The MotionMonitor xGen Hardware Guide: Interface to VICON Cameras- Nexus 2.0

Overview

The MotionMonitor xGen Edition software can collect data from VICON Nexus 2.0, Nexus and Tracker in realtime using ***The MotionMonitor xGen*** Rigid Body 6DOF Tracking. This process assumes that each segment is being tracked by at least 3 markers rigidly attached directly to the skin or to a rigid plate. **The MotionMonitor xGen** records the position and orientation of markers assigned to each rigid body, computes the centroid and coordinate system of these rigid bodies and then uses that data to perform ***The MotionMonitor xGen***'s standard analytical and visualization routines. The user has the option to use a fixed marker set to locate joint centers or, alternatively, can digitize landmarks using a stylus whose position and orientation are tracked using one of the 6DOF sensors.

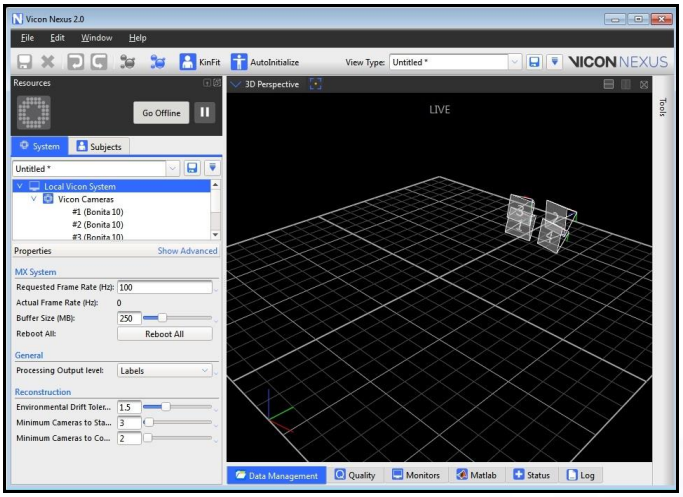
Rigid Body 6 DOF Tracking

Rigid Body 6 DOF tracking works on the following set of principles. The subject is instrumented with a minimum of 3 markers on each tracked body segment. The markers are relatively rigid (the more so the better) with respect to each other. Within Nexus 2.0, the markers are identified and combined into Segments. The purpose is to provide robust marker identification within Nexus 2.0 so that accurate, identified marker x, y, z positions can be streamed directly to **The MotionMonitor xGen**.

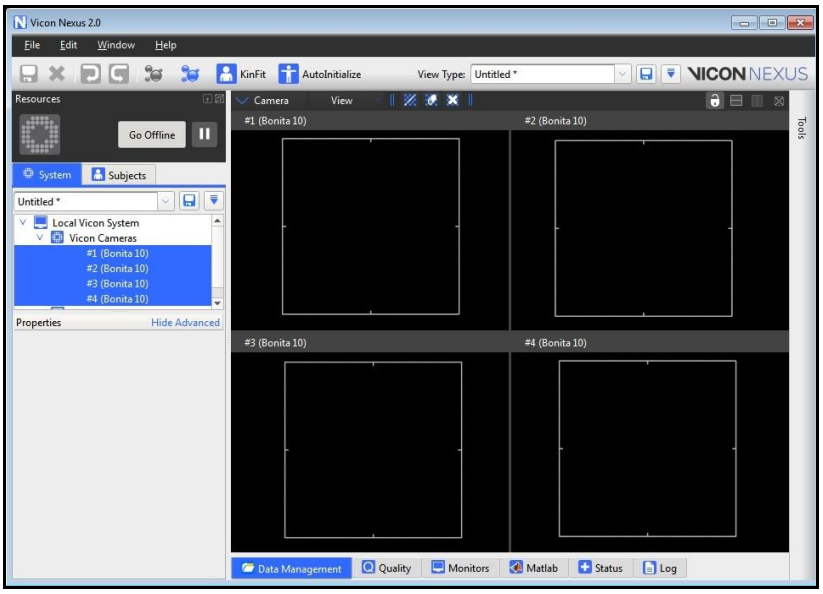
Within **The MotionMonitor xGen** rigid bodies are computed from the marker's streamed (x,y,z) coordinates from Nexus 2.0. The computed position and orientation of these rigid bodies is used within **The MotionMonitor xGen** to track objects, define subject segment lengths, locate joint centers, digitize and track landmarks of interest, etc.

A step by step guide to setup this method follows. This guide assumes that the camera hardware is connected and has been setup in the environment and that each camera is optimally zoomed and focused. It is also assumed that a Database has been created within Nexus 2.0.

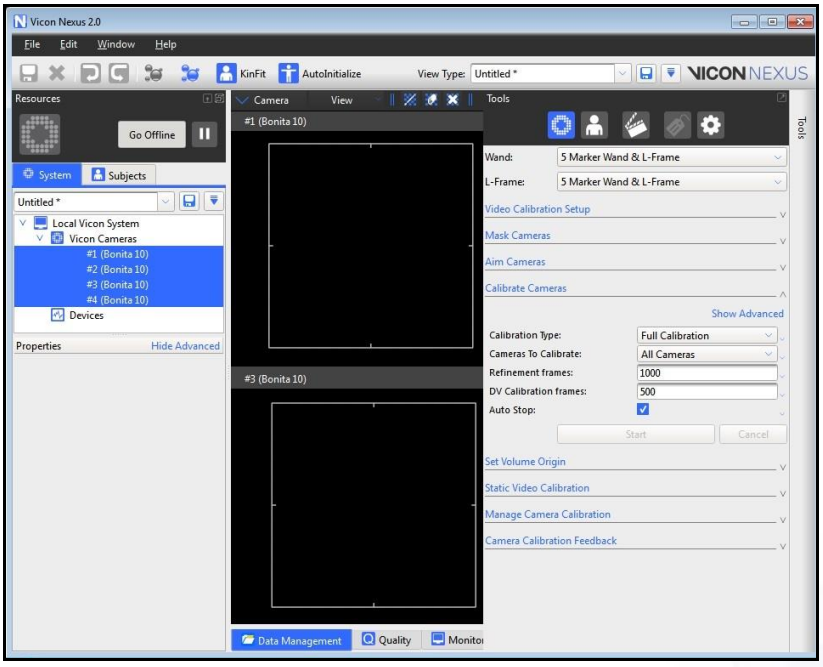
1. After launching the Nexus 2.0 application, go to the System tab in the Resources pane and highlight "Local Vicon System" in the tree view. Under the Properties section enter the Requested Frame rate (Hz) and set the Processing Output level to "Labels". Label is the preferred Core Processing level, since it uses the least amount of computer resources and provides **The MotionMonitor xGen** with all the information it needs, however, Kinematic Fit can also be selected here in order to stream 6DoF rigid body data calculated in Vicon to BI.



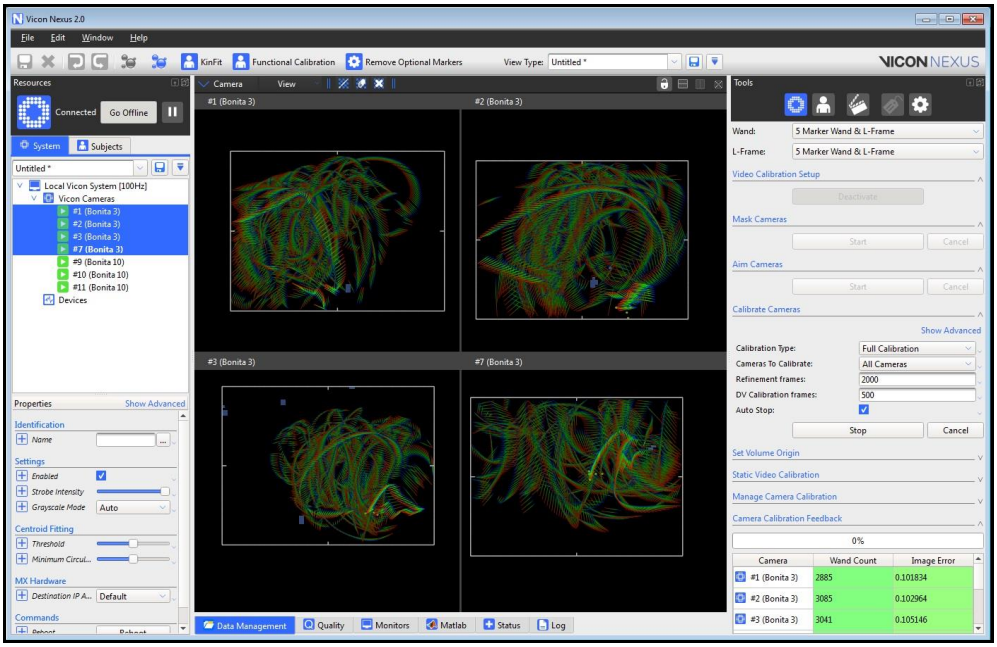
2. Next, highlight all the cameras within the System tab in the Resources pane, and select "Camera" view from the "Camera" dropdown in the Animation pane. At this time, all efforts should be made to eliminate unwanted reflections. If required, camera pixels can be masked automatically using the "Create Camera Masks" function in the Tools pane under System Preparation ( ) or manually using the masking icons in the Animation pane.



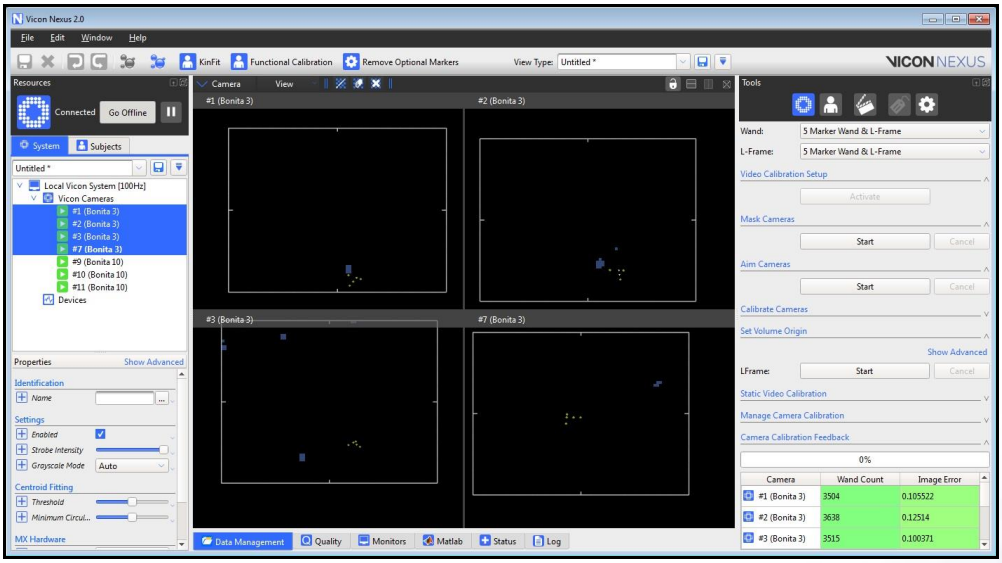
3. Now, begin the calibration process. From Tools, go to System Preparation ( ). Ensure the appropriate Wand and L-Frame are selected (i.e. "5 Marker Wand & L-Frame") and then expand the "Calibrate Cameras" section. In the Refinement Frames field, enter the number of frames required to complete a calibration with good coverage over the entire collection volume and enable "Auto Stop". Click Start when you are ready to begin.



4. Move the wand throughout the measurement volume, being sure to move in all three axes. The camera view will display the area that has been covered with a rainbow, and the Wand Count will update as frames are collected. Once all of the cameras have recorded at least the required number of Refinement Frames, the calibration will be calculated. **Note:** It's important that the Refinement Frames for each camera update at a uniform rate, in order to ensure good calibration coverage.



5. Now place the wand at the origin of the global coordinate system. Ensure that all 5 markers can be seen by each camera. Expand the "Set Volume Origin" dropdown. Click "Start" and then "Set Origin" when you are ready to take a reading. **Note:** It's important to place and orient the wand in an identical manner from calibration to calibration, to ensure that any force plate alignments remain valid relative to Vicon's origin.



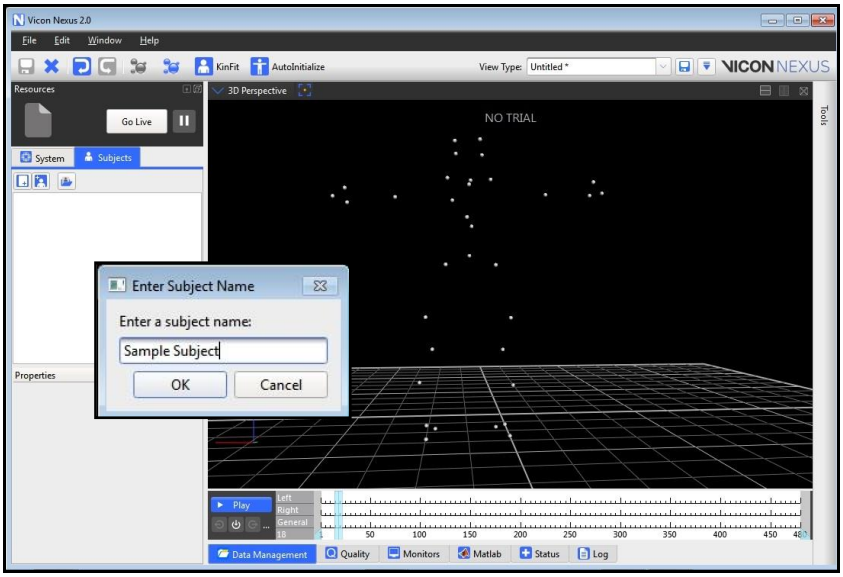
6. From the “Camera” dropdown in the animation pane, select “3D Perspective”. If Nexus 2.0 is in Offline mode, click “Go Live” to enter Live mode. The animation should replicate the real life position and layout of the camera system. Attach markers and/or rigid body clusters to the subject or objects to be tracked. Have the subjects/objects enter the capture space and confirm that the markers are displayed in real-time. **Note:** A minimum of **4** markers per rigid body are required to track rigid body clusters in Nexus 2.0, and markers *cannot* be shared between 2 rigid bodies. All markers must be assigned to a rigid body; unassigned markers cannot be streamed from Nexus 2.0 to **The MotionMonitor xGen.**

   Note: If VSTs, Vicon Subject Templates, have already been configured, skip to step #13

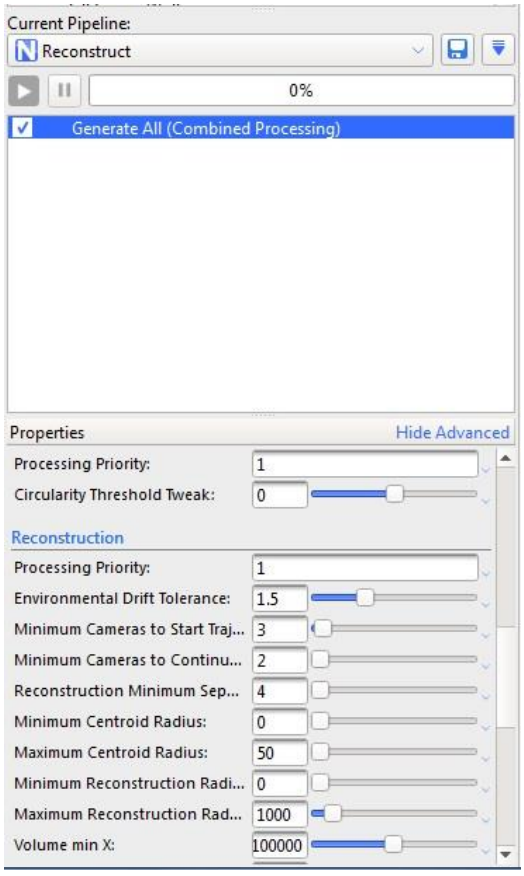
7. The next step is to generate a ‘Labeling Skeleton Template’, which will be used as a basis for setting up future subjects with the same marker-set. Click on the “Subjects” tab in the Resources pane. Click the “Create a blank subject” button ( ) and name the subject.

   Note: If using rigid body clusters, a separate Subject should be created for each cluster.

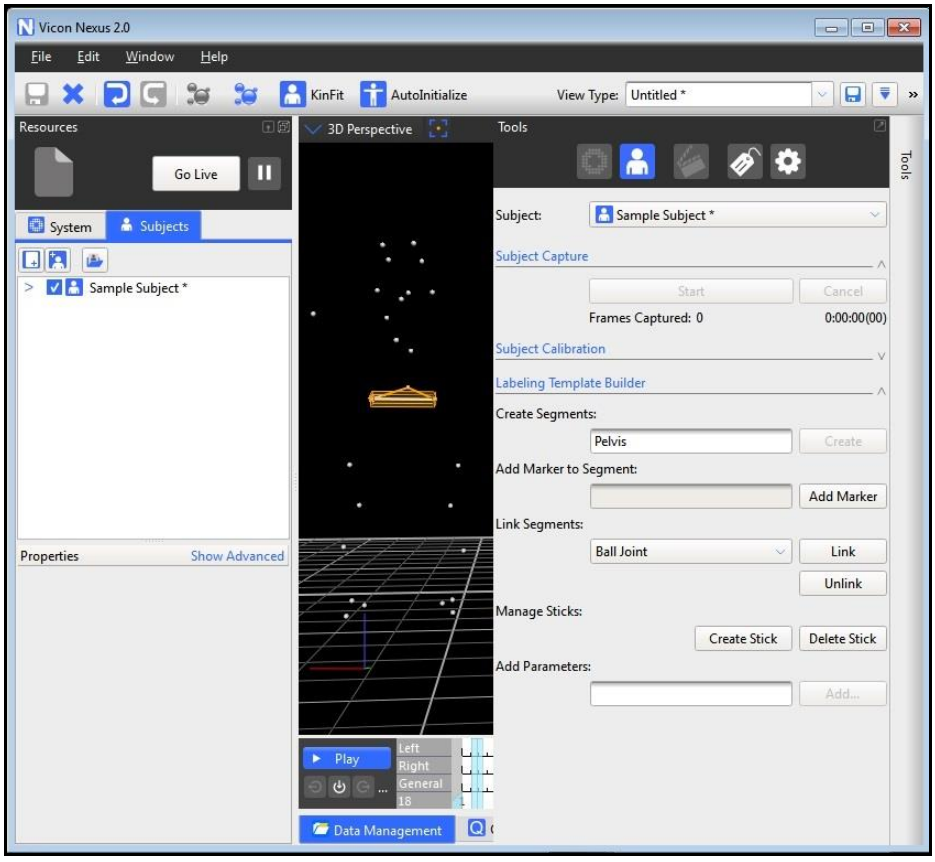
   Note: Use a naming convention that does not require spaces.



8. Click on the “Subject Preparation” icon ( ) in the Tools pane and select the name of the template you want to use from the “Subject” dropdown menu. Have the subject take a neutral position and select Start under the “Subject Capture” dialog to capture a trial. Click Stop to complete the data collection. Open the Data Management Window (Data Management) at the bottom of the application to load the file if it doesn’t do so automatically. If markers do not appear automatically, run a “Reconstruct” pipeline under the pipeline icon ( ) in the Tools pane. Alternatively you can use the shortcut button (containing default values) located near the top left-hand part of the screen ( ). If some marker trajectories are not reconstructed, you may need to reduce the “Minimum Cameras to Start Trajectory” number to 2 in the advanced options of the reconstruct pipeline.

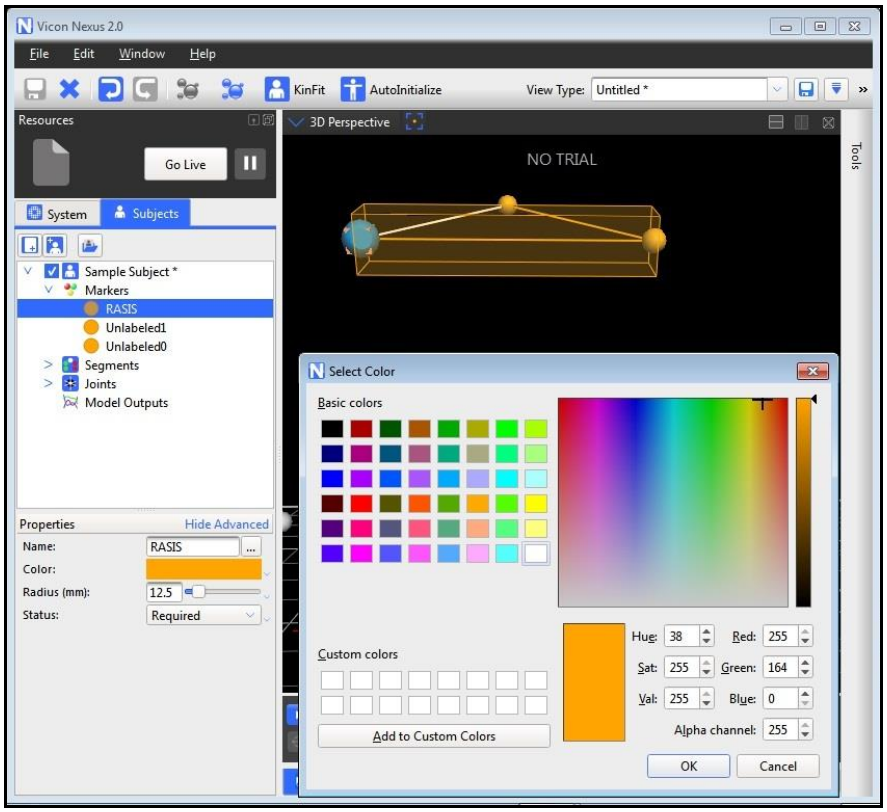


9. To create a body segment, select the Subject icon ( ) in the Tools pane and enter a name in the “Create Segments” field, then click “Create.” Select the markers in the Animation pane that you want to assign to the segment and then click “Create” again. **Note:** you should apply all of the markers you want to use for the subject setup (include medial and lateral markers if using a centroid method to define the joints for the knee, ankle, etc. clicking markers that will be removed for dynamic calibration last).



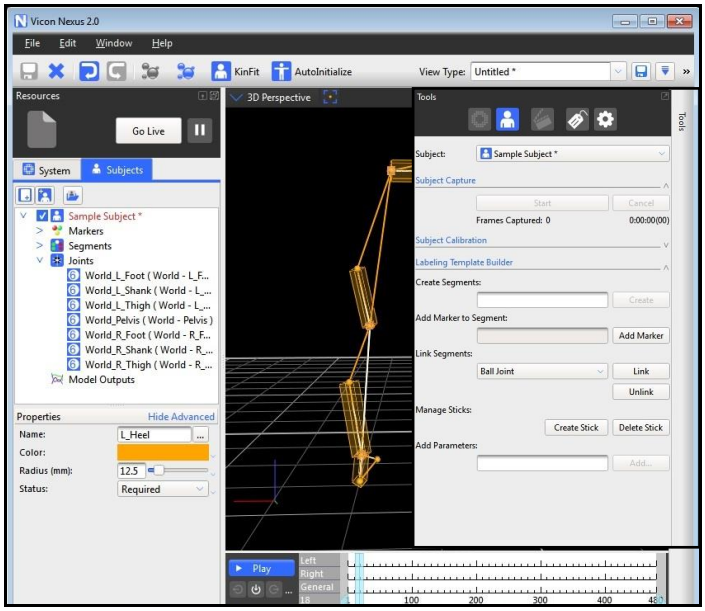
Identified markers will show up with connections to other markers on the same segment.

10. After the segment is created, the markers can be named and assigned custom colors. To name a marker, select the marker in the Animation pane or click on the marker name in the marker list under the subject name. Double clicking on the name here allows markers to be named quickly using the Tab key to tab down the list of markers. At least 3 markers on the rigid body must be “Required.” If additional markers are attached to the object, their status can be assigned at the discretion of the user. For example, if medial markers are used to locate joint centers, but these markers are not used for dynamic trials, their status could be assigned as “Calibration Only”.

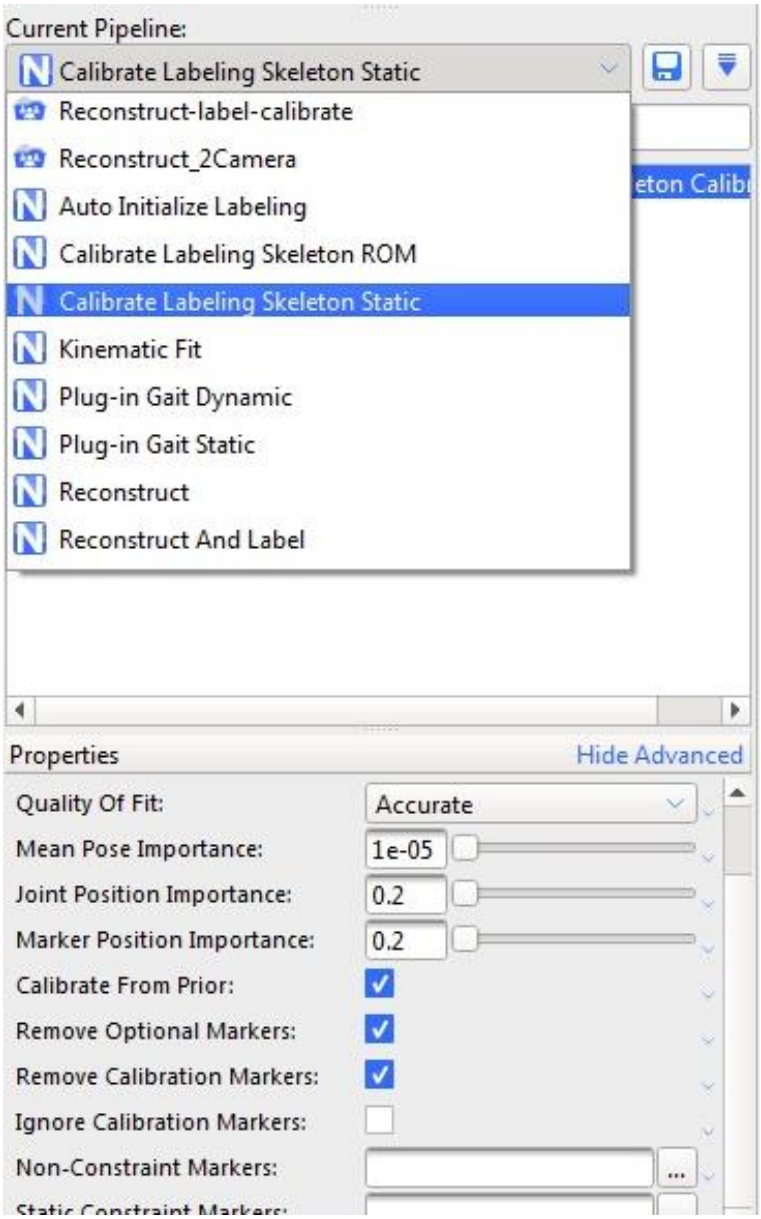


11. Create a segment for each rigid body that will be tracked in **The MotionMonitor xGen**. Once all the segments are defined, the segments will need to be linked to one another. In the Tools pane, select the appropriate link type from the “Link Segments” dropdown and click “Link.” Click on one segment and link it to the next adjoining body segment, repeating until all the segments are connected. When you are done, click “Link” to save your settings. If you make a mistake, press ‘Esc’ and start over.

Note: Segments are not linked when using rigid body clusters.



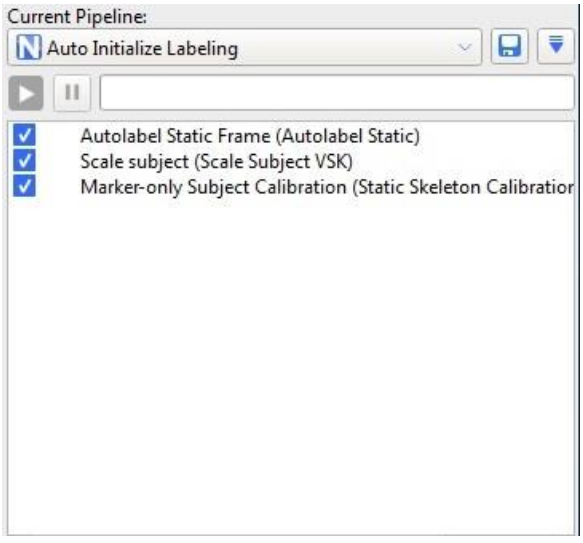
12. Once the model is completed, run a “Calibrate Labeling Skeleton Static” pipeline under the pipeline icon ( ) in the Tools pane. If calibration only markers are being used be sure to check the pipeline’s advanced properties and deactivate options listed to remove markers. When completed, right-click on the Subject name in the subjects tab under Resources and select “Save Labeling Skeleton as Template.” Name the template and click Save; this will save a *.vst file which is the marker template that will be used to setup subjects in the future.



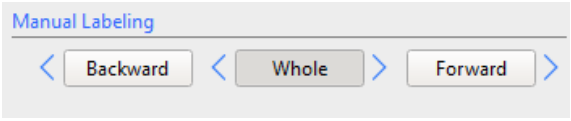
13. At this point, you are ready to calibrate a subject-specific model. This is what you will do *each time* a new subject comes in for data collection. For rigid body clusters, you will only need to perform these steps once, since the relationships between the markers within a rigid body cluster will always be the same. Of course, if the marker positions within the rigid body cluster ever do change or if a different Vicon camera system or camera configuration is being used, these steps should be repeated. To do this, go to the Subjects tab in the Resources pane, click on the "Create a new subject from Labeling Skeleton" icon ( ) and select your template. You will be given an opportunity to name the Subject. In the following example, the subject "Patient1" was generated from the "SampleSubject" template we created in the previous steps.

14. Now select the Subject icon ( ) from the Tools pane. Select the name of the template you want to use from the "Subject" dropdown menu. When the subject is ready, select Start under the "Subject Capture" dialog to capture a trial. Have your subject begin in a static neutral position at the start of the trial and then proceed through dynamic movements similar to those that will be performed during later trials. Click Stop to complete the data collection. **Note:** Collection should be taken over at least 500 frames. Open the Data Management Window (Data Management) at the bottom of the application to load the file if it doesn't do so automatically. Again, if markers do not appear automatically, run a "Reconstruct" pipeline under the pipeline icon ( ) in the Tools pane. Be sure to hit the Save button before clicking "Go Live" to capture data. If all markers do not show up in the 3D view, you may have to lower the number of "Minimum Cameras to Start Trajectory" to 2.

15. From the pipeline icon ( ) in the Tools pane run the "Auto Initialize Labeling" pipeline from the dropdown menu. This pipeline contains three operations: Autolabel Static Frame, Scale subject, and Marker-only Subject Calibration. These operations will identify and label the markers, scale the template to the subject, and generate a subject specific calibration based off of the first frame, respectively**. Note:** If the pipeline has been successfully completed, a green checkmark will appear.

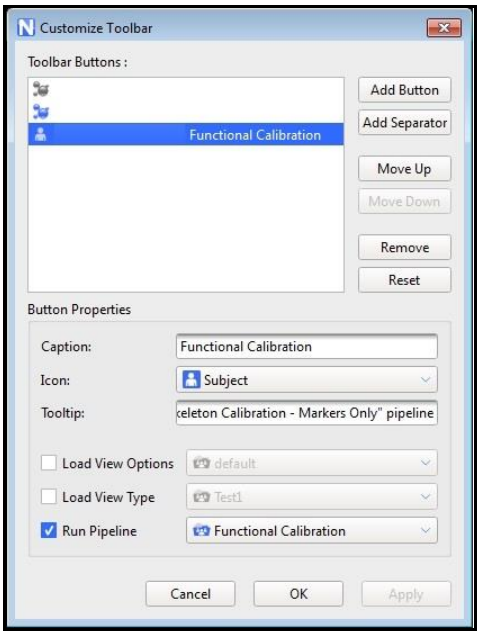


If marker labeling was inconsistent you may be required to manually re-label any markers that are not identified by going through the Label/Edit menu ( ) in the Tools pane. In the Manual Labeling section, Forward can be selected to extend labeling forward from the current frame rather than over the whole trial. This will preserve labeling before the current frame.



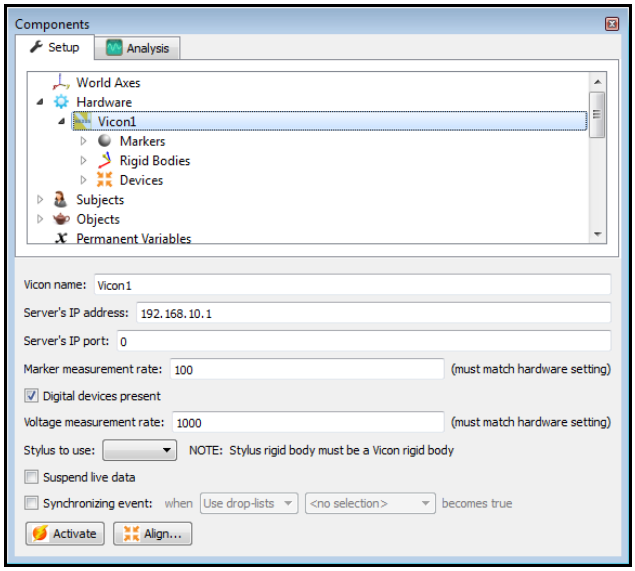
Note: If calibration only markers are *not* being used, as may be the case when digitizing the subject in **The MotionMonitor xGen**, the Functional Subject Calibration can be run now.

16. To streamline this process, pipelines can be saved and added to the toolbar (Window|Toolbar) at the top of the Nexus 2.0 application, as seen below. The icon, tooltip, and pipeline to execute can be selected through the Customize Toolbar dialog.

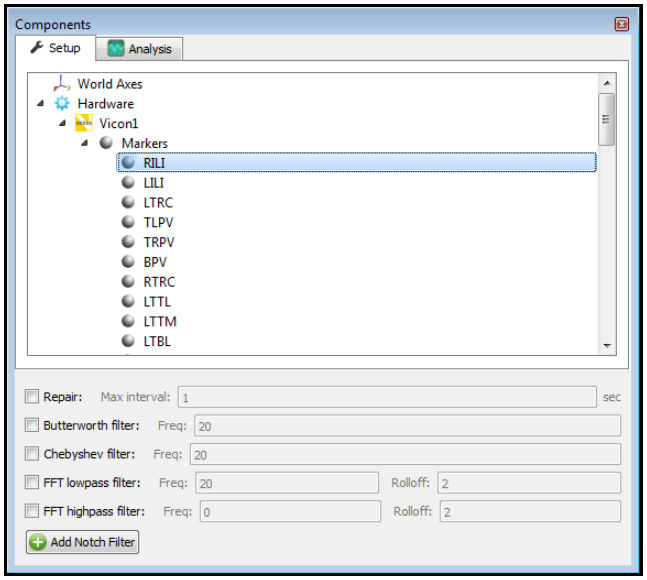


17. To save the subject calibration, right click on the subject name within the Subject tab in the Resources pane and select “Save Subject.” This will save a *.vsk subject specific calibration file. Click the “Go Live” button again to return to Live mode and check that the markers are correctly identified. Hitting “Ctrl + R” will reset the processing in the event that markers are incorrectly labeled. To save this model as your new template, right-click on the Subject name and select “Save Model As Template…” Name the template and click Save; this will save a *.vst file which is the marker template which will be used to setup subjects in the future.

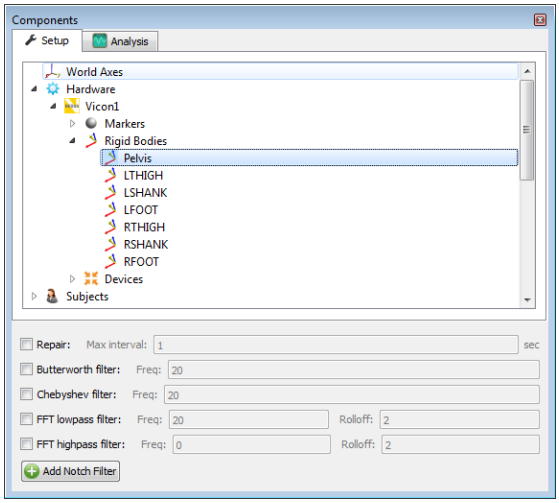
18. In **The MotionMonitor xGen**, go to the Setup tab in the Components Window and add or click on the Vicon hardware component in order to configure the hardware. Confirm that the settings entered here match the settings of Nexus for the measurement rate, number of markers and the IP address of the computer running Nexus. If analog data will be streaming from Nexus, enable the Digital Devices Present checkbox and set the measurement rate to match the settings of Vicon for analog data. Click the Activate button to initialize communication with the Vicon Nexus software. Please refer to the Vicon A/D Knowledge Base Article for more information on streaming analog data from Vicon into **The MotionMonitor xGen**



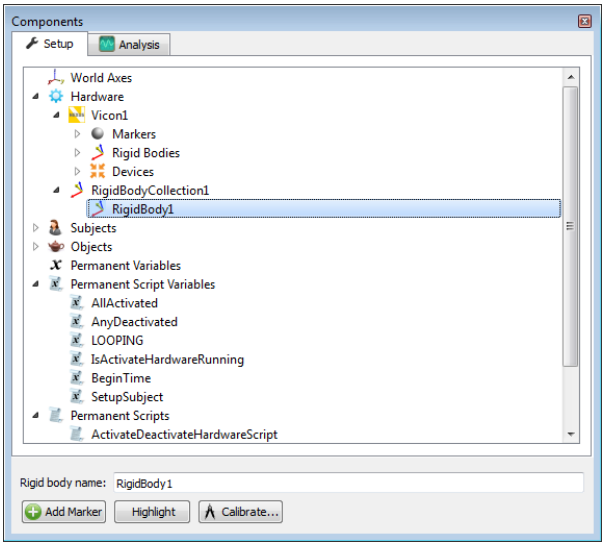
19. After successfully activating the Vicon device, the marker list, rigid bodies list and any analog data configured within Vicon will be populated under the appropriate headers for the Vicon component. Data repair and smoothing settings can be enabled or disabled here, pre or post data collection.

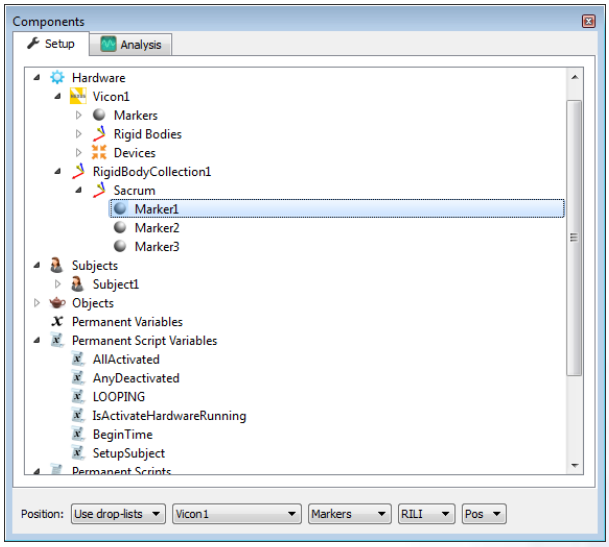


20. The Rigid Bodies header will be populated with any rigid bodies that were configured within Vicon Nexus. **Note:** In order for the rigid body data to actually be streamed, the Processing level within the System Resources tab in Vicon Nexus will need to be set to Kinematic fit and not Labeling.



21. 6 DOF rigid bodies could also be defined through **The MotionMonitor xGen** as seen in the dialog below. Rigid Body Collections can be added to the Setup Components dialog window as a Hardware device. Multiple Rigid Bodies can be added to a Rigid Body Collection, each of which can be defined using different combinations of marker assignments. Remember that 3 or more markers are required to create a Rigid Body. Markers can be selected for a rigid body either by selecting them through a drop down menu or defining them using a formula. Do not include markers in the rigid body definitions which will be removed for dynamic recordings. Clicking on the Highlight button will highlight the selected Rigid Body markers in the Animation Window.

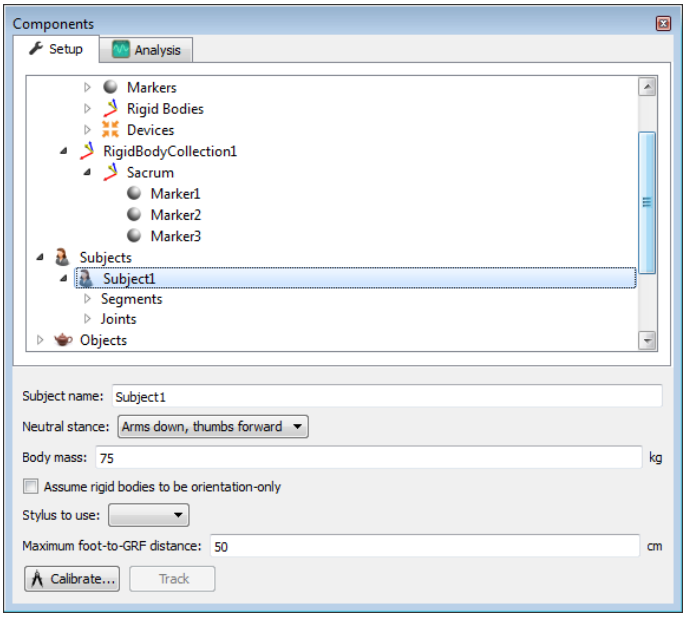




NOTE: The virtual markers "Calculated Left Hip Joint" and "Calculated Right Hip Joint" can be used as thigh markers. The Davis and Bell methods for locating the hip joint centers only require that you have 2 additional markers assigned to the thigh, whereas the Rotation method requires 3 markers during the static pose. During the dynamic trial, the hip joint and a minimum of 2 original thigh markers can be used to track the thigh when using the Rotation method. Any additional markers that are used for calibration only should not be included in the Rigid Body parameters.

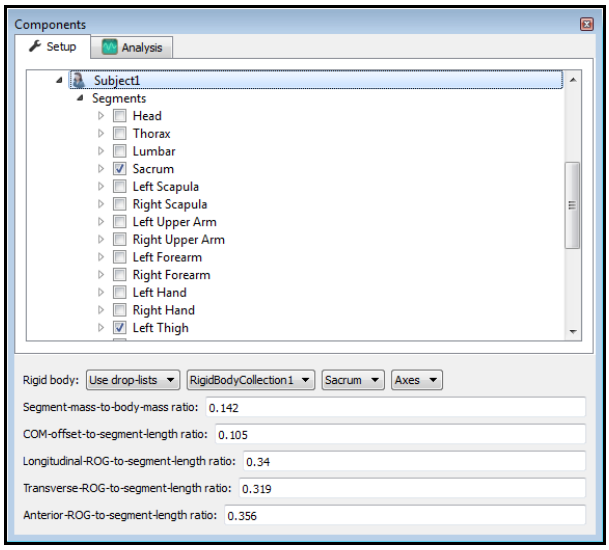
The Calibrate Rigid Bodies button takes a reading of the markers, computes centroids, creates sensor axes, establishes the relationship between markers and generally prepares the system to track the cluster of markers as 6 DOF data. Rigid Bodies can be calibrated one by one or all at the same time by going to the top level of the Rigid Bodies Collection and clicking the Calibrate All button. After this step, markers and their "sensor" axes can be viewed in Animation window or graphed and recorded as position and orientation data.

22. The next step is to define your biomechanical model within **The MotionMonitor xGen**, which entails selecting which body segments you'll be tracking, assigning rigid bodies to track each body segment, defining segment endpoints or joint centers and generating customized segment axes, if desirable. To begin this process, right click on the Subjects header within the Components Setup tab and add a new subject.

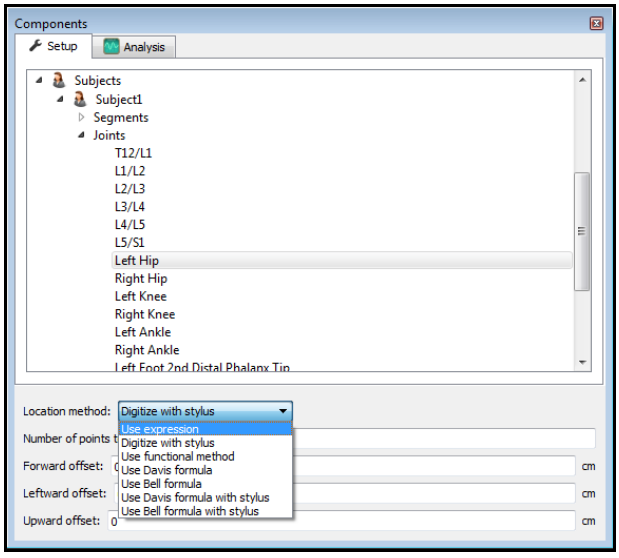


As seen above, a name can be assigned to the subject and basic anthropometric data can be entered. Confirmation for the orientation of the subject during the static reading and selection of a stylus to be used for digitizing, if required, are also selected here. The Calibrate button can be clicked after all of the required setup information has been entered.

23. The Segments header located under the Subject is where the desired segments to be tracked can be enabled as well as where the assignment for which rigid body will be used to track the segment is defined. Additional basic anthropometric information can be defined here for each segment as well.



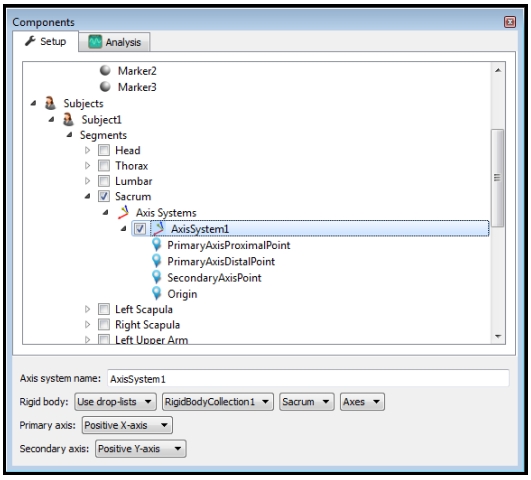
24. Each body segment which is enabled will require the definition of a proximal and distal endpoint or joint centers. The required joint centers will be automatically populated based on the selection of segments.



25. As seen above, each joint center can be defined using a digitizing method or expression based on marker positions. Alternatively, the hip and shoulder joints can be defined using linear regression algorithms or functional (rotational) methods.

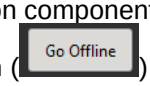
26. Once these definitions are completed, the Subject Calibrate button can be clicked. A warning message will be displayed for any definitions have not been appropriately defined.

27. Additionally, if alternative or anatomically based local coordinate systems are desired, they can be defined by right clicking on a segment and selecting Add Axis System. First, the Rigid Body axes tracking the segment and general axes layout are selected. Then, points can be defined for the proximal and distal endpoints of the primary axis, a point along the secondary axis and a point for the Origin. The default local coordinate axes generated by **The MotionMonitor xGen** are defined as having a long axes through the joint centers and A/P and M/L axes being orthogonal to the long axes and parallel to the world when the subject was standing in the neutral position.

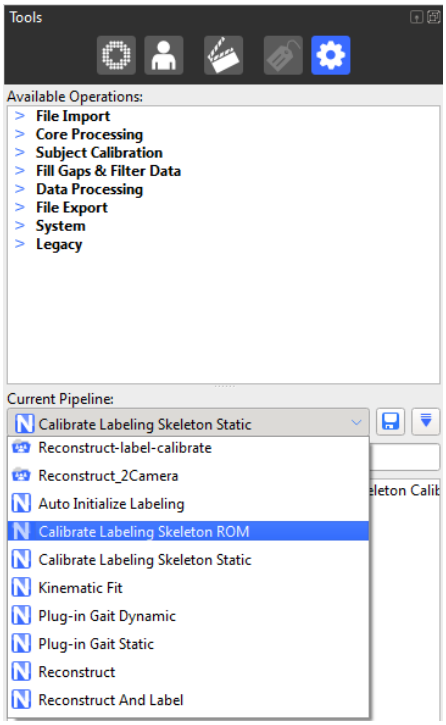


28. At this point, the **The MotionMonitor xGen** subject is fully defined and can be used for **biomechanical models, recording activities, performing computations and reducing data**.

    See “Getting Started Biomechanics Guide” for more information on these aforementioned topics.

29. If some markers are only being used for the calibration, complete the following steps: Deactivate the **The MotionMonitor xGen** connection to Nexus from the Vicon component in the Setup tab in the Components window and click on the “Go Offline” button (

) in Nexus 2.0. The previous recording in Nexus 2.0 should still be loaded. From the dropdown menu under the pipeline icon () in the Tools pane, run the “Calibrate Labeling Skeleton ROM” pipeline to run the functional subject calibration.



30. Once the pipeline is successfully completed, the chosen optional markers will be removed from the model. Right click on the Subject name within the Subject tab in the Resources pane and select “Save Model”. Physically remove the chosen optional markers from the subject. Click “Go Live” within Nexus 2.0 and re-establish communication with **The MotionMonitor xGen.**

    NOTE: If marker swapping occurs within Nexus 2.0 pressing “Ctrl + R” on the keyboard will reboot the camera’s processors and re-label markers according to the subject’s template.

31. By saving a Workspace file, File|Save Workspace As, in **The MotionMonitor xGen**, all of the setup selections will be retained as a template and can easily be re-loaded using File|Load Workspace.