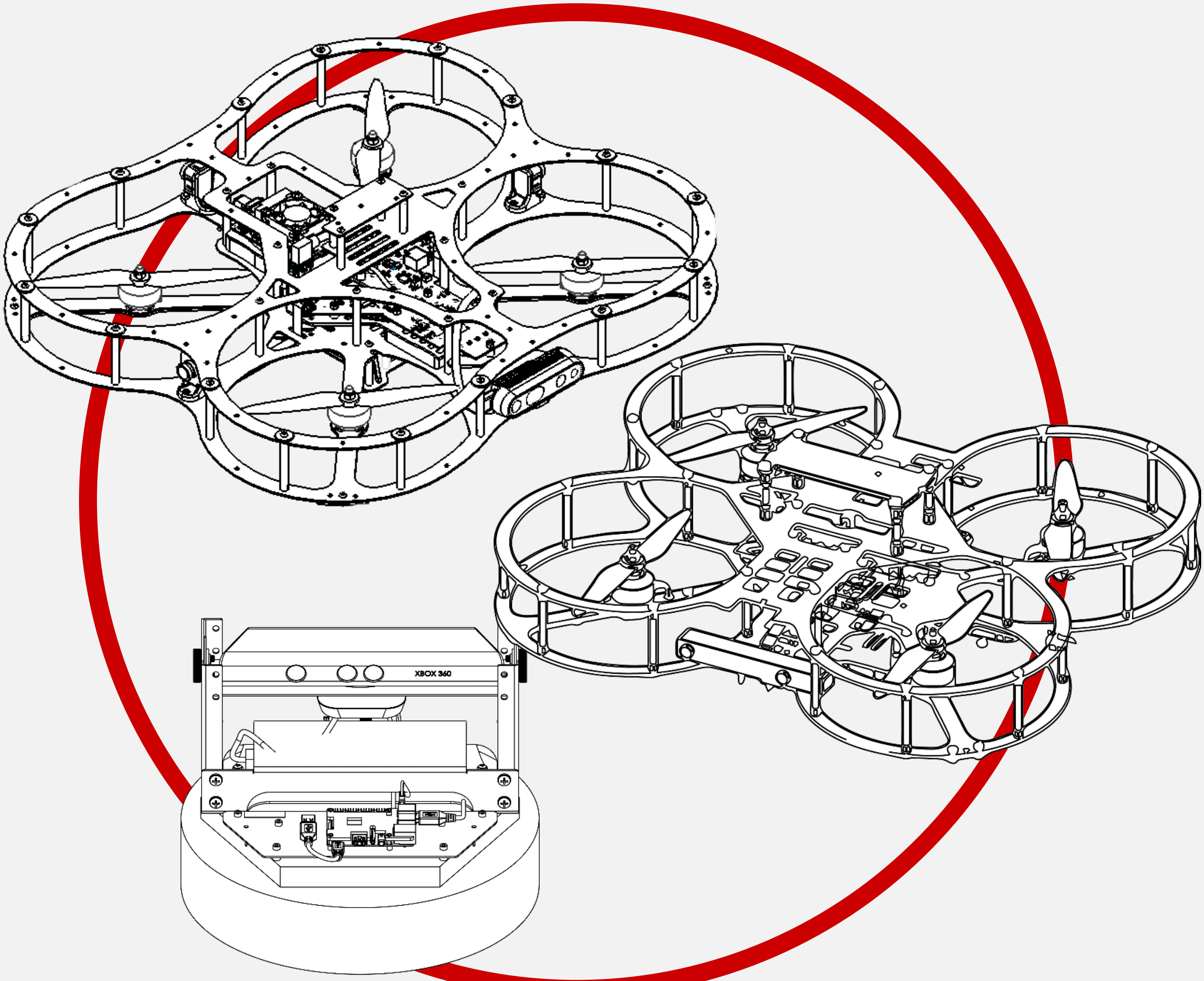

Autonomous Vehicles Research Studio

Setup Guide – Defining Rigid Bodies in Motive

v 2.0 – 18*th April* 2023

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A. Defining Rigid Bodies in Motive

> **Note**: Before defining rigid bodies, place a few markers on the workspace floor and observe their tracking in Motive. Flickering or missing markers may be an indication that a new calibration is required or that the cameras have not reached operating temperature. Calibrating cameras at least once a month is best practice.

Getting Motive to track your vehicles involves 2 steps:

1. Rigid Body Configuration: Placing markers on the vehicles which are tracked by the cameras. This involves identifying unique marker configurations that are rigidly attached to each vehicle, and hence, translate/rotate with the vehicle.
2. Rigid Body Definition: Tagging the rigid body configuration above in Motive: This involves configuring Motive to recognize what the rigid body looks like, so it can track its translation/rotation using the marker configuration.

i. Rigid Body Configuration

In Section C. Marker Configurations, we provide 10 unique configurations for the QDrone 1, 10 for QDrone 2 and 4 for QBot 2 (see: i. QDrone 1, ii. QDrone 2, iii. QBot 2). **Use these in case you have more than one of each product to be able to distinguish them in flight if both are in the same operating space.** The marker positioning that the QDrone(s) have when shipped and that we recommend for QBot are the following:

		
QDrone 1 Markers	Qdrone 2 Markers	QBot 2 Markers

Table 1. Initial marker positioning for products.

However, if you have more than one product of each, make each marker pattern unique. The ones in section C have already been validated. In case you want to use your own configurations, note the following important considerations.

> **Note**: The marker configurations for each rigid body operating within the workspace simultaneously must be unique for Motive to clearly identify one rigid body from another.

Note: It is recommended that five or more markers be used per vehicle, e.g., 5 markers for QDrones and 7 markers for Qbot 2/2e. This adds redundancy leading to higher robustness because Motive will be less prone to losing tracking due to a single marker that isn't visible. This also reduces the chance that the solution to the pose estimates may be interchanged/confused amongst vehicles.

Note: The placement of the markers on the rigid body must be in a pattern that is NOT symmetric about any arbitrary plane, as it may result in aliasing. For example, placing four markers in a square configuration would lead to ambiguous orientation solutions in 90˚ intervals. This would make it impossible to discern 90˚ rotations.

Note: Make use of different heights when placing markers; for example, placing a marker on the QDrone's handle as well as top frame, or placing markers near the base of the QBot 2 as well as above its camera.

Note: The QDrone uses markers with threaded holes, held in place using screws. For the QBot 2, use a hot glue gun to secure markers in place.

Note: Please contact tech@quanser.com if additional markers are needed.

ii. Rigid Body Definition

Once the rigid bodies are configured (markers being positioned) according to the guidelines in the previous section, they must be assigned an ID in Motive. This can be done for single vehicles, or multiple vehicles at the same time. This section covers details on both. Note that the instructions here are for Motive 2.0.1, but later versions may have very similar steps.

Important: Ensure that the cameras have been calibrated and warmed up for at least 15 minutes prior to defining rigid bodies.

Note: If the markers on the vehicles get damaged or fall off, they should be replaced. Redefining the rigid body in Motive is highly recommended to retain accuracy in the vehicle's pose measurement.

Note: When a vehicle's rigid body is defined in Motive, it identifies the vehicle's yaw reading as 0 the way it is placed. Ensure that you place the QDrone 1/2/QBot 2 in the workspace oriented as shown in Figure 1 when defining the rigid bodies. This means **always ensuring the vehicle's camera is pointed away from the ground control station PC.** This will provide consistency in measurement throughout the demo models and controllers provided with the Autonomous Vehicles Research Studio.

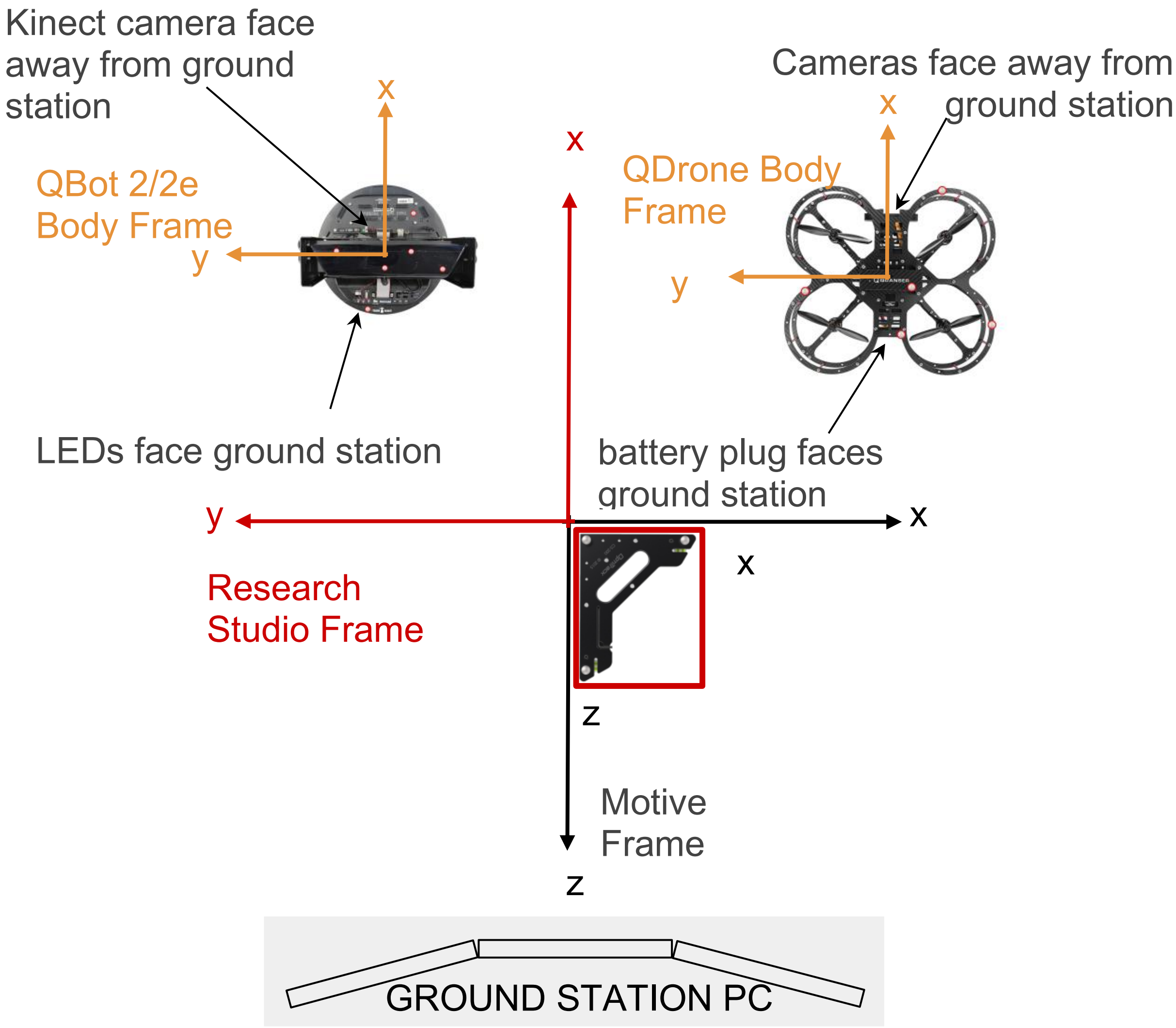


Figure 1. Vehicle placement orientation in workspace when defining rigid bodies in Motive

1. Open Motive. In the Quick Start menu (Figure 2), select the calibration file (*.cal) that was created when calibrating the cameras. If the Quick Start menu does not open, the calibration file can be loaded from the File menu as well. After the file loads, also load the Profile (File > Load Profile) saved when calibrating cameras. This will ensure no rigid bodies are currently in the workspace.

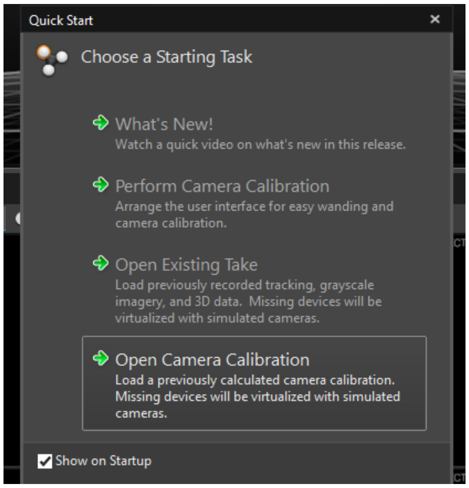


Figure 2: Quick Start menu in Motive 2.0.1

2. Place the vehicle in the workspace according to the frame guidelines in Figure 1 (Camera of the vehicle towards the back of the room away from the ground station PC). Motive should display the markers picked up by the cameras in the Perspective View, (Figure 3).

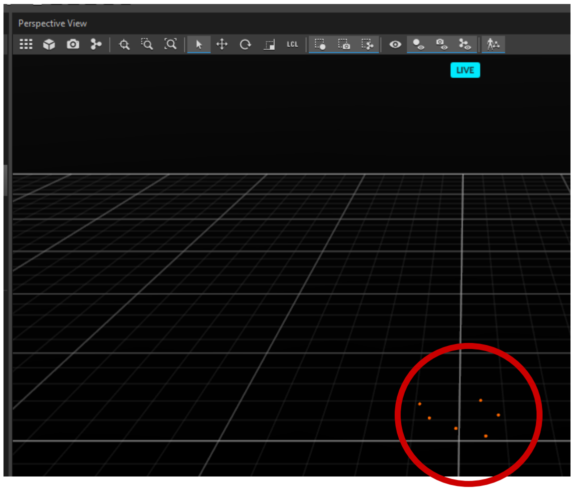


Figure 3: Perspective view in Motive 2.0.1

3. Drag and select all the markers in the Perspective View window, right-click, and select Rigid Body > Create From Selected Markers. (Figure 4)

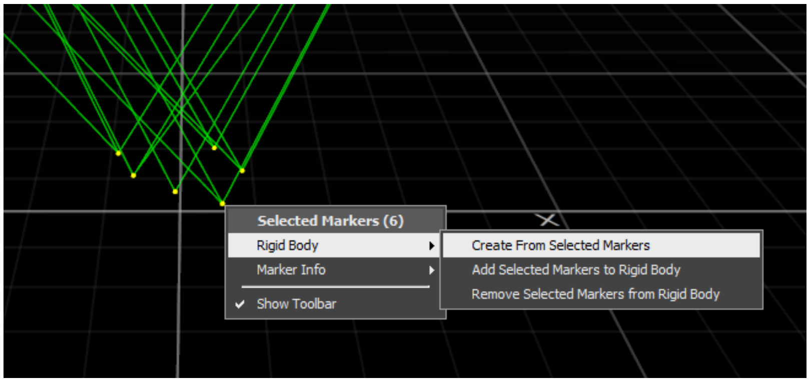


Figure 4. Creating rigid body from selected markers

4. Motive now shows the properties of the rigid body defined (Figure 5). Ensure that the Streaming ID is set to 1 (default). If the Properties pane does not get displayed by default, you may access it from the View > Properties pane.

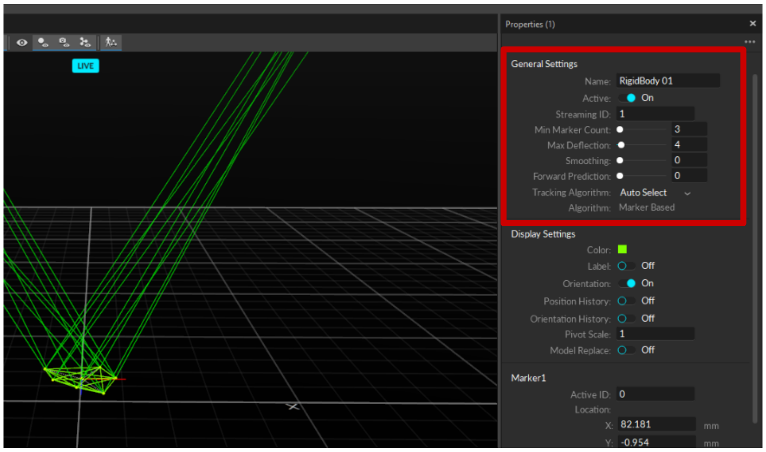
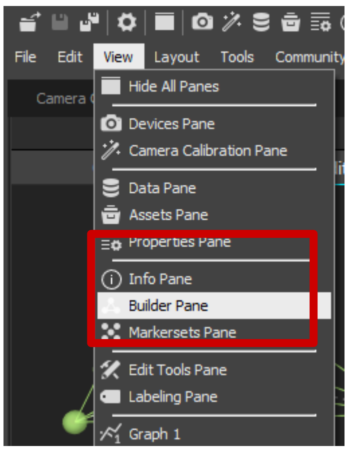


Figure 5. Properties pane

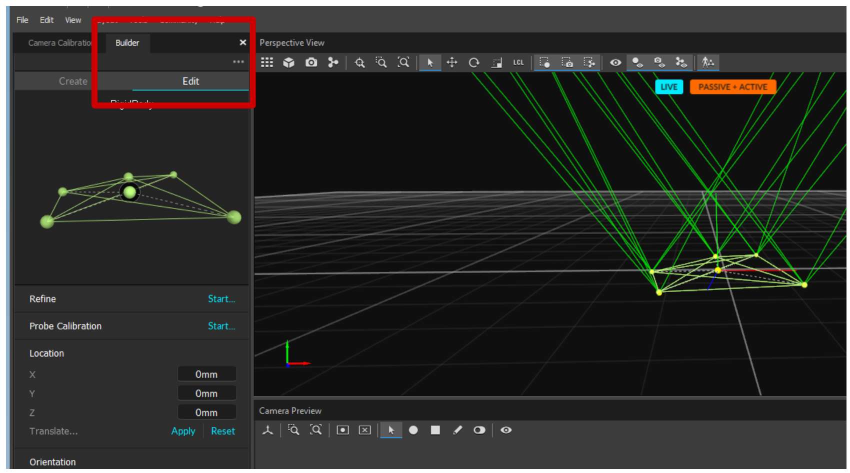
Note: When streaming data using VRPN, please keep a note of the **Name** given to the rigid body. As a reference it's recommended to make the name **RigidBodyx** where x denotes the rigid body number. If you have one agent in the space the name would be RigidBody1.

5. If you have a QDrone 2, you might need to move the pivot point to the geometric center of the drone for better tracking, steps 6 to 9 will explain this. If you have a QBot 2/2e or a QDrone 1 this might not be necessary, you can skip to step 10 that explains how to save this rigid body.

6. Open the builder pane (Figure 6a). Click **View>Builder Pane**. Drag and select the rigid body, and inside the Builder pane, click on Edit (Figure 6b).



a. Opening the Builder Pane



b. Selecting the edit option in the Builder Pane while the drone's rigid body is selected

Figure 6. Builder Pane in Motive

7. While the rigid body is selected, in the properties pane, scroll down to see all the markers position. If you only have one marker on the handle, find that marker in the list since that one is positioned in the actual center of the drone, it should be the one with the largest and most positive Y position as shown in Figure 7.

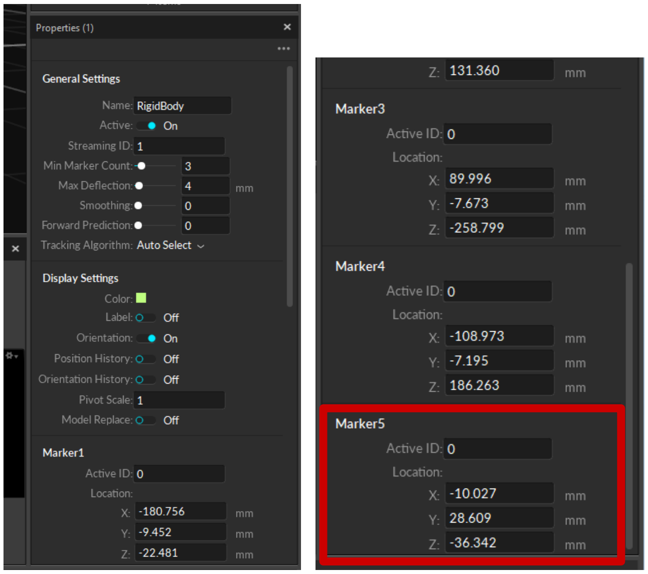
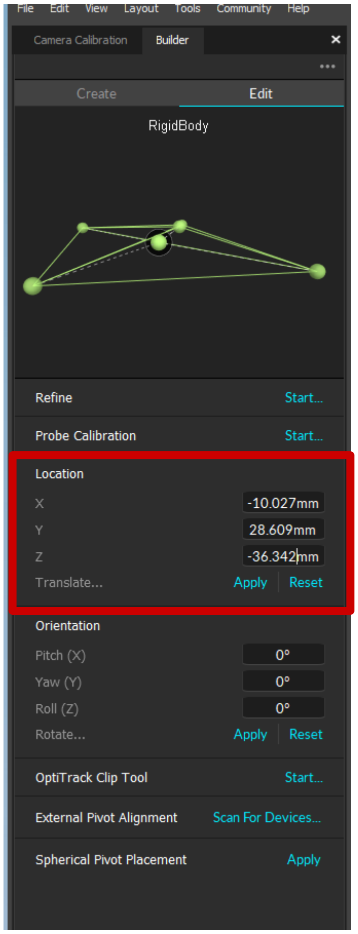
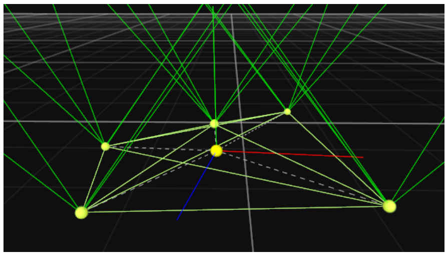


Figure 7. Finding the top center marker

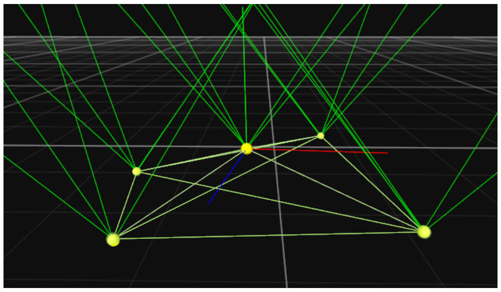
8. Since we know that the top center marker is at the actual center of the drone (only higher), we want to use that as reference. So, we first want to move the pivot point to it. In the Builder Pane, under the Edit tab, write down the position of the top marker you found in the previous step as the location values and click apply (Figure 8a). In the main workspace screen, you should see the pivot point move towards the position of the top marker as shown in figure 8b and 8c.



a. Setting the location of the top marker



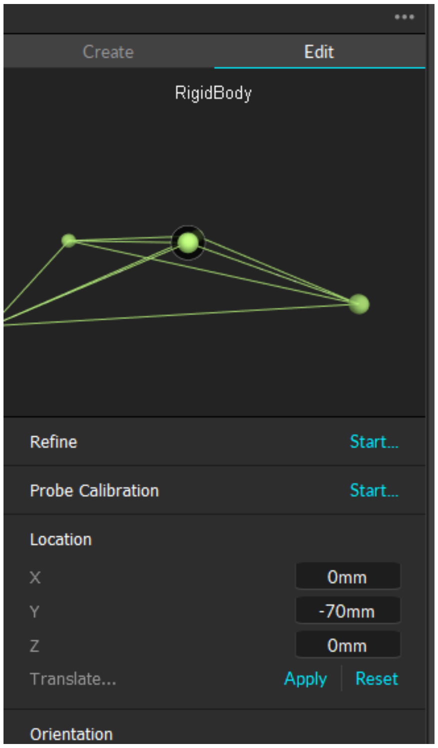
b. Pivot point before applying the change



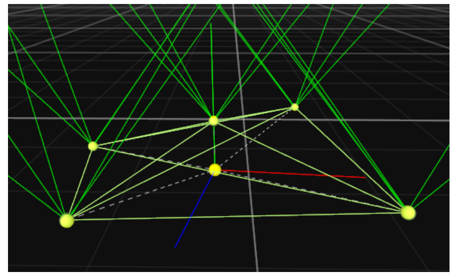
c. Pivot point at the position of the top marker (notice how the red and blue line are now coming from the top marker instead of the geometric center between the markers)

Figure 8. Moving the pivot point to the position of the top center handle marker

9. After the pivot point moved, change the location values in X and Z to zero (0) and the Y value to -70 mm (shown in figure 9a) and click Apply. This is done as the real center of the Drone is at the PCB level which is 7 cm under the top center marker as shown in figure 9b.



a. Moving the pivot point



b. Lowering the pivot point directly under the top marker

Figure 9. Lowering the pivot point

10. Drag and select the rigid body just defined and click on File > Export Rigid Bodies … (As shown on figure 10). Save the *.tra or *.motive file with a convenient name in the same folder as the camera calibration (*.cal).

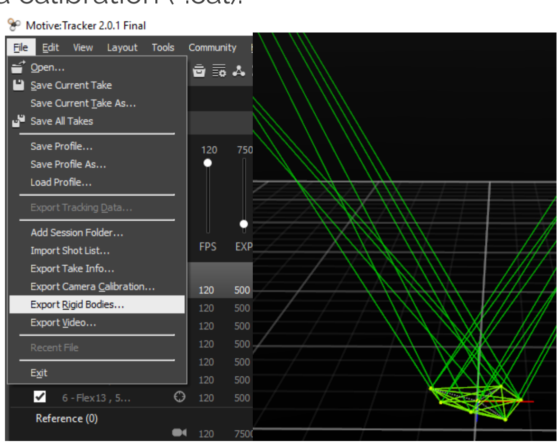


Figure 10. Exporting rigid body to a trackable file

11. QUARC supports motion capture systems streaming data using VRPN functionality. For motive to enable VRPN data broadcasting navigate to the streaming icon  and turn on VRPN Streaming Engine.

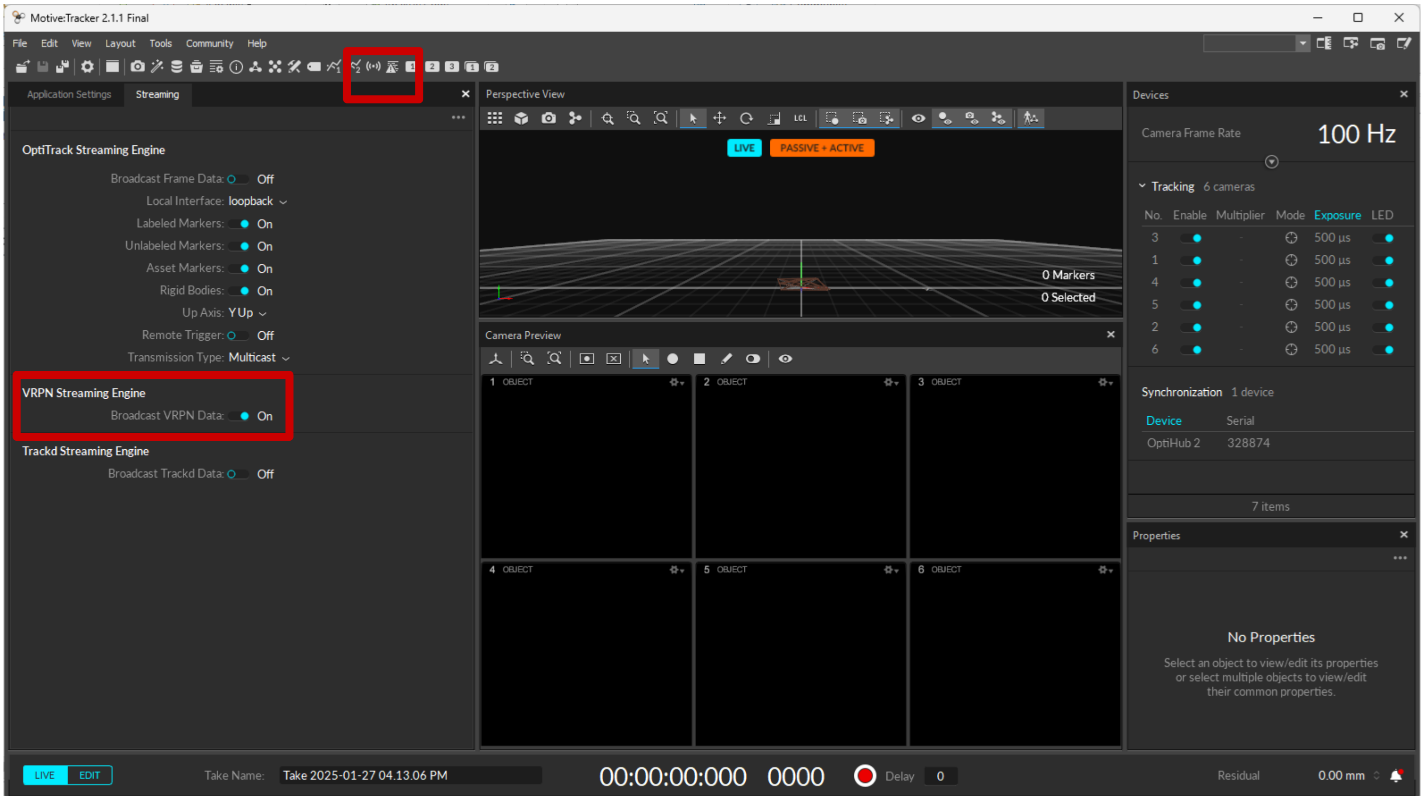


Figure 11: VRPN streaming enable toggle screen

USE THE FOLLOWING INSTRUCTIONS IF YOU ARE GOING TO BE RUNNING MULTI VEHICLE SCENARIOS

12. For multi-vehicle scenarios, all the vehicles must be defined in a single trackable file (*.tra). After step 4, place the second vehicle in the workspace and define a new rigid body (Refer to step 3) (Figure 4).

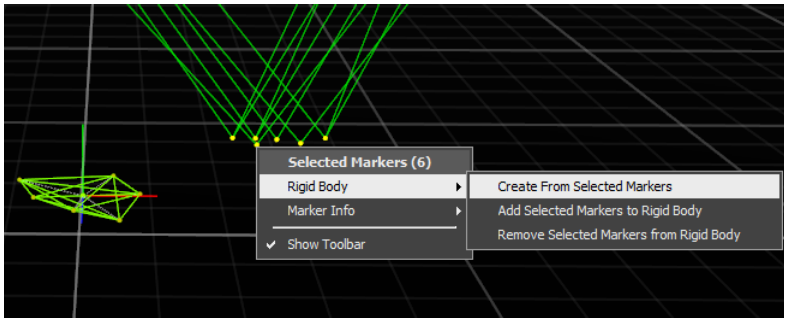


Figure 12. Exporting rigid body to a trackable file

13. The properties pane should now display the second rigid body's properties. Ensure that the streaming ID is set to 2 (default) as shown in Figure 13.

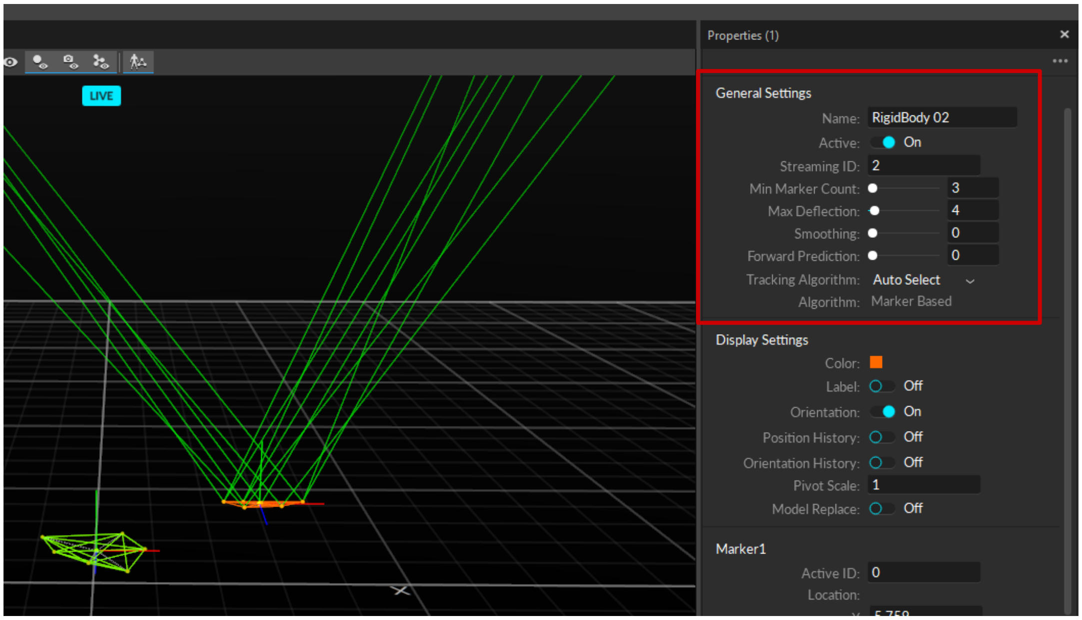


Figure 13. Exporting rigid body to a trackable file

14. Repeat steps 12 and 13 for all vehicles involved. Drag and select **ALL** the vehicles, and click on File > Export Rigid Bodies… (similar to step 10). Save the rigid body trackable (*.tra or *.motive) file in the same location as the camera calibration (*.cal) file.

> Note: **Make a note of the order in which these vehicles were defined, and the Streaming IDs of these vehicles as well.** Later, the vehicle data will be retrieved in MATLAB/Simulink in the same order.

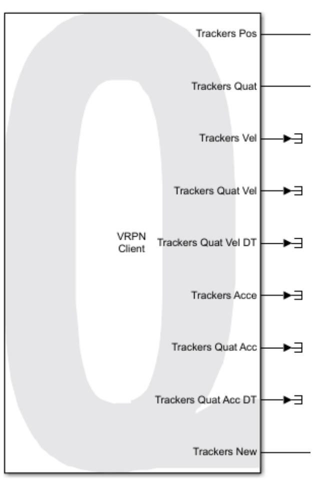
B. Checkpoint – Localization Visualization Demo

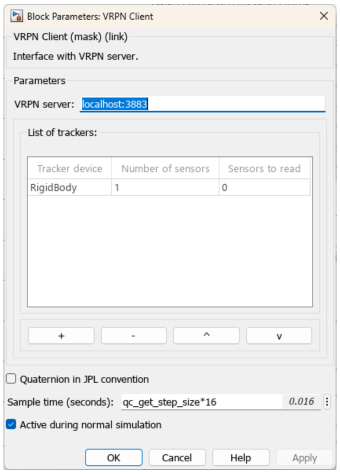
Quanser provides different methods for visualizing motion capture data. The following instructions demonstrate visualizing a rigid body using **VRPN** or **Motive 2.x**. This section guides you on how to use either method for visualizing data.

Visualization using VRPN

1. From the same folder as this file, open Localization Visualization Demo Folder and open VRPN_Visualization_R2021a.slx
2. Navigate inside the **Localization Data Server (VRPN)** and change the **Localization System Index Number** based on the motion capture system installed. As default this is set to 1 for motion capture systems using OptiTrack cameras.

3. Double click the VRPN Client block to configure the name of the rigid body streamed by the motion capture system. The name of the rigid body can be found under the General settings for each asset.
   Note: In the case of tracking multiple agents, click the + to add more than 1 rigid body.





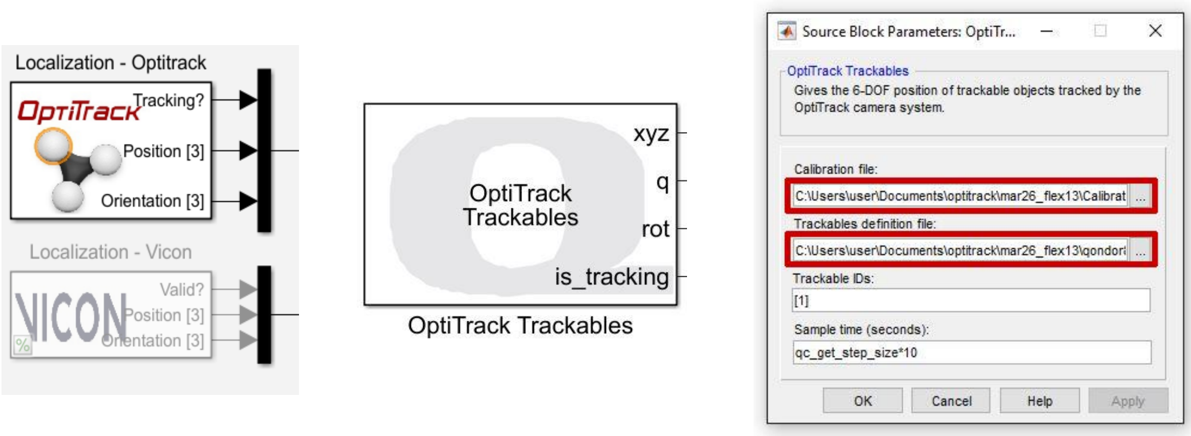
a. VRPN Client QUARC block b. VRPN Block Properties

Figure 14: Specifying tracker information for VRPN Client block

Note: For each rigid body keep the **Number of sensors** as **1** and the **Sensors to read** to **0**.

Visualization using Motive 2.x

1. From the same folder as this file, open Localization Visualization Demo Folder and open LocalizationVisualization_R2018a.slx



a. Localization subsystems | b. Optitrack Trackables block | c. Calibration and Trackable file selection

Figure 15: Specifying Calibration (*.cal) and Trackable (*.tra) definition files

2. From the same folder as this file, open Localization Visualization Demo Folder and open Optitrack_Visualization_R2018a.slx

3. If you are using Vicon instead of OptiTrack, follow the instructions in the model to change the system you are using and set things up correctly.

4. Open the **Localization (Optitrack)** subsystem (Figure 15a), and double-click on the **Optitrack Trackables** block (Figure 15b). Select the calibration file (*.cal) defined in **Calibrating Optitrack Cameras** (step 11) and the rigid body trackables definition file (*.tra or *.motive) defined in the **Rigid Body Definition** section (Figure 15c) for the QDrone.

Generic Instructions

1. Place the QDrone 1/2 in the workspace at the origin of the Research Studio Frame in the same orientation as when defining the rigid body in the section above (camera looking away from the studio PC). Make sure the QDrone used here matches the tracking ID specified in the previous step.
   NOTE: You DO NOT need to power the QDrones.
   NOTE: No Battery is required for this demo.

2. Back at the root level in the model, click on the **HARDWARE** tab on the top menu and click the green play button (**Monitor & Tune**), This should build and Start the model. (If you are using an older version of MATLAB and do not have a hardware tab, under the **QUARC drop menu**, click **Build**. Once it is complete, click on **Start** under the same menu.)

3. Ensure that the **isTracking?** display reads 1 (the QDrone is being tracked by the Localization System).

4. Step into the workspace and move the QDrone around manually.
5. The RED frame will move with the QDrone, giving you a sense of the QDrone's orientation.
6. Stop the model by clicking the Stop button under the Hardware Tab.

This completes the checkpoint task and confirms that your Localization System has been configured successfully with the rigid bodies in the space. If you have any errors, make sure that all the steps prior to this checkpoint have been followed. If further issues persist, please contact Quanser technical support (tech@quanser.com).

C. Marker Configurations

i. QDrone 1

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10 Unique QDrone 1 Marker Configurations

ii. QDrone 2

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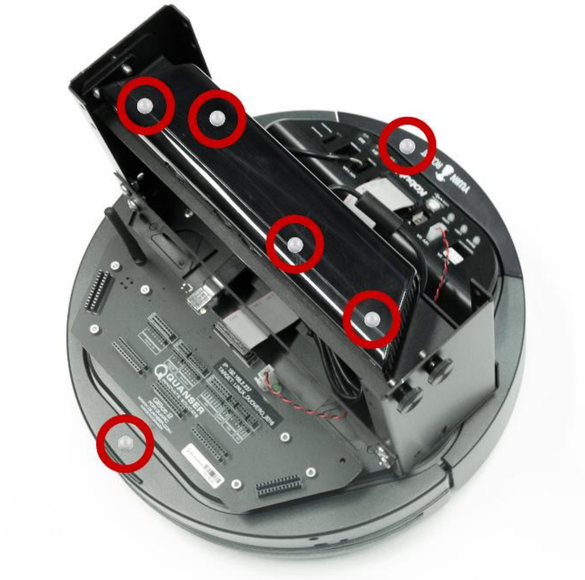
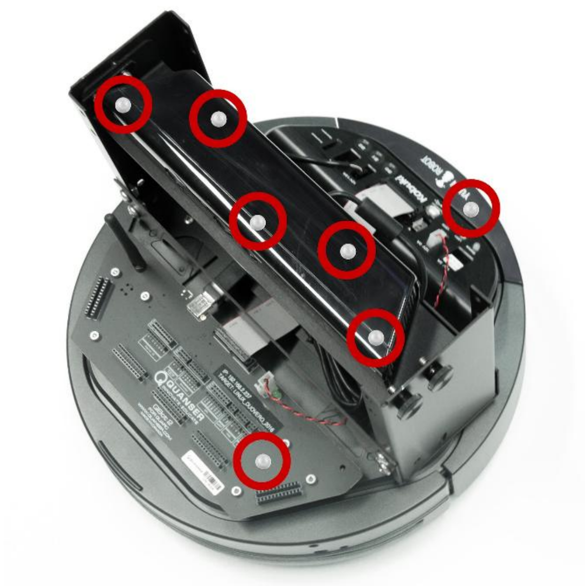
10 Unique QDrone 2 Marker Configurations

iii. QBot 2

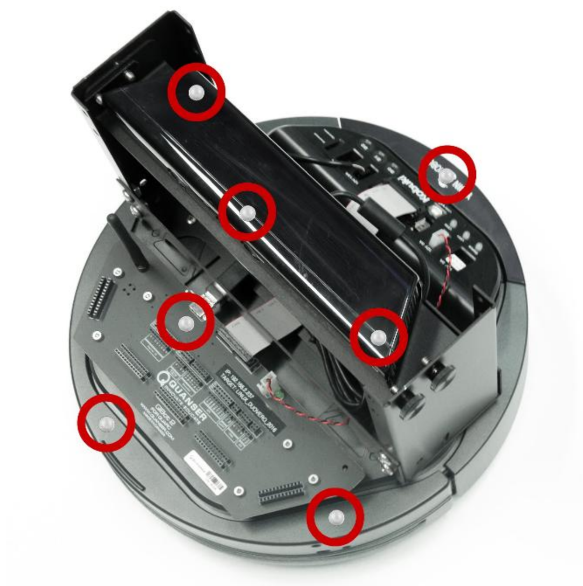


1

2



3



4

4 Unique QBot 2 Marker Configurations

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