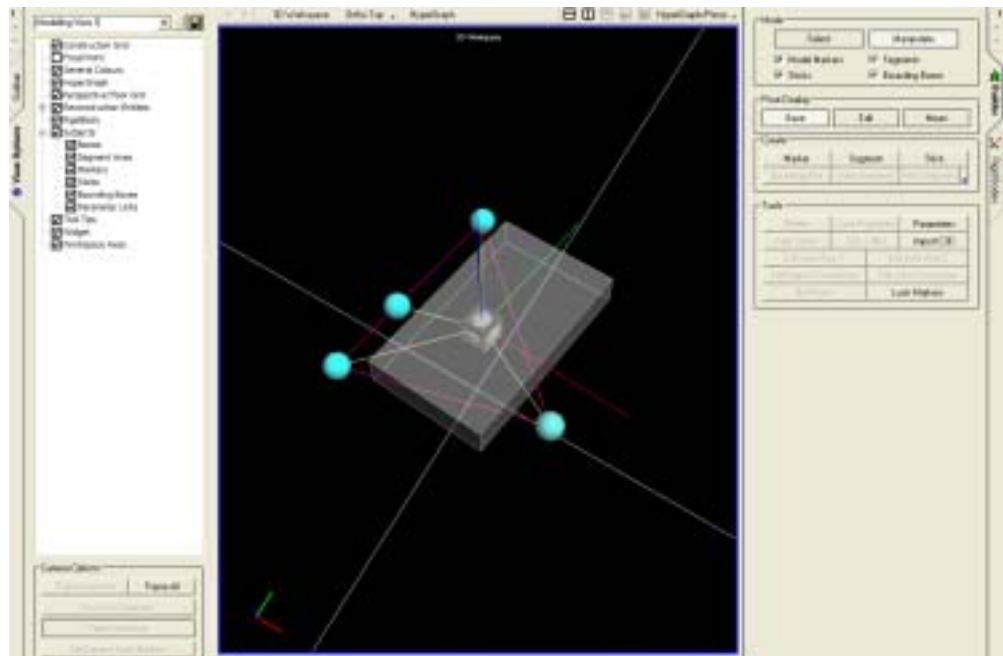
Select and open the 4MKR_Object.vst file. Vicon

Vicon iQ 1.5's modelling mode will automatically launch, and the VST file will be graphically displayed in the 3D workspace.

Manipulate the camera view to zoom in on the VST file, until your workspace resembles the view below.

Check your View Options to the left, and make sure that all elements of the Subjects tree are checked:

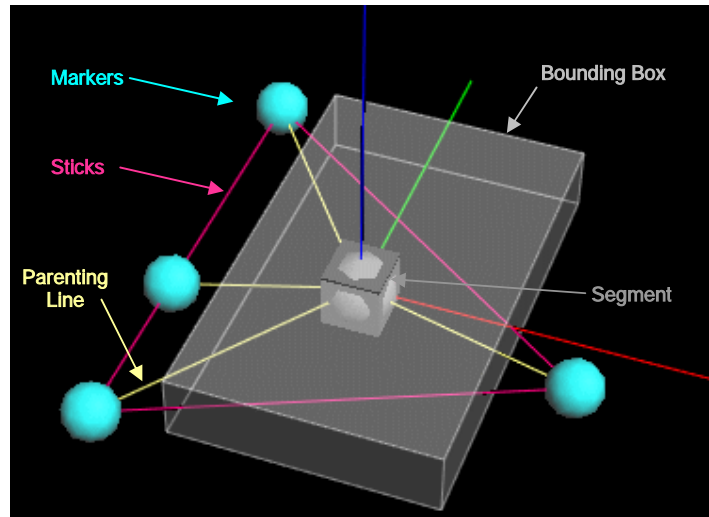
Fig 1: The 4MKR_Object.vst file displayed in the Modelling window



The main elements of the VST file, with the exception of Parameters, can all be visualized in the Workspace:

Markers, Segments, Bounding Boxes, and Sticks. Figure 2 below highlights each of these items in this .vst file:

Fig 2: A Close-up of the 4MKR_Object.vst file, highlighting the various elements of the .vst file



Parenting lines, which are not explicitly part of the .vst file, indicate a marker's parent segment. This information is obtained from the SEGMENT attribute of a marker definition.

The segments representation as a cube/sphere overlay indicates a free joint relationship with its parent segment (the world, in this case).

Different joint attributes, which will be discussed in Lesson 5, will have different graphical representations.

Additionally, the segment's local coordinate system is represented by the thin red, green and blue axis lines emanating from the origin of the segment. Red represents the X-axis, green represents Y, and Blue represents Z.

Step 2: Experiment with Subject's View Options

To make working with VST files easier, the display of each of these elements can be toggled on and off using the View Options pane.

Open the View Option Activity Bar, found on the left hand side of the main Vicon iQ 1.5 window, and click the "+" symbol next to subjects

This will drop down a list of the various elements that can be displayed.

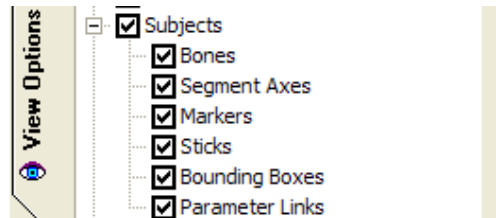
Experiment with toggling on and off each of these items, and note how the display of the 4MKR_Object.vst file changes.

Additionally, the appearance of these different elements can be customized in View Options.

Double-Clicking on "Bones", for example, will bring up an options box that will control how the segments and joints are visualized.

These options really come in handy when editing different sized objects.

Fig. 3: Elements of the Subjects View Options Tree



Note: Nothing is being edited in the VST by changing View Options, only the display in the 3D workspace.

Note: Parameter Links, which will be discussed in Lesson 5, are not present in this particular VST file. You will not notice any change in the display by toggling Parameter Links on/off during this lesson.

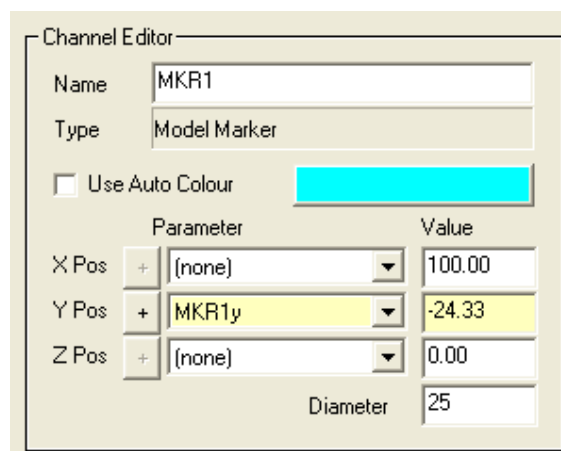
Step 3: Selecting and Editing Markers

Left-click on one of the markers in the 3D workspace.

It will turn bright green to indicate its selection.

In the lower-right portion of the Activity Bar, the Channel Editor for this marker will activate, as shown below:

Fig. 4: The Channel Editor



Tip: As an alternative to selecting the marker in the 3D workspace, you can highlight it in the Model Marker list within the Outliner bar.

Within the Channel Editor, several different attributes about this marker can be altered.

Select MKR1 in the name box, and rename MKR1 to "Tip".

Highlight the turquoise box, and a colour selection palette will appear.

Select a new colour for the marker.

Alternatively, you may wish to toggle the "Use Auto Colour" checkbox. This, when enabled, assigns a colour property of "Auto" in the VST file. Anything with the Auto colour property will be assigned a colour during subject calibration.

Note: As discussed in Tutorial 1, one of the options available to you in the Subject Calibration is the Auto colour property. During the subject calibration, anything from the VST file with an Auto colour property will be assigned the specified colour. This feature is useful for captures involving multiple subjects using the same underlying VST file. By assigning different values to the Auto colour, the appearance of different subjects will be visually different, which improves data visualization and editing efficiency.

The position editing tools are located just below the colour editing tools. Each X, Y, and Z component of the marker's position can be assigned Parameters and Values here.

Start by changing the X-Position of this marker from 100 to 150. Type 150 into the X-Position value box, and then hit Enter.

The marker position will snap to the new position in the workspace.

In the parameter section of the X-Position, the parameter association is set to (none). As described in lesson 1, this means that the X-Position of MKR1 is essentially fixed. The subject calibration routine is not allowed to alter this position during its optimization routine.

This is an example of a model constraint.

In contrast, notice the Y-position. This component is assigned a Parameter of MKR1y, and a value of -24.33. The Value can also be changed here, in the Value text box.

Go ahead and change the value of the Y-component from -24.33 to -45.

Again, the marker will snap into the new location.

Click the small "+" button next to the parameter drop down.

The sign of the value will now change from -45 to +45. This ability to change the sign of parameterized values will come into play later, in Lesson 5.

One crucial distinction exists between altering the X-component and Y-component of this particular marker. In the case of the Y-component rather than changing a "fixed" value, as in the X-component, we have now changed the value of *Parameter* MKR1y. The Y-component, by nature of its parameter association, can be altered by the Subject Calibration routine. Altering this value only alters the starting point of the subject calibration. It's position will be refined to match the input Range of Motion trial. Parameter associations can be re-assigned using the parameter drop-down box. By selecting this, all a given component's parameter association can be changed to any existing parameter in the VST. Or, if a fixed Value is desired, the (none) choice can be selected from the list.

Note: All units within Kinematic Models and that are represented within the Vicon iQ 1.5 Modelling Mode are in millimetres with orientations are in degrees.

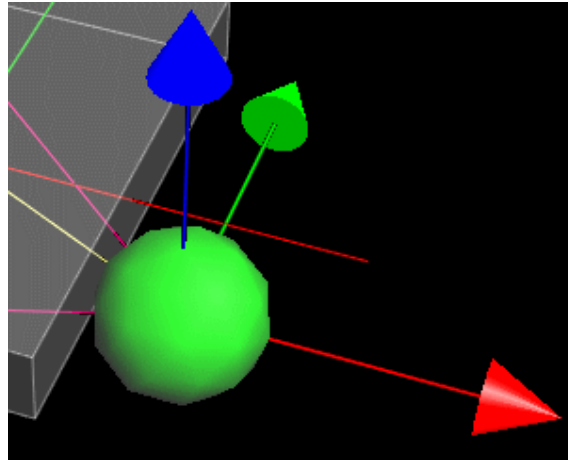
Important Note: However, within the VST file itself, units are in millimetres, but orientations are described as Angle Axis, and radians.

At the bottom of the Channel Editor, the marker diameter can be altered. This marker diameter property is for visualization purposes only. Change the diameter of MKR1 from 25mm to 50mm, and hit Enter.

Note: marker diameter is used for display purposes only in Vicon iQ 1.5. The size of the marker within the model is not used for any labelling or reconstruction processes.

In addition to typing in specific values in the Channel Editor, the position of markers can also be accomplished via manipulators in the 3D workspace. With MKR1 still selected, click the "Manipulate" button in the upper-right of the activity bar.

Fig. 5: Marker selected, in Manipulate Mode



X, Y, and Z manipulation handles will now appear at the marker.

Click and drag on any of the 3 cone heads to alter the markers position along the selected axis.

The Vicon standard Axis-system is Red= X, Y= Green, and Blue = Z. If you keep an eye on the Channel Editor, you can see values change as you drag the marker position to a new location.

Tip: To drag the marker location in increments of 50mm, hold down the CTRL key while dragging a particular axis.

Tip: To drag the marker location within a plane, hold down the SHIFT key while dragging on a particular axis.

After making these changes, it's a good idea to save your work.

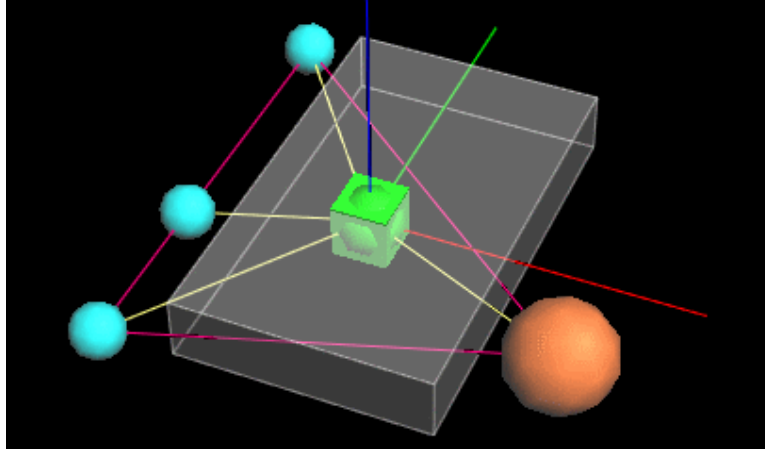
Using the main drop down menu "File->Save As", and save the modified VST as Lesson2.vst

Step 4: Selecting and Editing Segments

In much the same way that we selected and edited a marker's properties in Step 3, we will now select and edit the properties of a segment.

Begin by selecting the segment, either by clicking on it in the workspace, or highlighting the segment "Object" in the Outliner window. The segment will turn green when selected.

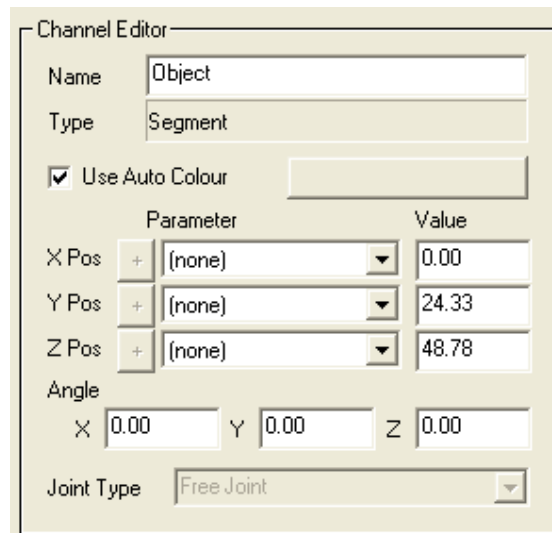
Fig. 6: Segment Selection



Tip: Are you having trouble selecting the segment? It may have to do with the Bounding Box getting in the way. If it is completely surrounding the segment, it could be difficult to select the segment. To fix this, either un-check the display of bounding boxes in View Options, or, in the Mode area of the activity bar, un-check Bounding Boxes. This will disallow the selection of Bounding Boxes in the workspace.

Once the segment is selected, the Channel Editor will again display, allowing you to edit several of the segment's properties.

Fig. 7: Segment Channel Editor



Similar to the Marker Channel Editor, we can change the segment's name, colour, and position attributes using the text boxes and drop-downs.

Change the segment's name from Object to My_Object.

Remove the Auto Colour property, and assign a colour of your choice to the segment.

Position Parameters and Values can be keyed in here, just like in the Marker Channel Editor. Additionally, the angle of the segment with respect to its parent can be altered using the X, Y, and Z angle boxes.

Experiment for a moment with these, noting changes to the segment's position and orientation.

However, keep in mind that we are working with the Root segment of this model. Changes to the position of the root segment have no impact on a calibrated subject, because the root segment's position and orientation will always have a free association with the world. For display purposes when modelling, however, it sometimes makes the display easier to read by altering the root segment's position and orientation.

In addition to typing in specific values in the Channel Editor, the position and orientation of segments can also be accomplished via manipulators in the 3D workspace.

With the segment My_Object still selected, click the Manipulate button in the upper right of the Activity Bar.

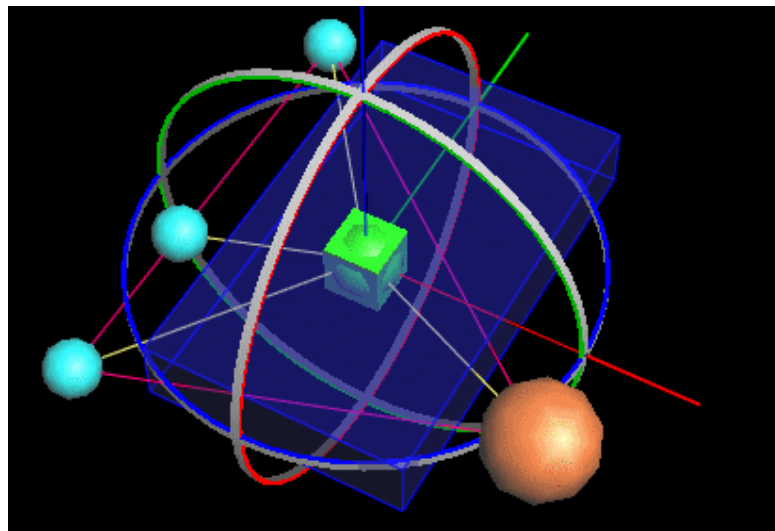
Position adjustment handles will now appear at the segment origin, allowing you to drag the segment to a new location, just like altering a marker's position.

Tip: CTRL and SHIFT keys will constrain the manipulators behaviour similar to that for markers (see above)

Experiment with this a bit, noting that all of the segment's markers move with the segment, as the marker's positions are all expressed in the segment's local coordinate system.

Now, left-click on any of the position adjustment cone-heads. The position adjustment handles will now switch to rotation adjustment handles, represented as 3 hoops.

*Fig. 8: Segment
Rotation
Adjustment
Handles*



Rotations about a given axis can be adjusted by selecting the desired adjustment hoop, and dragging in the desired rotation direction. You will see the orientation of the segment change as the hoop is dragged.

Tip: To move or rotate the segment in 50mm or 15deg intervals, hold down the CTRL key while dragging the manipulator handles.

Step 5: Selecting and Editing Bounding Boxes

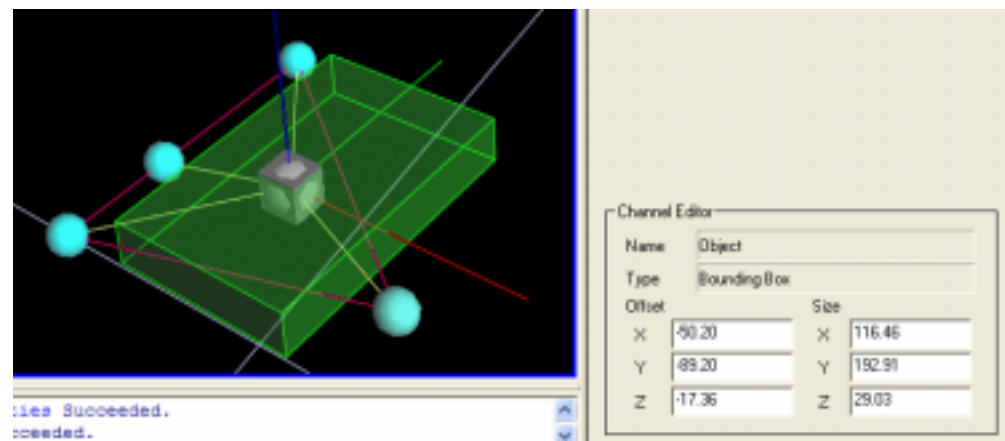
In a similar fashion to Markers and Segments, the properties of Bounding Boxes can be edited in Vicon iQ 1.5 modelling mode.

Note: If you turned off the display or selection of Bounding Boxes during step 4, you will need to un-do your previous action to allow selection of Bounding Boxes.

See the Tip on Page 10 for instructions.

Begin by selecting the bounding box by clicking on it. It will turn green to indicate its selection, and the channel editor for the Bounding Box will appear in the lower left area of the screen.

Fig. 9: Selected Bounding Box, and Bounding Box Channel Editor



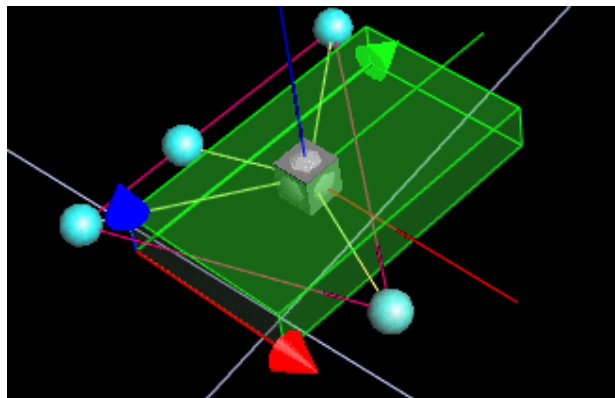
As with Markers and Segments, numerical values can be keyed in to the Offset and Size components in the channel editor. If you recall from Lesson 1, the BOUNDS attribute of a segment is represented by 2 points in space, that represent 2 corners of the box. Corner 1 is reflected in the Offset, and Corner 2 is reflected in the Size.

Key in a few changes to the Offset and Size of the boxes, and notice the changes in the workspace.

The offset and scale can also be manipulated graphically in the workspace. With the bounding box selected, click the Manipulate button in the upper-right portion of the activity bar. Position adjustment handles will appear at the origin of the Box, and you can select a cone-head and drag to a new location.

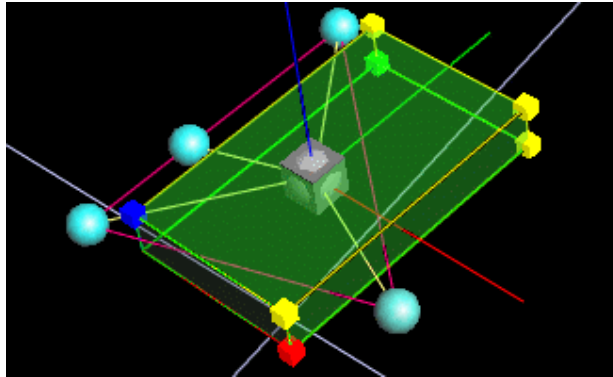
Manipulate the bounding box using these handles to get a feel for the control.

Fig. 10: Bounding Box with Position Adjustment Handles



By left-clicking on any of the cone-heads, the adjustment handles will switch from position adjustment to scale adjustment, represented by small cubes at the vertices of the box. Click and drag the Red, Green or Blue cubes to adjust the size of the box along that axis; Click and drag any of the yellow cubes to uniformly scale the size of the box.

Fig. 11: Bounding Box with Scale Adjustment Handles



Note: The Bounding Boxes are used for visualization purposes only, to help you quickly identify segments and their orientations.

Finish by saving your work, using the main drop down menu "File->Save"

End of Lesson You have reached the end of Lesson 2. In this lesson, we learned the basic editing tools in Vicon IQ 1.5's modelling mode:

- Opening and viewing VST files
- Altering View Options, to alter the appearance of the VST
- Selecting and editing Markers
- Selecting and editing Segments
- Selecting and editing Bounding Boxes

Chapter 3 - Using the Modelling Mode to Create a Subject.

Lesson 3 – Creating a Single Segment VST

Introduction In this lesson, you will create a Single-Segment VST from scratch. The workflow will be useful for creating a VST for any Single-Segment object, such as simple props, head mounted displays, or other items where a small quantity of markers will be used to define a rigid object.

The example to be used is a pair of glasses. The glasses have 5 markers attached to them, and we wish to make a VST for this object. Further, we wish to make the +Y axis the anterior-posterior axis of the glasses, such that when a person is wearing the glasses, +Y will represent their perspective.

For a simple object like this, 4 markers is the minimum recommended quantity. Although it should theoretically only take 3 markers to define the object, the addition of extra markers will add a measure of redundancy to handle the occasional occlusion, and maintain high data quality through the occlusion.

Step 1: Launch Vicon iQ 1.5 Modelling Mode

Begin by launching Vicon iQ 1.5, and clicking on the Modelling mode button.

This will launch the modelling interface, with an empty VST file. You will see a single segment at the origin, with no markers present.

Alternatively, if you have left the model builder open from the last lesson, and wish to start with an empty VST, use the main drop down menu "File->Clear". This will remove the current VST from memory, and load in an empty VST.

Step 2: Import a previously captured C3D file of the Glasses

In the tools area of the Activity Bar, click the Import C3D button.

In the File Name text box, browse for the file:

["UserDatabase\iQ15_Tutorial_Data\Project 1\Capture day 1\Session 2\Lesson3.c3d"](#)

Note: This will have been installed to your install folder for Vicon iQ 1.5. This is typically "C:\Program Files\Vicon"

Set Use T-Pose = No, and enter 1 in the Frame text box.

Once all the options are set, click OK.

Frame 1 of the C3D file will now load into the workspace. You should see 4 white, unlabelled markers appear as in the image below. You may need to adjust your workspace view to see the markers.

Fig. 1: Unlabelled Markers in the Modelling Workspace



Step 3: Rough Adjust of Segment Position to Marker Cluster

In the activity bar's Pose Display area, click the Edit pose.

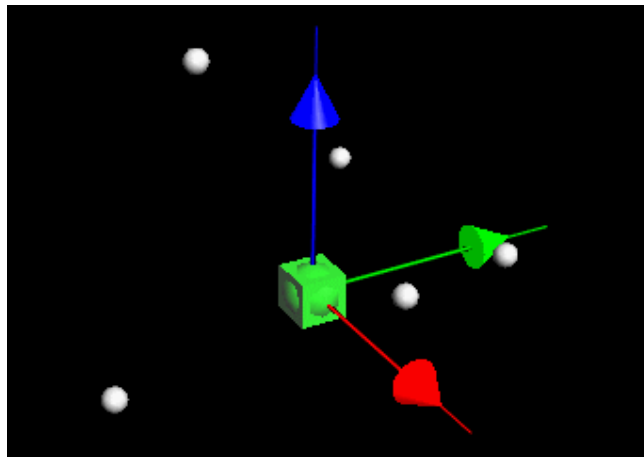
The Edit pose will allow us to manipulate a few items in the model, without actually changing any of the POSITION attributes in the VST.

Now, select the segment, down at the origin, and then click the manipulate button to bring up the position adjustment handles.

Tip: The 'S' hotkey will toggle between Select and Manipulate modes quickly

Move the segment using the position adjustment handles until it is roughly in the middle of the marker cluster in the workspace.

Fig. 2: Unlabelled Markers, with the segment roughly positioned



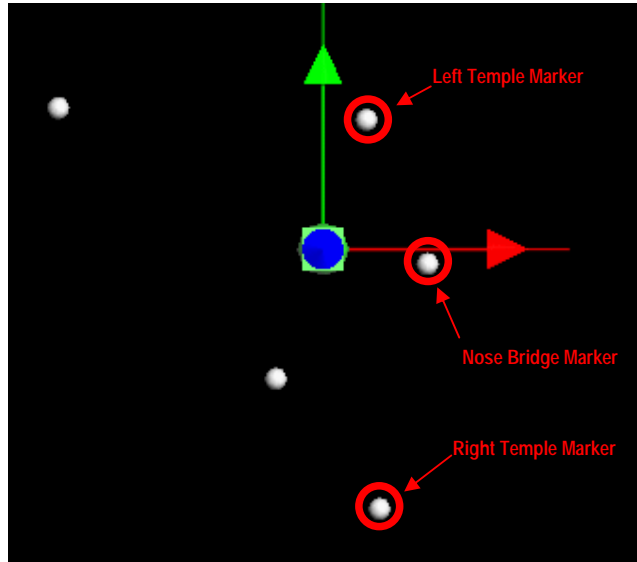
Step 4: Fine Adjust of Segment Orientation and Position to Marker Cluster

As stated in the introduction, it is desired to have the +Y axis facing forward for our subject. Also, the segment origin should be located mid-way between the subject's eyes when wearing the glasses. For the marker set on these glasses, that means that we can use the marker at the bridge of the nose as a guide for setting the segment location. Locating our segment this way will require some fine adjustment of the segment position and orientation.

Begin by selecting Ortho Top view from the Workspace Layer Bar. This will assist us with a purely top view of our segment.

Use the X and Y position adjustment handles to move the segment origin into place. The image below highlights the temple and nose bridge markers, and shows the segment before adjustment.

Fig. 3: Segment Positioned Between Temple Markers, in Ortho Top View

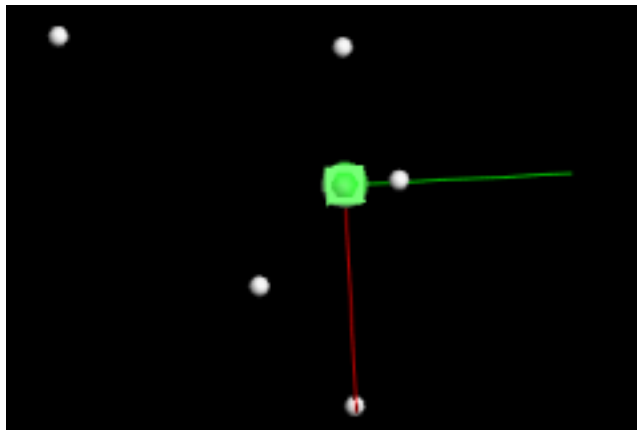


Once the segment is positioned, click the position adjustment handles, and switch to rotation adjustment handles.

Click and drag on the blue hoop, and rotate the segment until the + Y axis (Green) is oriented towards the Nose Bridge Marker.

You may have to iterate a bit between rotation and position to get it right; in the end, your segment orientation and position should ultimately match Figure 4 below.

Fig. 4: Segment Oriented to Desired Axis Orientation

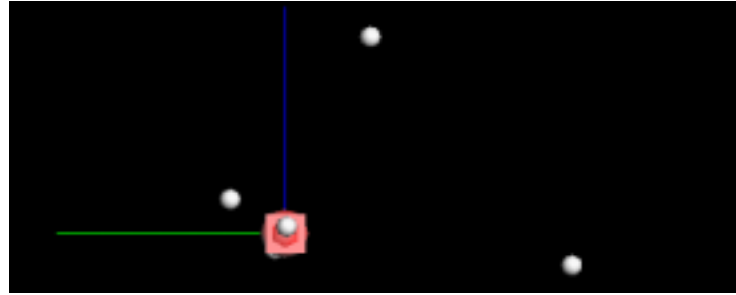


Lastly, we need to adjust the Z-position of the segment.

Use the Workspace View Type (at the top of the 3D Workspace, to select the Ortho Back workspace view.

Zoom in, and then manipulate the segment location to make the segment height equal to the height of the temple markers, as in Figure 5.

Fig. 5: Ortho Back View, with Height-Adjusted Segment Position



Note: The purpose of going through this detailed segment location is to place the segment location properly with respect to the markers. Since we are working with a pair of glasses, it is logical to have the segment location roughly approximate a person's eye-point when wearing the glasses.

Step 4: Generate Model Markers from C3D Marker Positions

Once our segment has been properly located, it is time to generate Model Markers (the markers called out in the <Markers> section of the VST file).

Begin by changing your workspace view back to 3D Workspace in the Workspace Layer Bar.

Next, toggle Select mode by either hitting the S key, or clicking the Select button in the Activity Bar.

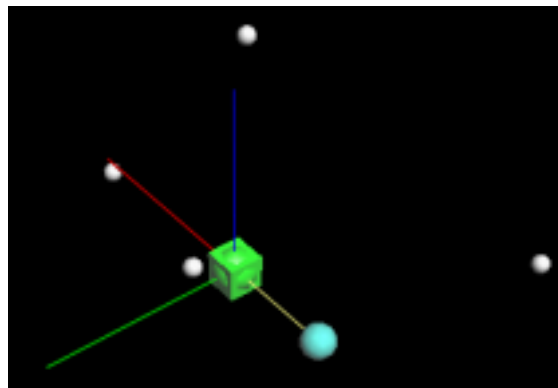
Select the segment, hold down the CTRL key, and select one of the C3D markers.

With both of these items selected, click the "C3d->Mkr" button.

A Model Marker will be created in this position, using the coordinates of the C3D marker, relative to the segment coordinate system.

You have just added a <Marker> to your VST file! Look for a pale yellow parenting line between the new Model Marker and the parent segment.

Fig. 6: Newly created Model Marker, Showing Parenting Line to Segment



Go ahead and finish parenting the remaining 4 markers to your segment.

You can speed this process up a bit by lasso-selecting multiple elements. Simply drag the mouse in the workspace to lasso-select the remaining markers, along with the segment. Click the C3d-Mkr button, and all 4 model markers will be generated.

Save your work using the main drop down menu "File->Save", and save your newly minted VST as "MyLesson3.vst."

Step 5: Edit Segment and Marker Properties

To further edit the VST, it is necessary to switch to the Base Pose Display in the Builder Activity Bar.

Once this is done, the VST's position in the workspace will snap back to the origin, and leave the original C3D file's marker positions unlabelled in the workspace.

Select these 4 C3D markers, and delete them using the delete button in the Activity Bar, or the Delete Key, as they are no longer needed.

Next, we will alter some of our segment and marker properties to make things more intuitive.

By default, the newly created Model Markers were assigned ambiguous names—NewMarker, NewMarker1, etc.

Begin by locating and selecting the various markers, and renaming them to more descriptive names:

LeftTemple for the left temple marker, RightTemple for the Right Temple Marker, NoseBridge for the Nose Bridge Marker, LeftBackHead for the left back head marker, and Snorkel for the remaining marker.

Tip: Although not required, it is recommended to not use any spaces, commas, or slashes in your marker and segment names.

Renaming markers was covered in Lesson 2; but there is an alternative method. Select the Outliner pane from the View Options/Outliner Bar.

Select one of the markers in the Marker List, and double-click. This will bring up a renaming dialog box where you can type a new name for the marker.

By default, the segment is named "Root"; using similar methodology, rename the segment to "Glasses".

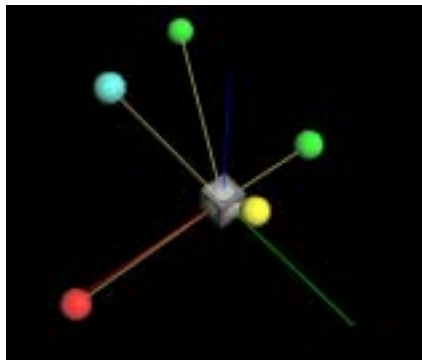
Select the RightTemple marker and re-colour it to red. Similarly, re-colour the LeftTemple and LeftBackHead markers green; make the NoseBridge Marker Yellow.

At this point, with the outliner window displayed, you should also re-order the marker label list. The order displayed in the Outliner will be the order presented to the user when using the VST for manual labelling; it will speed up your efforts to make the order of the label list intuitive.

To re-order the label list, simply select a marker in the list, and drag it to a new location in the list. Adjust your marker label list to the following order: LeftTemple, NoseBridge, RightTemple, LeftBackHead, Snorkel.

Select the Glasses segment, and assign it an Auto-Colour property. Your VST should now resemble the image in Figure 7 below.

Fig. 7: VST file with Edited Segment and Markers



Step 6: Add Visualization Elements to VST

You should now add sticks and bounding boxes to your VST file. While not specifically required from a functionality standpoint, these visual elements will help you quickly identify markers and segment orientations when using Vicon iQ 1.5.

To create sticks, first click the Stick button in Create section of the Builder Activity Bar.

Next, create a stick between the LeftBackHead and LeftTemple markers by selecting the markers sequentially.

Once created, re-colour the stick to green by selecting it, then using the Channel Editor to select Green.

Next, select the LeftTemple Marker and the NoseBridge marker to draw a second stick. This stick should be drawn green by default.

Now select the RightTemple marker, which will then draw a stick between NoseBridge and RightTemple. Re-colour this stick to Red.

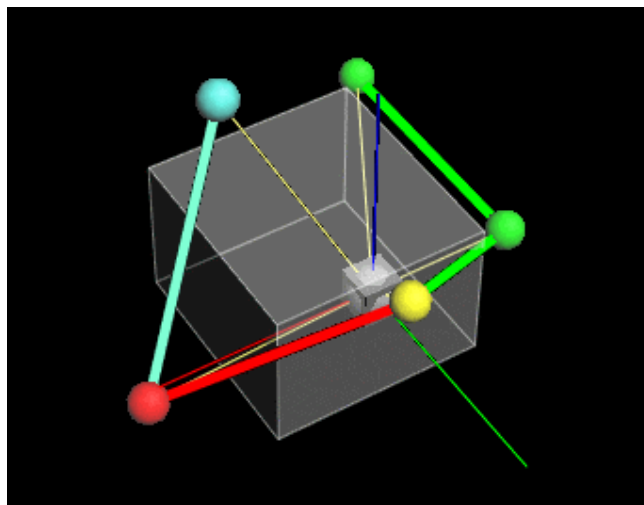
Finally, select the RightTemple marker, followed by the Snorkel marker. Re-Colour this stick Turquoise.

As a final visual element, create a Bounding Box by first selecting the segment, and then clicking the Bounding Box button in the Activity Bar's Create area.

Note: Bounding Boxes must be visualized in View Options in order to create Bounding Boxes.

Select the Bounding Box, and adjust its size and proportions to your liking. Your VST should now resemble Figure 8.

Fig. 8: VST with Sticks and Bounding Boxes



Save your work at this point, using main drop down menu "File->Save".

Step 8: Add Constraints to the VST

As a final step, it is time to decide on the appropriate constraints for this model.

Let us recall from lesson 1 the concept of a parameterized value versus a constrained value.

By default, all of our markers were created by the Model Builder as fully parameterized, i.e. there are no constraints on this model. The subject calibration optimization routine will freely adjust all positions of all of the markers to match an input ROM trial.

Depending on the work to be done, this totally unconstrained model may work fine.

If the model is being created solely for the purpose of producing correctly labelled trajectories, then the unconstrained model should work fine.

A given pair of glasses, with 5 markers randomly positioned anywhere on the glasses, could be used as a subject with this VST file.

Because the marker positions are totally unconstrained (parameterized) in the VST, the subject calibration is allowed to adjust the dimensions of the resultant VSK to match the input ROM trial. If we do this, the resultant VSK will accurately work for trajectory labelling and gap filling.

However, because the model is unconstrained, the decision of where to locate of the Glasses segment (root segment) will be left to the subject calibration process, and could be placed in an undesirable position for our needs.

The goal of this model was initially defined to have certain end results: the +Y axis of the calibrated VSK should represent the eye view of a person wearing the glasses.

The segment's axis system should be aligned with the horizon when the subject's head is at a level position. These goals will ensure the most reasonable and realistic representation of our subject. To ensure that these goals will be met, constraints need to be added to the VST file which will restrict the subject calibrator's ability to freely adjust segment and marker positions.

One way to constrain the model, as already discussed, is to remove Parameter associations.

Select the "LeftTemple" marker. In the channel editor section of the Activity Bar, change the Z Pos Parameter association from LeftTemplez to (none).

This will constrain the optimization such that the Z-component of the LeftTemple marker MUST be the value specified in any resulting VSK. This should force the height of our Glasses segment to be consistently this value.

Repeat this procedure for the Y Pos component.

Next, select the NoseBridge marker, and change the X Pos Parameter association from NoseBridgex to (none). Similar to the Left Temple, this will constrain the position of the segment/marker relationship in the X-direction.

The segment location has now been constrained in all 3 dimensions. Theoretically, *any* 5 marker object, when calibrated with this VST, will have its segment constructed to be these 3 Non-parameterized values with respect to the LeftTemple and NoseBridge markers.

For the glasses result to be meaningful and realistic this implies that the markers on a pair of glasses to be calibrated should have some characteristic marker positions: the left temple marker should be placed as evenly with the subject's eye as possible in the anterior/posterior and vertical directions. Also, the nose bridge marker should be placed approximately in the middle eyes.

Conversely, the 3 remaining markers (RightTemple, LeftBackHead, and Snorkel), are all completely parameterized (un-constrained). Physical placement of these 3 markers will

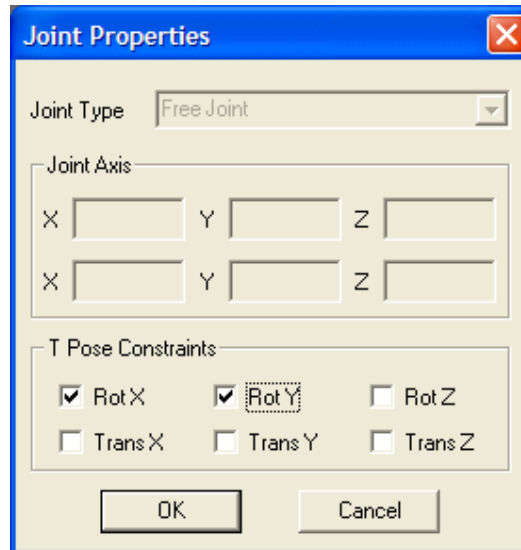
not affect the segment's location and orientation, and the Subject Calibrator will fully optimize their positions in the resulting VSK.

The segment's position has now been constrained, but not the rotation.

As stated above, the goal for this model was to have the orientation of the segment represent the subject's perspective; to ensure this, we will need to constrain the segment rotations as well.

Select the segment, and then click the "Joint Properties" button in the Tools palette of the Activity Bar.

Figure 9: Joint Properties Dialog Box



Check the Rot X and Rot Y tick-boxes. By doing this we are constraining the orientation of the segment at the T-Pose frame. This frame, specified just before performing a subject calibration, should have the subject in a consistent, known pose. Because of this, assumptions can be made about certain joint orientations at this frame.

By enabling these T-Pose constraints, the VST file specifies that at the T-pose frame, the X-axis and Y-axis orientation of the Glasses segment shall be exactly 0 degrees, with respect to the parent segment (the world coordinate system, in this case). This will ensure that the elevation and roll of our segment match the perspective of a subject wearing the glasses.

What about Rot Z, and the Trans X, Y, and Z components? Why not constrain those as well?

These would be very bad constraints for this model, if you think about the optimization process a bit. If we restricted the Rot Z direction, as well as X and Y, then all rotations for the segment would be fixed at 0, 0, 0 at the T-pose frame with respect to the world. But what if our subject was not perfectly lined up with the world coordinate system? Then the segment would be over-constrained, the azimuth of the subject would possibly face the wrong way, and our model would not achieve the desired results. Similarly, if we constrain the Trans X, Y, and Z components, then the location of the segment would change depending on where the subject stood in our volume with every subsequent subject calibration. The goal of having the segment placed mid-sagittally, at the subject's eye, would not be achieved as well.

Note: This is a crucial point to grasp—over-constraining your models can produce undesirable results.

The components of the joint that can be constrained in this way will vary with different joint types. A 6 DOF free joint, such as our glasses segment, can be constrained in each

of its 6 degrees of freedom. A 1 DOF hinge joint, on the other hand, will only have 1 T-pose constraint available. Lesson 4 will explore this topic further. For now, tick the Rot X and Rot Y boxes, and close the Joint Properties window with OK.

To end the lesson, save your work.

End of Lesson You have reached the end of Lesson 3. This lesson introduced several important concepts necessary to create models in Vicon iQ 1.5:

- Using the C3D import functionality to generate accurate starting points for model construction
- Editing Segment and Marker Properties
- Adding Visual identifiers to VSTs: sticks and bounding boxes.
- Constraining the model properly to meet the goals of the tracking application

A Final Thought The lesson began by using an imported C3D file which was an actual pair of glasses with 5 markers.

We then built up a VST of this marker pattern, using the Vicon measured marker positions.

Constraints and visual aids were added, but the marker positions in this VST exactly match the marker positions from the glasses. Essentially, for this *specific* object, we have already done the work of the Subject Calibration optimization process.

If we want to now track this *specific* pair of glasses, it is perfectly acceptable to save the VST constructed in lesson 4 as a VSK. This subject specific, calibrated subject, can be used for labelling, gap filling, and real time visualization for this specific pair of glasses.

To save the VST file as a VSK, simply choose File->Save As from the main drop down menu.... and, in the Save as type: drop-down, select Vicon Calibrated Skeleton File (*.vsk). MyObjectLesson3.vsk will be saved to disk, and available for you to import in the Subjects Activity Bar of Vicon iQ 1.5's Post-Processing mode.

Chapter 4 – Creating a more complex VST

Lesson 4: Creating a complex Upper body model

Introduction In this lesson, you will add on to the Glasses VST example created in Lesson 3. The model complexity will be increased to include the torso, arms, and hands of the subject.

The thorax segment shall include 5 markers, 2 chest and 3 back markers. 3 shoulder markers, upper arm, elbow, and forearm markers will define the arm. 3 markers will define the hand. The model will be constrained such that, when in a T-pose position, the segment orientations should generally align such that +X points anterior, +Y points to the subject's left, and +Z points vertically upward.

Step 1: Create Left Clavicle, Shoulder, Forearm, and Hand Segments Begin by opening the example Lesson4.vst. (Found in your "models" directory)
 Make a unique copy of this model by using File->Save As and call it "MyLesson4.vst."
 This file should look somewhat familiar; the head segment is the finished glasses model from product from Lesson 3.

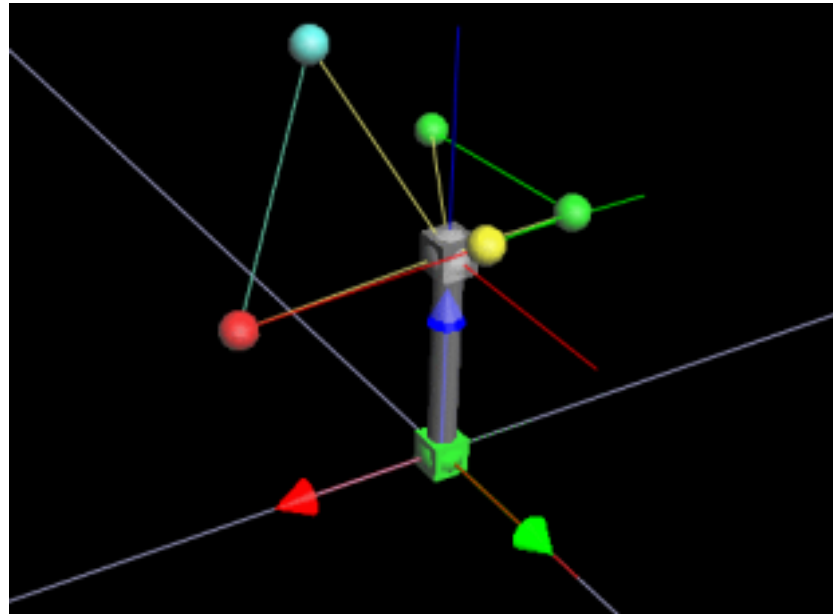
However, there is now a second segment added to the model, and this new segment is at the world origin.

We have added a new root segment, and specified the glasses segment as a child of this segment.

As a general rule, for more complex models, it is desirable to make the root segment central to the physical hierarchy of the skeleton. In typical full-body models, either the pelvis or thorax segments are the typical root segments.

For this upper-body only model, all joint hierarchy will branch from the thorax, making it the logical choice for the root segment.

*Fig. 1:
Lesson4.vst*



Using the View Pane Layout Bar, select Ortho Front view, and zoom in tight to the model that we are working on.

In the Builder Activity Bar's Create area, click the Segment button. This will enter the Create Segment Tool mode.

Note: You can exit out of any of the tool modes, by pressing the ESCAPE key.

To create a new segment, the parent segment must first be selected.

Click on the thorax segment to select it, and then click your mouse anywhere in the workspace. The new child segment will be created at the cursor location.

Rename this segment LeftClavicle.

Exit the Create Segment Tool mode, by clicking on the button again, or by pressing the ESCAPE key.

Switch to Manipulate mode.

Using channel Editor, key in (0, 40, 0) for the segment location.

Click the Create Segment button again.

The LeftClavicle segment should still be selected.

Click the mouse to the left of the LeftClavicle to create another new segment.

Key in (0, 200, 50) for its position, and rename this new segment to LeftShoulder.

Back in the workspace, click to the left of the LeftShoulder segment to create yet another new segment.

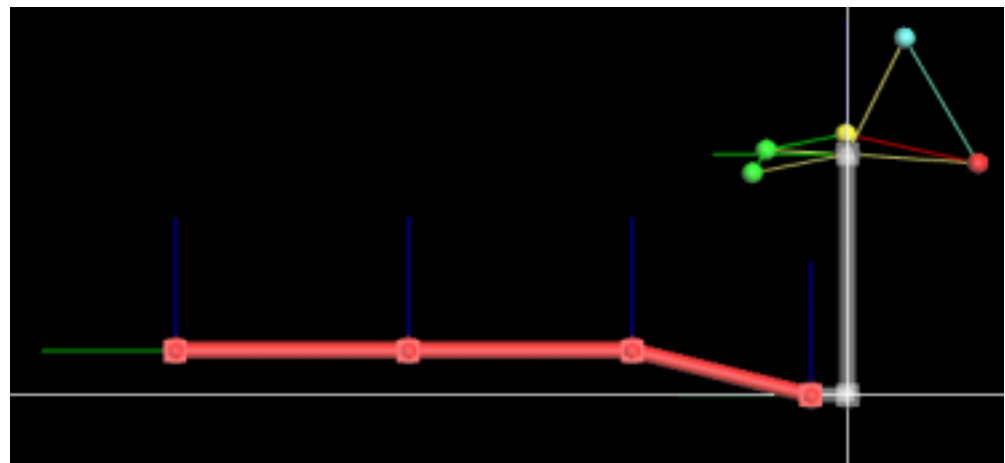
Key in (0, 250, 0) for its values and LeftArm for its name.

Repeat again, to create another new segment.

Key in (0, 260, 0) for the values, and LeftHand for the name.

When finished with all of these steps, your VST should now look like Figure 2.

Fig. 2: Left Arm Segments



Step 2: Create Torso Markers Switch to Ortho Left Side view in the Workspace Layer bar. Zoom in to the subject, and select the Thorax segment.

Within the Builder Activity Bar, within the "Create" group, Click on the "Marker" button, this will enter the Create Marker tool Mode.

Click in the workspace to create a marker parented to the Thorax segment.

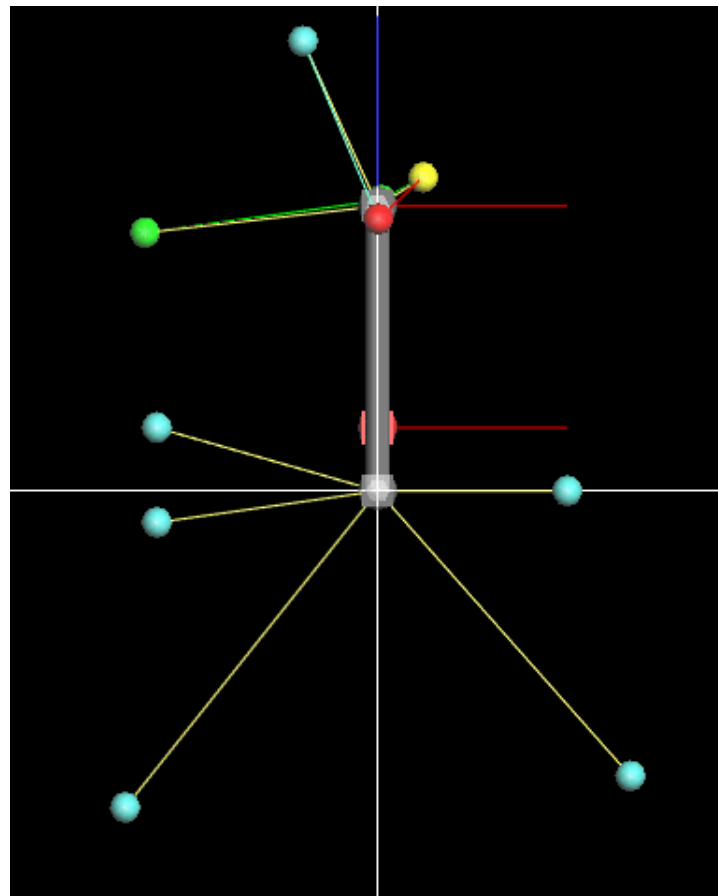
Name this marker TopChest, and give it coordinates of (150, 0, 0).

Repeat this procedure to add an additional 4 markers to the Torso segment, and give the markers the following properties:

Name	X Pos Value	Y Pos Value	Z Pos Value
LowerChest	200	0	-225
LowerBack	-200	0	-250
RightBack	-175	-100	-25
TopBack	-175	0	50

Your VST should now resemble Figure 3.

Figure 3: Ortho Left Side with Thorax Markers

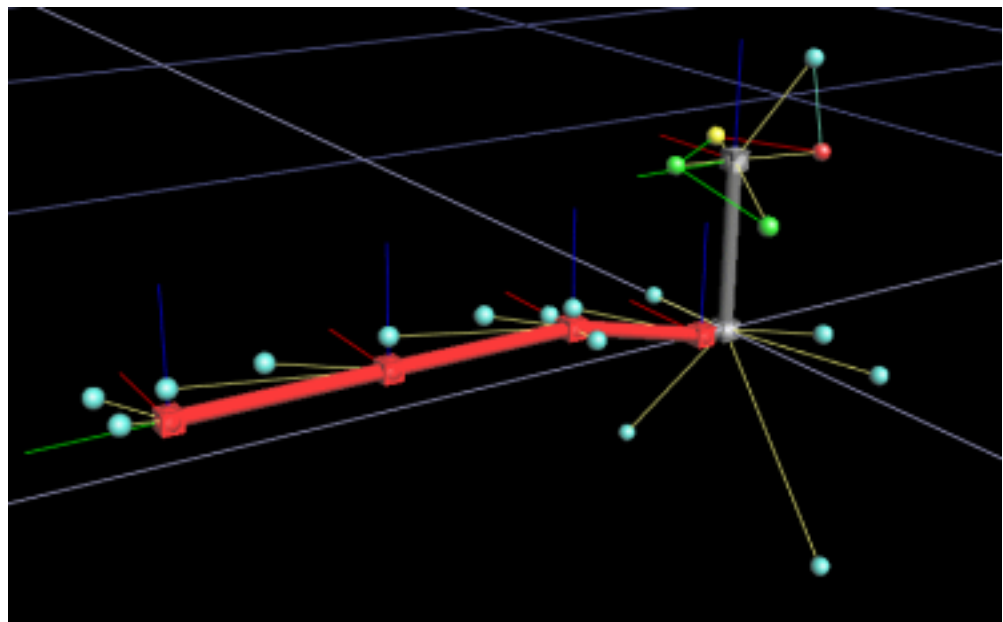


Step 4: Create Left Arm Markers You should now be familiar with the procedure to create a marker parented to a particular segment. Create all the markers for the left arm in this way, using the following table as a reference:

Marker Name	Parent Segment	X Pos Value	Y Pos Value	Z Pos Value
LShoulder	LeftClavicle	0	200	75
LFrontShoulder	LeftShoulder	50	0	0
LBackShoulder	LeftShoulder	-50	0	0
LUpArm	LeftShoulder	0	125	40
LElbow	LeftShoulder	0	250	40
LForearm	LeftArm	0	150	40
LWrist	LeftArm	0	260	35
LIndex	LeftHand	40	50	25
LPinky	LeftHand	-40	50	25

Your VST should now resemble Figure 4.

Fig. 4: Left Arm Markers and Segments Created



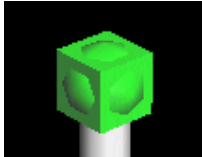


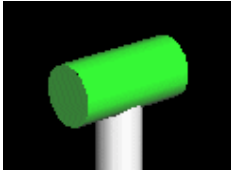

Note: Typically a model is constructed with generic marker and segment placement, that will then be constrained using parameter assignments, and constructed so that the subject calibration process correctly deduces the marker and segment positions. The creation process above is just specific to this tutorial, to ensure consistent results.

Step 5: Adjust Joint Properties of Left Arm

By default, all of our joints were created as 6 DOF free joints.

However, we know that our subject's motion will be limited in many of the joints (we are tracking a human after all.). We should, therefore, alter some of the joint properties to more closely reflect human motion.

There are 5 different joint types available for Vicon iQ 1.5 subjects. The table below describes the various joint options:

Joint Type	Degrees of Freedom	Graphical Representation in iQ 1.5 Subject
Free Joint	6 (X, Y, Z rotation and position)	
Ball Joint	3 (X, Y, Z rotation)	
Hardy-Spicer Joint	2 (2-Axes of rotation; axes are user specified)	
Hinge Joint	1 (1 Axis of rotation; axis is user-specified)	
Rigid Joint	0	

Begin by selecting the LeftClavicle segment.

In the channel editor, change the Joint Type from Free Joint to Hardy-Spicer Joint.

Notice the default orientation of the 2 joint rotations. The rotation axes should be changed to match the expected subject motion. Looking at the segment's orientation, the X and Z axes should be the rotation axes of the joint.

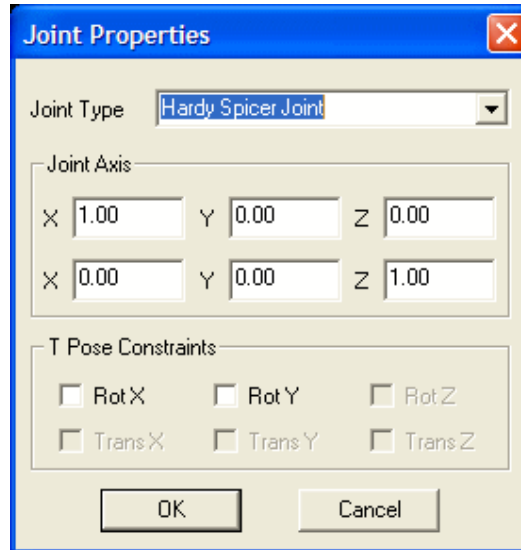
In the Tools area of the Activity Bar, select Joint Properties.

Note: This can also be brought up by pressing the "P" key.

To change the joint rotation axes, the Joint Axis boxes need to be altered.

These numbers represent unit vectors that define the 2 joint rotation axes in its local reference system. Change the second rotation axis to the Z-axis, as in figure 5.

Fig. 5: Joint Properties Dialog Box



Select the LeftShoulder segment, and change its Joint Type from Free Joint to Ball Joint.

Select the LeftArm segment, and change its Joint Type from Free Joint to Hinge Joint. The default rotation axis is incorrect, as with the Clavicle segment. Select Joint Properties, and edit its Joint Axis unit vector to [0, 0, 1].

Select the LeftHand segment, and change its Joint Type from Free Joint to Ball Joint.

Note: Later you will discover how to edit/manipulate the joint axes directly in the 3D workspace.

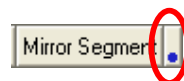
Step 6: Mirror Left Arm Segments and Markers to Right Arm

With the left arm segments and markers constructed, it is now time to work on the right arm. Using Vicon iQ 1.5, the segments and markers can easily be mirrored to minimize the amount of work.

Select the LeftClavicle segment.

In the Activity Bar Tools area, select the Mirror Segment options button

Fig. 6 Mirror Segment Options Button



For the options, select the X-Z plane as the mirror plane, and CopyMarkers = Yes.

Close the dialog box, and then click the Mirror Segment Button. Vicon iQ 1.5 will now remember these settings for you.

The LeftClavicle segment, along with all of its child segments, and markers, will be mirrored to the right side of the subject.

The newly created segments and markers, unfortunately, will all be given default names and properties. These need to be changed as follows:

Select the Right Clavicle segment, and rename from NewSegment to RightClavicle.

Change its Joint Type from Free Joint to Hardy Spicer Joint

Edit the Joint Properties, making the X and Z axes the joint rotation axes.

Select the Right Shoulder Joint, and rename to RightShoulder. Change the Joint Type from Free Joint to Ball Joint.

Select the Right Elbow Joint, and rename to RightArm. Change the Joint Type from Free Joint to Hinge Joint. Edit the Joint Properties to make the Z-Axis the joint rotation axis.

Select the Right Hand Joint, and rename to RightHand. Change the Joint Type from Free Joint to Ball Joint.

Using the Left Side markers as a guide, rename all the right arm markers in a similar fashion - RShoulder, RFrontShoulder, etc.

Tip: You can use the Outliner to easily select, double-click, and rename markers. When you select a marker in the Outliner, it will turn green in the workspace to indicate its selection.

Save your work.

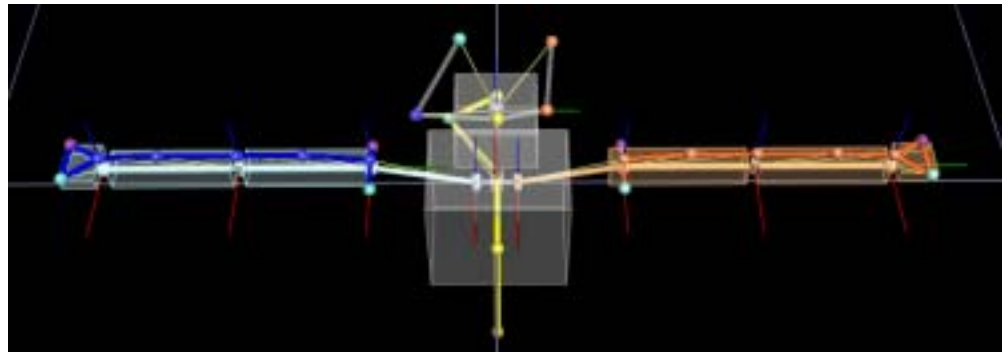
Step 7: Add Sticks and Bounding Boxes

Using the skills and techniques introduced in the previous lesson, add sticks and bounding boxes to your model. Use any colouring and connection scheme that you find visually intuitive and appealing.

Tip: Multiple Items can be simultaneously re-coloured. Use either lasso-select, or hold down the CTRL key to selecting multiple items. Once multiple items are selected, apply the colour change in the Channel Editor, and the change will apply to all items selected.

Tip: Multiple items can also be selected from the Outliner, using either CTRL or SHIFT keys.

Fig. 7: VST with coloured markers, sticks, and bounding boxes



Tip: Don't forget about the Auto-Colour property, discussed in Lesson 2. It's a good idea to give at least some of the items in your VST the Auto-colour Property, especially if you do any multi-subject captures. In this example, the Thorax and Head segments, along with the head marker's sticks, are assigned the Auto-Colour property.

You should also rearrange the marker order, to make manual labelling more efficient when using the VST. This work, described in lesson 3, involves simply rearranging the marker list in the Outliner window.

Simply click and drag the marker labels in the Outliner window, and re-order in a sequence that makes logical sense - top to bottom, left to right, etc.

Save your work.

Step 8: Constrain the Left Arm of the Model

So far, our model constraints have been left to the defaults. All markers currently are fully unconstrained, with 3 unique parameters for each marker. All segments are fully constrained, with no parameter associations.

To illustrate the different results that can be produced with different constraints, the model will be partially constrained: the right arm's constraints will be left with the defaults - a rigid skeleton, and unconstrained markers. The left arm will have modified constraints, which you will create.

Then, the model will be calibrated against a previously captured ROM trial, and the results of the left and right sides will be compared.

When thinking about how to constrain a model, recall an important point from Lesson 1:

"The segment is defined by the markers, not the other way around. Ultimately, the only things that will be known are the marker positions and all segments must be defined with respect to the markers."

With that in mind, you will usually get the most consistently good results by constraining segment locations to marker locations when feasible. Several techniques will be used in the following steps to tie segment locations to marker positions.

Begin by constraining the thorax segment. Ideally, we would like the origin of this segment to lie in the centre of our subject - both left/right and front/back. The only way to guarantee this is with constraints.

Select the TopChest marker.

Remove Parameter association from the Y and Z components. This will fix the location of the Thorax segment vertically and laterally to the location of the TopChest marker. Provided that the TopChest marker is centered on our actor, then this constraint will fix the left/right placement of the thorax segment.

Select the TopBack marker. For its X component, select the Parameter drop-down, and choose TopChestx as its parameter association. It will jump to that value, namely +150mm, which isn't close at all to where it started

Click the small '+' button next to the parameter to change the sign of the parameter value, to -150 mm.

What have we done here? Several ways to constrain a model have been discussed in previous lessons. However, as a final way to constrain a model, parameters can be *shared* between elements of a VST. Previous discussions have treated parameters as the opposite of constraints. But in this case, by forcing 2 different items to have the same parameter, the definition of the model is constrained. Often this technique is used to fix segment locations mid-way between 2 markers, and that is what we have done in this step. By specifying that the X-component of both the TopBack and TopChest markers have to be the exact same magnitude, the location of the parent segment (Thorax, in this case) must be mid-way between the 2 markers in the X-direction.

The X, Y, and Z locations of the Thorax segment have now been constrained. What about the clavicles? The clavicle segments, by default, are totally constrained. Their relationship to the thorax segment is fixed by default. This will work for our model, as the specific location of the clavicle segments is not terribly important, as long as they are close to the centreline of the body, their motion should be just fine. No changes are necessary to the clavicle segments.

To obtain the most realistic motion of the shoulder joint, its location should be constrained to lie within the triad of markers on the subject's shoulder.

Select the LeftShoulder segment.

Assign its Y Position the Parameter LShouldery. By sharing the Y-parameter between the LShoulder marker and the LeftShoulder segment, we are constraining the segment location to match the LeftShoulder marker's Y-position.

Select the LFrontShoulder marker.

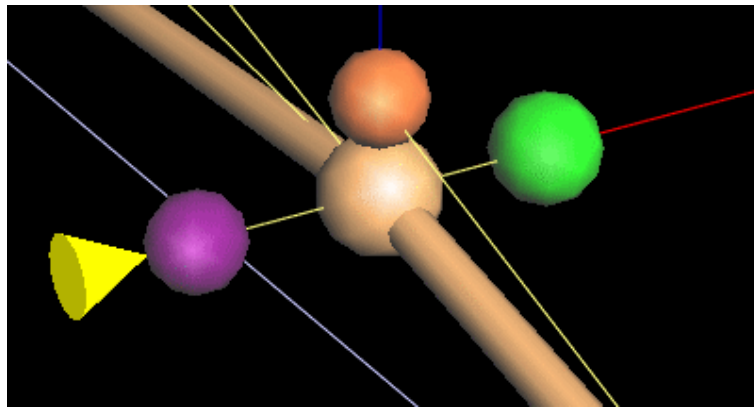
Remove its Z-Position parameter association, locking the height of the LeftShoulder segment.

Finally, select the LBackShoulder marker. Change its X-Position parameter to LFrontShoulder x, and then click the '+' button to change sign. This shared parameter forces the shoulder segment to be located mid-way between the front and back shoulder markers.

Shared parameter links can be visualized in the workspace. To display parameter links, they need to be toggled on in View Options>>Subjects>>Parameter Links.

When markers or segments have shared parameters, yellow cones will indicate the shared relationship (see Figure 8). By hovering your mouse pointer over the cone, a popup will specify the shared parameter(s).

Fig. 8: Shared Parameters in the Shoulder Markers



Note: If you now select either of the shoulder markers, and adjust their X-position, the X-position will change in both markers, since the X components are referring to the common parameter

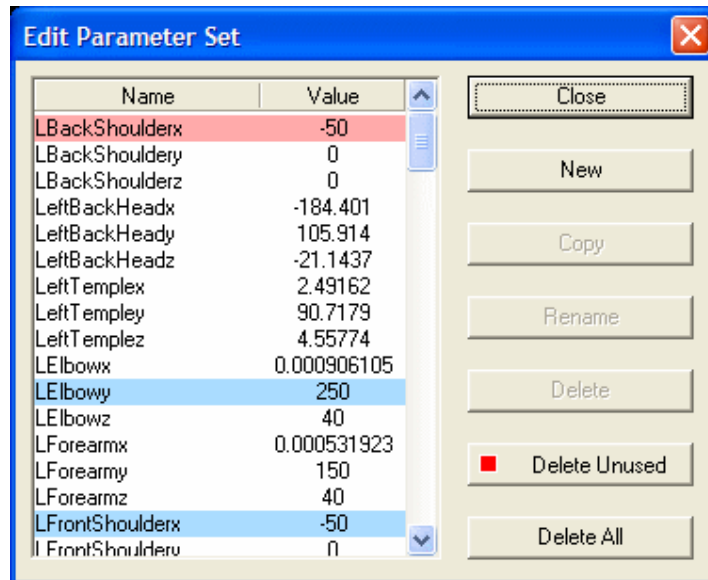
Assuming that the elbow markers are positioned at the elbow joint, it is desirable to have the arm segment origins positioned there as well. To do this, we need to constrain the elbow joint location to the elbow marker.

Select the LeftArm segment. Change the Y-Position parameter association from (none) to LElbowy. This will force the segment location to match the marker location in the Y-direction.

The X and Z positions of this joint are still constrained. Is this desirable? Probably not. It is unlikely that an actual human will have such a perfectly aligned skeleton. For this reason, the constraints on the X and Z directions should be removed. However, you do not want to share any existing parameters with markers. Instead, you should make new, unique parameters for these 2 components.

Click the Parameters button in the Activity Bar Tools area. This will bring up the Edit Parameter Set dialog box.

Fig. 9: Edit Parameter Set Dialog Box



This dialog box has multiple tools for editing the <Parameters> section of the VST.

Parameters can be created, renamed, copied, and deleted. Shared parameters are highlighted in blue, and unused parameters are highlighted in pink.

Click the New button, and create a parameter named LEIbow_x.

Repeat for a second parameter, LEIbow_z, and close the dialog box.

Assign the X Position of the LeftElbow segment the parameter LEIbow_x. Assign the Z Position of the LeftElbow segment the parameter LEIbow_z.

Select the LeftHand segment. It is desirable to have the Hand segment located near the Wrist marker. To force this constraint, change the Y-position parameter association of the segment from (none) to LWristy. Change the X-position parameter association to LWristx.

For the hand segment, only the X and Y directions are constrained. The Subject Calibrator should be allowed to optimize the Z direction. Create a new, unique parameter called LHand_z, and assign it to the LeftHand Z Position.

Step 9: Test the Model The model has been partially constrained. Using your knowledge of the Subject Calibration procedure explained in Tutorial 1, open up the Lesson4.c3d file, and complete the subject calibration procedure using your MyLesson4.vst file.

The "Lesson4.c3d" can be found in:

"UserDatabase\iQ15_Tutorial_Data\Project 1\Capture day 1\Session 2\Lesson3.c3d"

Note: This will have been installed to your install folder for Vicon iQ 1.5. This is typically "C:\Program Files\Vicon"

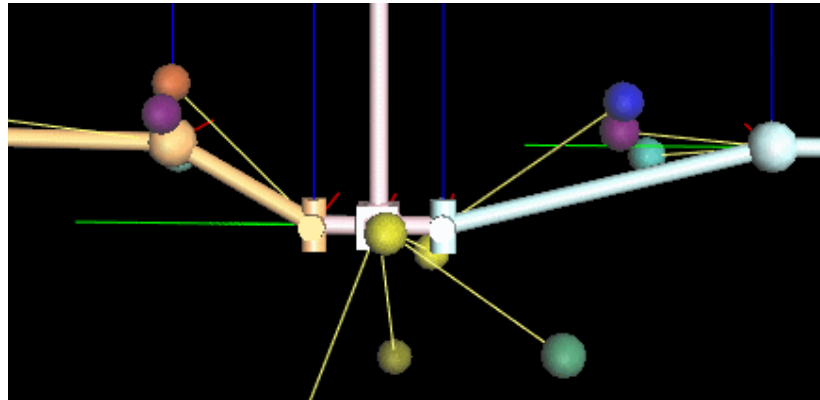
Once the subject calibration is complete, click the Base Pose display in the Subjects Activity Bar, and examine your newly calibrated subject.

Can you notice any differences in the left and right arms? By over-constraining skeleton of the VST's right arm, the optimization routine produced some undesirable results. See Figure 9 below.

Save the Post-Processing work by choosing File->Save, and create a Lesson4.trial file for later use.

Note: This will be automatically saved to the same location that the "Lesson4.c3d" was loaded from.

Fig 9: Comparison of Left vs. Right Shoulders



Due to the over-constrained right arm, the segment location is positioned far away from our shoulder markers. The rotations produced from this segment would probably not be as realistic as those produced on the left shoulder, where the shoulder joint was properly constrained to lie within the shoulder marker cluster.

Similar observations can be seen in the elbow and wrist joints of the right arm compared to the left arm.

This exercise demonstrates the importance of properly constraining the model. For the best possible results, it is crucial to get the right balance of constraints in your model. Models can be over and under constrained, and in both cases, the quality of your end results will suffer.

Step 10: Adjust Right Arm Constraints, replace the Subject, and Test the Model

You have just seen the results of properly and improperly constrained models. To finish out this Lesson, return to Vicon iQ 1.5's modelling mode.

Mirror the left arm's constraints to the right arm, using the same processes outlined in step 8.

Save your work when finished.

Go back to Post-Processing mode.

You will now perform an easy workflow for replacing subjects.

Often, when working with new models, a little trial and error is necessary. Getting the right balance of constraints in your VST will not happen right away; sometimes it will take several iterations to produce the best VST for your work.

In Post-Processing mode open the Lesson4.trial file created in step 9.

At this point, you should have a fully labelled trial, with the poorly constrained VSK as the subject.

We have a new VST to test; within the subjects tab, we can easily replace the existing VSK with a new generic subject, and transfer all of the existing labelled trajectory information to the new generic subject.

Select the "Subjects" Activity Bar.

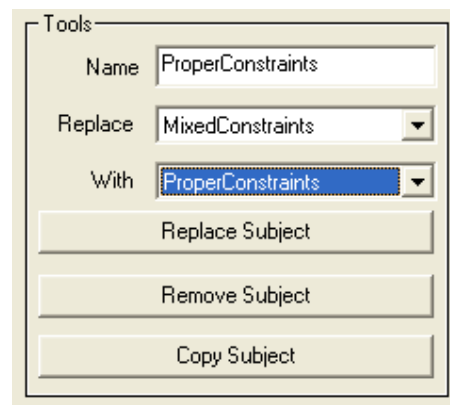
Click the Create Generic Subject (VST) button.

Locate your MyLesson4.vst file as the template, create a new subject name, and choose OK. You should now see a second subject in the trial, near the origin of the workspace.

In the lower portion of the activity bar, look for the Tools section. Using the 2 drop downs, enter the original subject in the "Replace" box, and the new, uncalibrated subject in the "With" box, as in Figure 11 below.

Click the Replace Subject Button. All the labelled trajectory data from the original subject will be transferred to the new subject.

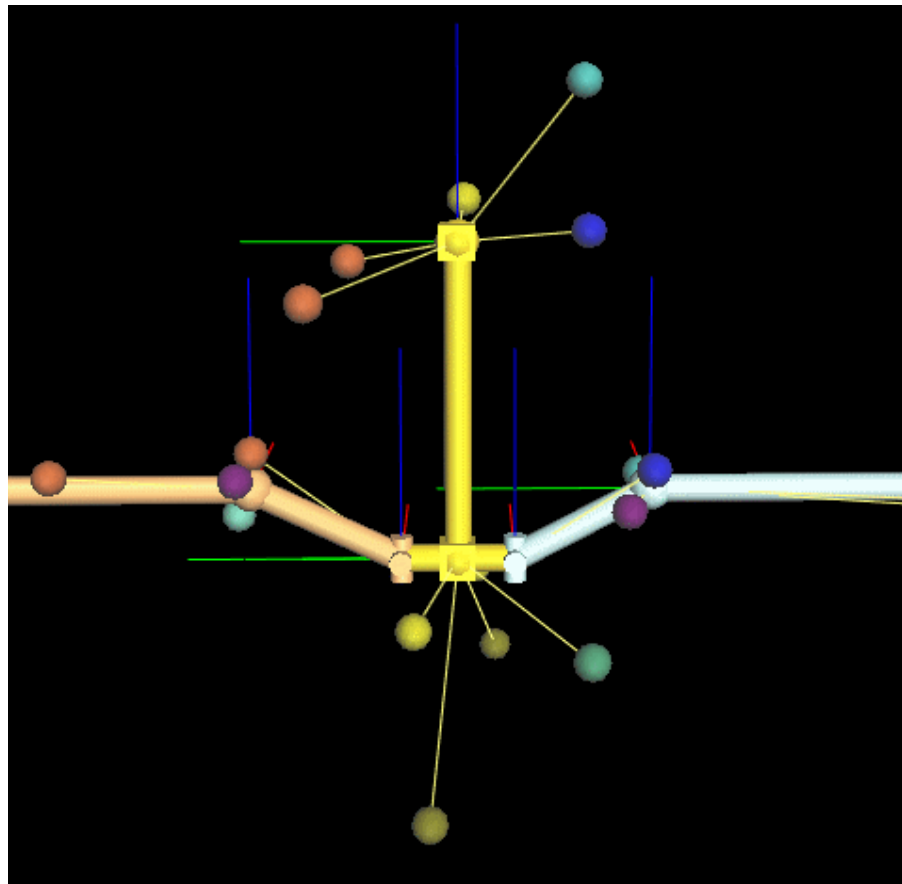
Fig. 11: Replace Subject Tools



Once the subject has been replaced, the new subject needs to be calibrated. Set your subject calibration options (Refer to Tutorial 1 if necessary), and click the Calibrate Subject button.

Once the Subject Calibration is complete, click the Base Pose button, and have a look at the new subject compared to the original iteration. How do the results compare? Do the left and right arms look similar? Do the skeleton's joints line up with the proper markers? Does the skeleton look natural?

Fig. 12: Calibrated Subject, Version 2



As a final check of your model, open the Pipeline activity tab, and run the Kinematic Fit pipeline operation on the trial. Observe the fitted subject's motion, noting any erratic or unnatural motions. It may help to turn off the display of some of the subject elements in the view options, to get the clearest view of the subject skeleton.

End of Lesson Congratulations, you have just created a complex VST file from scratch! This experience will prove invaluable as you integrate Vicon iQ 1.5 into your daily workflow.

Key points to take away from this lesson include:

- Creation and editing of various model elements - segments, joints, markers, sticks, and bounding boxes
- Various methods of constraining your models - non-parameterization, shared parameters
- How to use tools in Post-Processing mode to quickly evaluate changes to models
- The importance of having the proper balance of unconstrained and constrained elements of a VST