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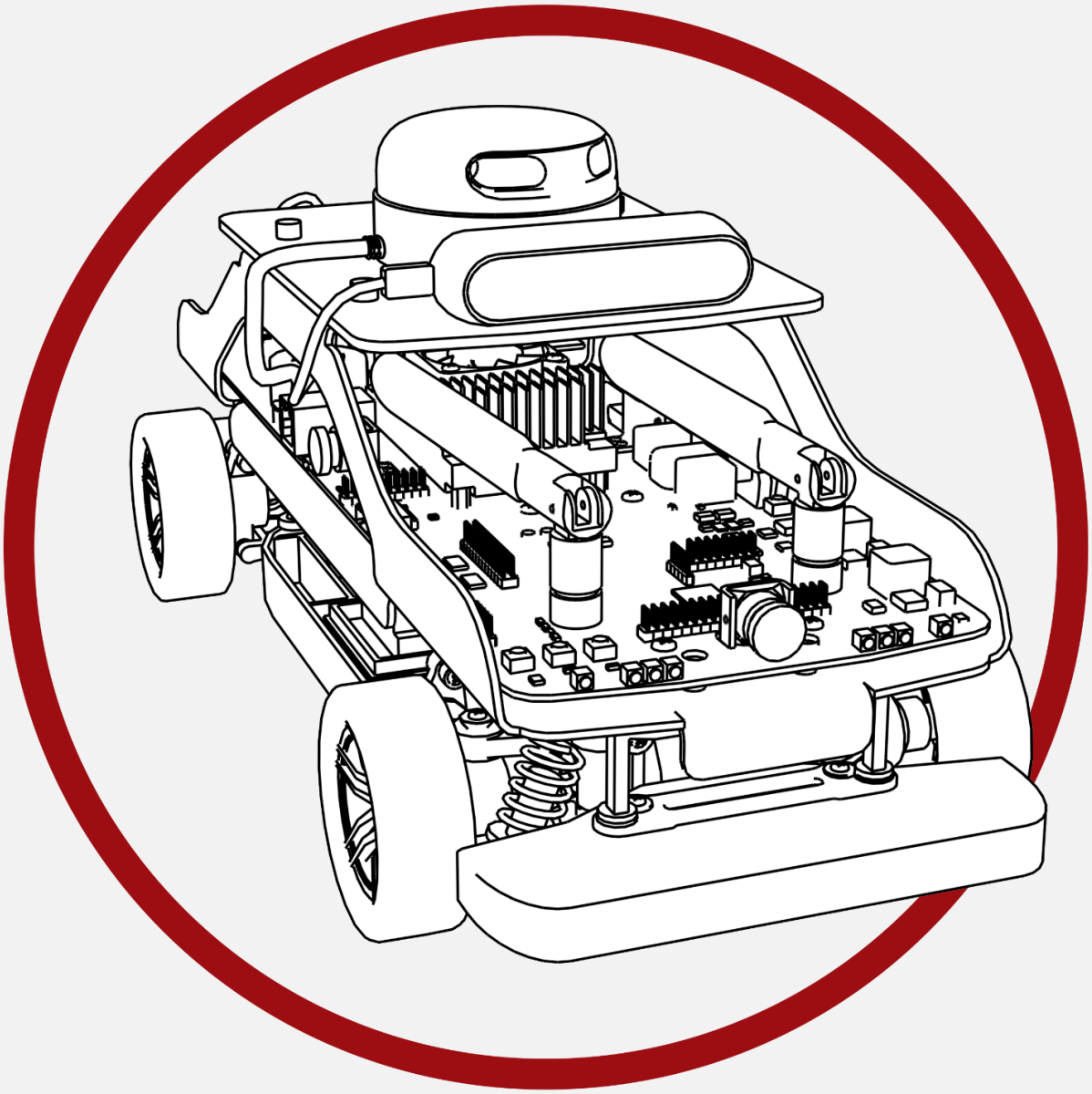

STEM Experience

V1.0 - May 2025

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A. Description

Within this STEM Self-Driving Experience, there will be up to five (5) QCars driving autonomously around a custom-designed roadway track pattern on a raised platform. The QCars will obey certain traffic rules defined for the track, such as stopping at the traffic light and not crashing into other QCars. The QCars will continue to drive and navigate around the track autonomously until a stop condition is encountered, such as, having a hand or an object in front of it or another QCar being too close.

The laptop will have a Graphical Interface App running that will connect to and communicate with one QCar at a time. There are different "tabs" on the app that the user can switch between to examine different aspects of Self-Driving Autonomy. Each tab will have different interactive elements to affect the otherwise autonomous behavior of the connected QCar. The affected behavior serves to highlight relevant information related to the theme of the current tab. With the tablet, users will also be able to enable manual driving mode to allow them to drive the car using a joystick/wheel as the input to help them understand the benefits of self driving.

The laptop also serves as the central hub of operations for the STEM Experience and provides the main display for the system. The app running on the PC/TV renders a virtual environment that reflects the real-time status of each of the components in the systems, such as the traffic light status, the speed and position of the QCar on the track and their corresponding battery levels. When the QCars are turned off and/or not connected to the Mission Server, that QCar will be shown at its default location at side of the track.

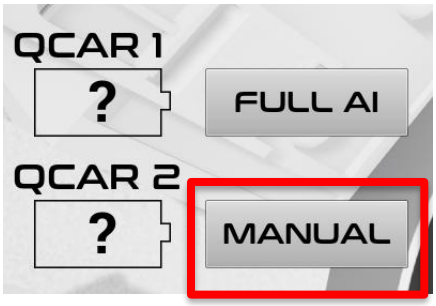
B. Normal Operation

During normal operations, the QCars will

- If not connected to Graphical Interface App, the car will randomly choose a path to follow and a speed to drive at to have some variability in the system
- Steer based on detecting the selected Color coded Pre-Defined Path as specified on the laptop
- Adjust speed and keep a certain distance from other objects, such as another QCar
- Go back to its followed Color coded Pre-Defined Path after minor collision
- Speak when it is lifted up
- Produce different honk sounds when following different lanes
- Turn on signal lights and break lights as appropriate
- React to the traffic signs, such as the Stop and Slow signs

C. Manual Driving

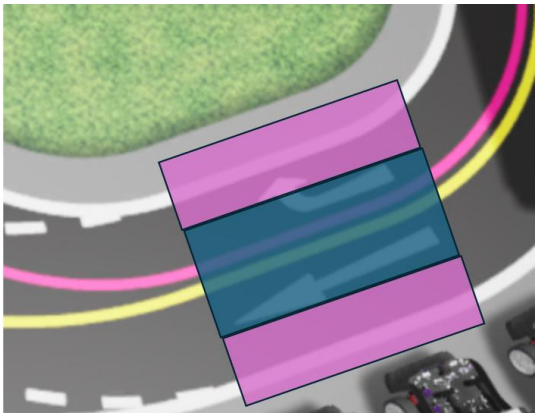
To enable manual driving, on the infrastructure PC, next to the cars enabled, click on the **FULL AI** button next to the battery level of the QCar to toggle on **MANUAL**.



Once this is clicked, a new tab will appear on the car tablet all the way to the right named **DRIVE**. To use it, the car will need to be already following the yellow line. Once you are in this tab you will be able to start manual driving when clicking on the **ENABLE** button. This will stop the car in place and wait for the input to come from the joystick or wheel.

The manual driving has some assistance using the car's position with respect to the center of the lane. If the car is near the center of the lane (within a predefined threshold), the user has full autonomy of the car, the further away from the center of the line beyond the predefined threshold, steering assistance will provide proportional correction. If the user drives too far from the lane, the car steers autonomously to prevent cars from driving all over the map. Once they are back in the driving area, they regain control to manual drive.

Using the next image as a reference for how this would work based on the distance to the center of the lane, while the user is driving the car in the blue area, they have full autonomy. In the pink area, the steering assistance will proportionally correct the car based on how far from the lane they are. Everything outside the pink area, the car will only use autonomous steering until it is back inside the pink boundary.



D. Race/Game Scenario

Cars used for race/game scenario will need to be following the yellow lane which is selected on the app. Once the car is in the start position, click **Stop Car** from the Do tab so it stops in the correct position. Change to the **DRIVE** tab. Once both cars are stopped at the correct position, click on Enable Manual on both tablets and click **Start Car** (in the same spot where Stop Car was pressed) so that the 'race' begins.

As the drivers drive along the roadway, their "score" will be calculated as an accumulated weighted sum of the distance traveled from the starting location (positive weight) and the "distance offset" of the car from the "yellow" center line (negative weight). This total "score" will be saturated at 0 (i.e., the score can only be positive, with 0 being the minimum score). If the cars run through an intersection without a green light, a fixed value will be subtracted from the total.

After the "race" is started and as the car starts to move, the "score" will start to increase. If the car remains within a certain distance threshold from the "yellow" center line, their score will just be proportional to the distance traveled. If the car deviates beyond the "threshold" from the "yellow" center line, then a penalty (negative weighted value of the distance offset) will be applied to their score. Passing an intersection without a green light will also have a negative impact on the score.

Wherever the end position is, once the cars are there and the user stops driving, they can look at the score at completion.

The instantaneous value of these "scores" (or the "running total") is transmitted continuously as part of the data packet to the laptop. The score will be reset to zero when the "Enable Manual" drive button is toggled off.

E. Setting Up

If things have been set up properly, the laptop should run 3 files on startup: the NN, the V2V and the Infrastructure file. The cars can also be configured to run the appropriate code on startup. In addition, the router should have already been setup to reserve the proper IP addresses for the QCars and Traffic lights.

Device Setup

1. Make sure router and traffic lights are on, and the laptop is connected to the router.
2. Ensure the connected cars and traffic lights have appropriate IP address. For the cars, the IP addresses should be within the range from 192.168.X.11 to 192.168.X.15, and the IP addresses for the traffic lights should be 192.168.X.20, and 192.168.X.21, where "X" is dependent on the IP gateway of your router. Refer to the following subsection if you need to change the IP addresses.
3. The configuration file can be found in "***Documents/STEM Experience RT Files***". It contains variables such as the IP gateway of the router, car type ("QCar1" or "QCar2",

case sensitive), and delay time in seconds for RT models to run on boot. Ensure the ***IP_GATEWAY*** variable is consistent with that of your router.

4. To configure the behaviours of the devices (Traffic light, QCars, Laptop), Batch scripts and ReadMe files are provided for each device in their respective directories. Within the RT files directory, they can be found in "***STEM_Experience/Cars***"," ***STEM_Experience /Infrastructure***", and "***STEM_Experience /Traffic_Lights***".

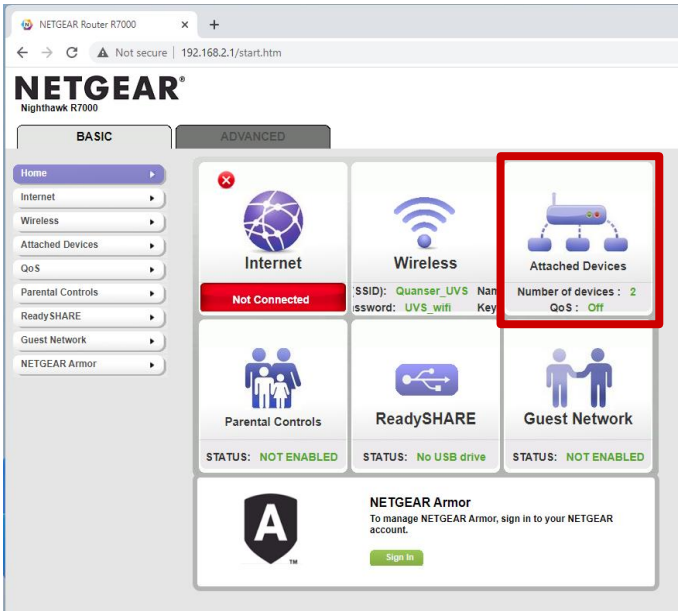
5. Before starting the QCars, reference scans must be transferred to the QCars. The instructions and scans can be found in "***STEM_Experience /Cars/Reference_Scans***".

Router Setup

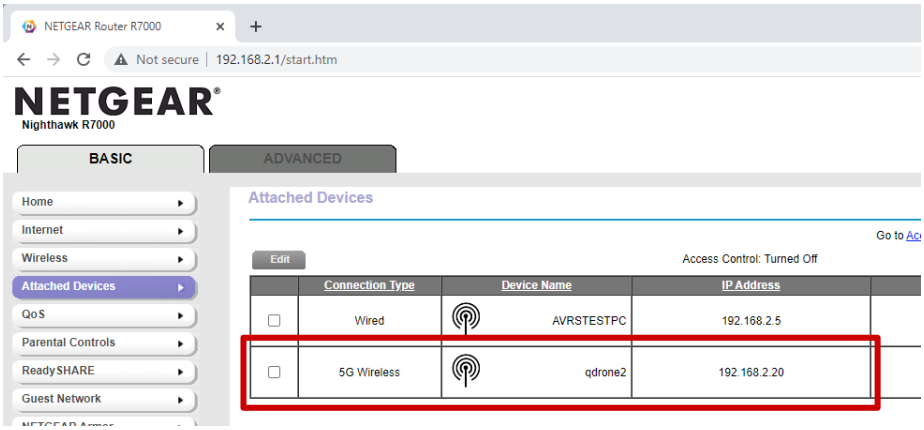
1. Launch a web browser from a device that is connected to your router's network

2. Enter the IP gateway in the address bar, for example "http://192.168.2.1", and log in. The IP gateway can be found by entering ipconfig command to Windows PowerShell.

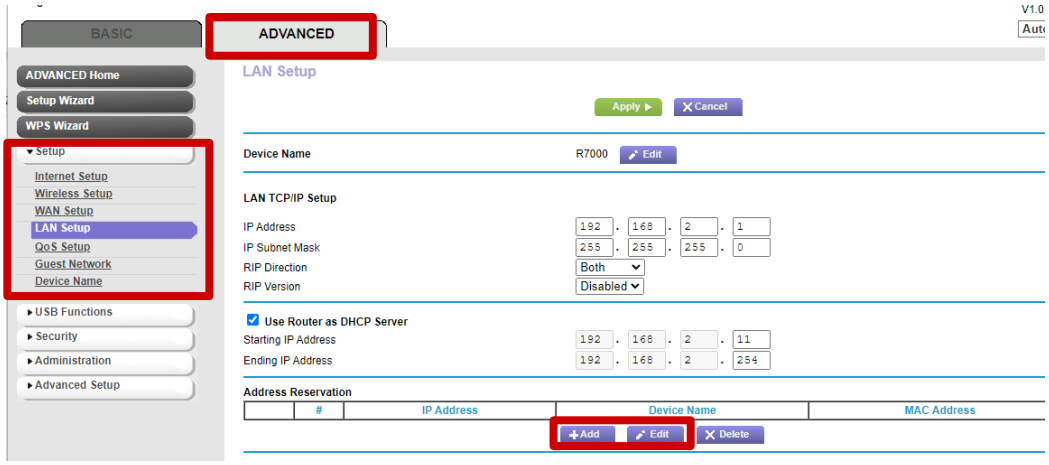
3. In the router interface, Click on Attached Devices.



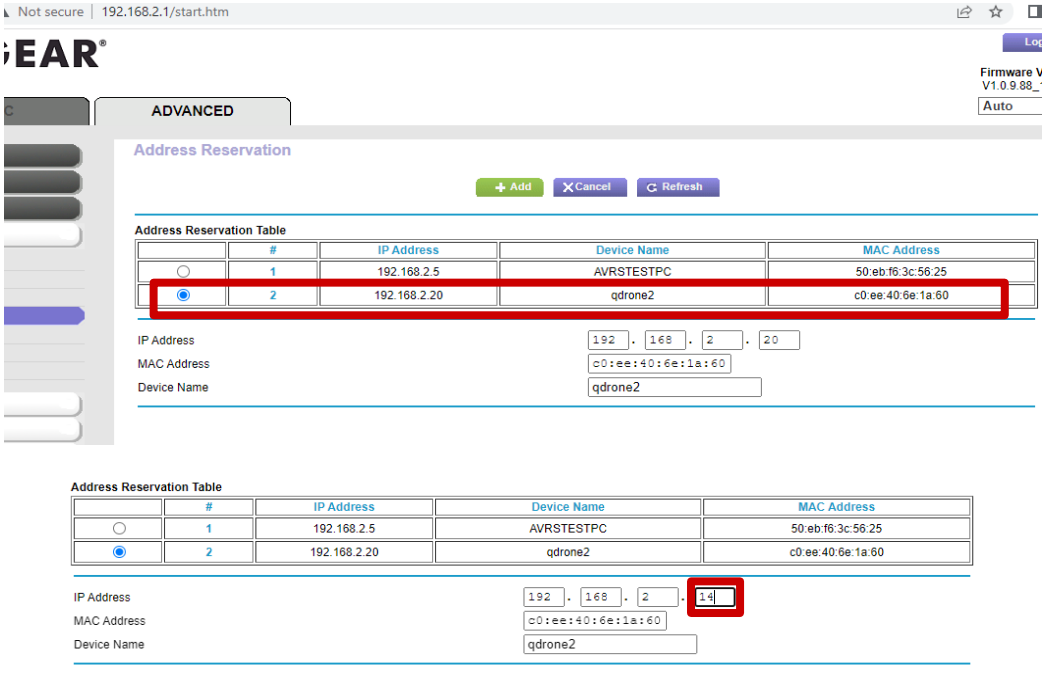
4. You should see a list of devices connected to that network as shown below. Verify that the connected devices have the correct IP addresses as specified in the previous section.



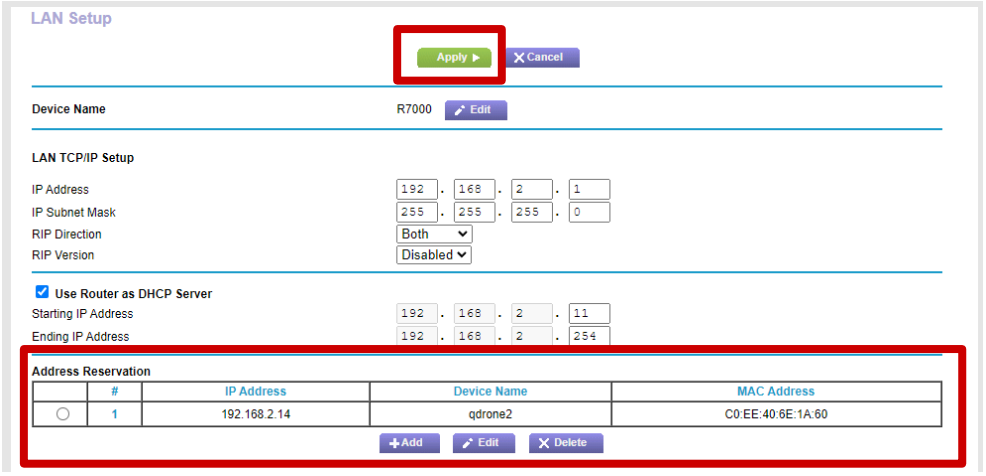
5. To add/correct a fixed IP address go to the *Advanced tab* > *Setup* > *LAN Setup* and click on the **Add/Edit** button at the bottom of the page, as shown below.



6. Select the device in the *Address Reservation* table, as shown below. To change the IP address, go to the *IP Address* box below and change the last digit to the IP address (keep the IP gateway consistent). For example, instead of using **192.168.2.20**, you can choose another IP address between 192.168.2.11 and 192.168.2.254, for example **192.168.2.14**.



7. The *Address Reservation* table should show the device with the new IP address, as illustrated below. Click on the green **Apply** button to submit the changes.

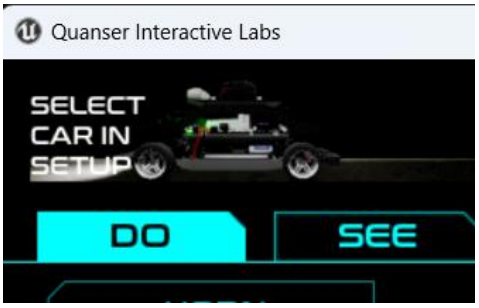


8. Once the setting is updated, the devices will have the new fixed IP.

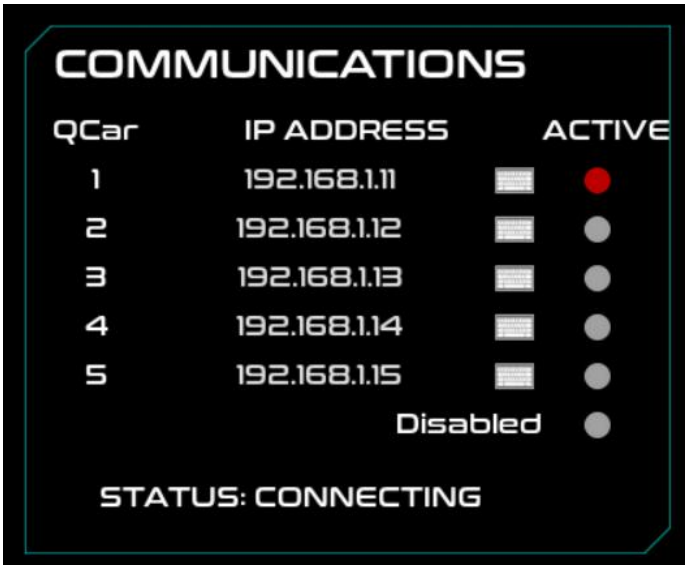
9. Reboot your devices to make sure the settings are properly applied. It is recommended to label the devices with the IP address for future usage.

App Setup

1. Open the UE app on the laptop and click on the bottom option **infrastructure** to open the map
2. Open the UE app on the laptop and click on the **QCar interface**. That will open the application in full screen mode (to exit this press f11 in the keyboard)
3. On the top left corner next to the small version of the car, above the Do tab, click SELECT CAR IN SETUP



4. This will prompt you for a password. The password is *STEM_table*; you will be able to change the password on the next screen if you want.
5. On the communications side of the application, select what car that laptop will connect to. It's also possible to connect to multiple cars with multiple tablets. If you have 3 tablets for the 3 cars, select QCar 1 on one tablet, QCar 2 on the second one and so on. The selected car will be saved, so this step will not need to be repeated when the system starts.



6. If your cars were not on, it will hang in the "connecting" status. That will change once the cars are set up and turned on.
7. For any subsequent uses, just open the app on each tablet and the system will proceed with saved configurations.

Physical System Setup

1. Place the cars following traffic order along the area where the yellow and blue tracks are together. The cars will not localize properly if they do not start inside the table.

2. Turn on all the cars by pressing once the red button on them. It will make a few pop sounds once it is ready and after around 15 seconds the lidar should start spinning. If the app is open on a tablet and connected to the car it will wait for the start button to be pressed on the tablet. Otherwise, it will start by itself.

3. Ensure positions are correct in the **infrastructure** app display. It might take a few seconds after the car starts moving for the car position to be correct.

4. If the car lidar starts spinning but stops immediately, please turn the car off and turn it on again.

5. Never lift the car to place it in another position in the track, it could stop being able to localize properly. Moving it a little bit to one side in case it crashed or drove wrong is okay.

Common Issues

1. QCar not running applications on boot properly:

   Use QUARC "Monitor" app to connect to device by selecting "Target -> Remote" and type the IP of the QCar. After connected to the QCar, open the console by selecting "Console" and run the application manually but executing "**run_car_model.bat**"

   a. QUARC console showing "**video format not supported**" or "**camera not found or not supported**" error:

      Unplug the RealSense camera cable and plug it back in then reboot the QCar. If this fails, replace the camera cable with a new one.

   b. QUARC consoled doesn't show any error, and the application runs properly:

      The QCar might not have sufficient time to start up properly before running the application. Increase the "**INITIAL_WAIT**" variable in the config file then execute "**enable_run_on_boot_car_model.bat**" to deploy the changes.

2. Application does not run after executing the batch scripts:

   Ensure the laptop and the devices are connected to the provided router. In addition, ensure the "**IP_GATEWAY**" variable is consistent with the IP gateway of connected network.

3. The application is running (LiDAR is spinning) but QCar is not moving:

   Restart the infrastructure models by running "**stop infrastructure model**" and then "**run infrastructure model**" batch scripts.

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