

Software Manual

for

Pittsburgh Train Automation System

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Aurora, Inc.

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1 Overview

1.1 Launching the Program

If not already installed, install the software using the steps outlined in [installation guide.md](#). Once this is complete, run the file by entering the following commands from a terminal in the ECE1140 folder:

```
conda activate trains
python main.py
```

After a few seconds the launcher screen will open. Click the Start System button to start the simulation clock. You are now able to click the buttons for each module to open each one's GUI.

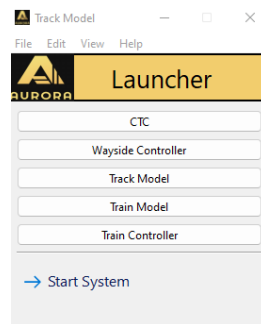


Figure 1.1

2 Module Guides

2.0 Top Panel

Each module GUI has a top panel like the one shown in figure 2.1. The left side of the panel shows the company logo and the title of the module. On the right side are several simulation time-related widgets. The **Simulation Speed** slider allows the user to adjust the simulation speed from 1 to 10 times wall clock speed. The button placed to the immediate left of the slider is the **Pause Button**. Clicking this will stop or start the simulation clock.

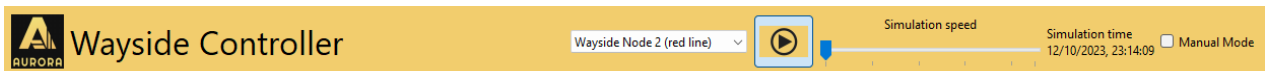


Figure 2.0.1

2.1 CTC Office

The CTC Office UI allows the user to perform various functions including controlling train dispatching, monitoring track faults, and viewing passenger throughput data.

On the **Send Trains** tab, the leftmost widget controls train dispatching. The radio buttons in the top left allow the user to choose between automatic and manual dispatching mode. In automatic mode, shown in figure 2.1.1, the user may use the **Upload Train Schedule** button in the bottom left to upload an excel file to automatically schedule and dispatch trains.

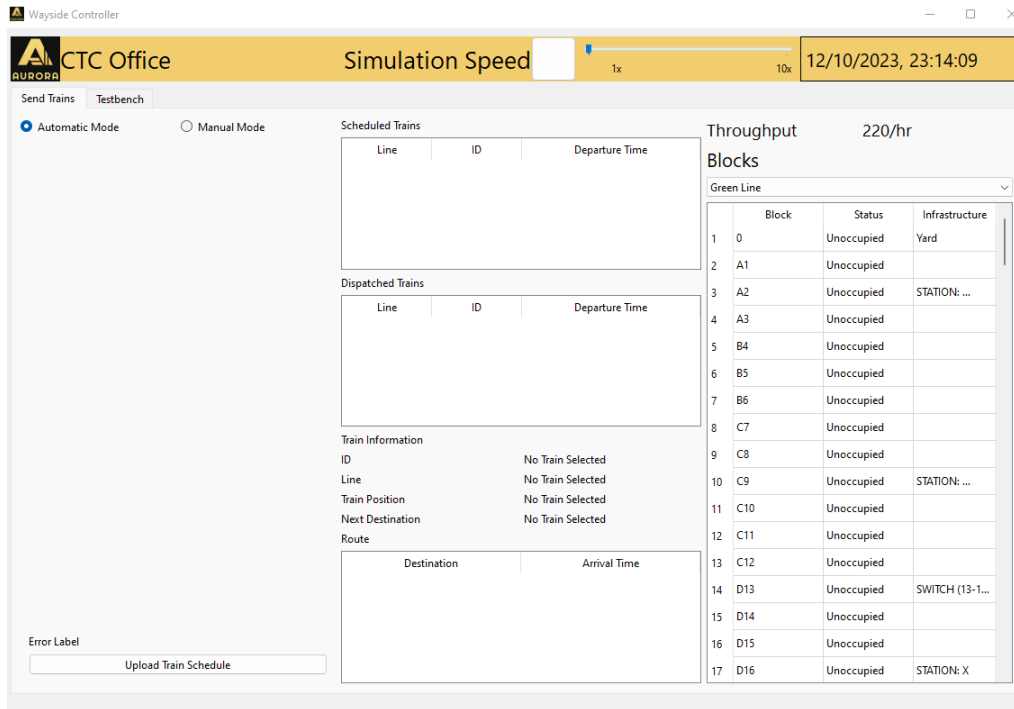


Figure 2.1.1

In manual mode, shown in figure 2.1.2, the user can manually plot and dispatch trains. The buttons in this section of the widget perform the following functions:

- **Select Line Dropdown**
 - Selects which line to dispatch the train on
 - Effects the contents of the **Select Station** and **Select Block** dropdowns
- **Select Station Dropdown**
 - Selects a station stop to add to the train's schedule
- **Select Block Dropdown**
 - Selects a track block stop to add to the train's schedule (not used for standard operations)
- **Time Selector**
 - Selects arrival time for stop
 - If left unchanged, the train will immediately depart from the yard when the **Dispatch** button is clicked
- **Add Destination**
 - Adds the stop described by the **Select Station**, **Select Block**, and **Time Selector** options
 - Must have either a station or track block selected from their respective dropdown menus
- **Schedule Table**
 - Shows an ordered list of stops for the train to be dispatched
- **Reset Route Button**
 - Clears all stops shown in the table and resets the trains route to null
- **Dispatch Train Button**
 - Dispatches a train with the schedule described by the above widgets

The middle section of the **Send Trains** tab contains train information. When a train has yet to depart, it will appear in the **Scheduled Trains** table (top). When the system reaches the departure time,

the train is moved from the **Scheduled Trains** table to the **Dispatched Trains** table and the train is spawned in the yard. Both tables indicate the trains line, ID number, and departure time. When the user selects a train in either table, the information below the tables gives more detail about the selected train, including:

- **Train Position** – The block that the train currently occupies
- **Next Destination** – The next stop in the train’s schedule
- **Route** table – shows the full route of the train in order with the first entry being its next destination

At the top right of window, the dispatcher can see the total throughput of the full system. This value is calculated from ticket sales. The table below shows block information including block ID, occupancy, and infrastructure.

The screenshot shows the 'CTC Office' simulation window. At the top, it displays 'Simulation Speed' at 1x and the date/time '12/10/2023, 23:14:09'. The interface is divided into several sections:

- Left Panel:** Contains controls for 'Send Trains' and 'Testbench'. It has radio buttons for 'Automatic Mode' and 'Manual Mode' (selected). Below are dropdown menus for 'Select Line', 'Select Station', and 'Select Block', followed by a date/time field '12/10/2023 23:11' and an 'Add Destination' button. A table with columns 'Station' and 'Arrival Time' is present, along with an 'Error Label' and buttons for 'Reset Route' and 'Dispatch Train'.
- Top Center:** A 'Scheduled Trains' table with columns 'Line', 'ID', and 'Departure Time'.
- Bottom Center:** A 'Dispatched Trains' table with columns 'Line', 'ID', and 'Departure Time'.
- Bottom Left:** 'Train Information' section showing fields for ID, Line, Train Position, Next Destination, and Route, each with a 'No Train Selected' message. Below is a table with columns 'Destination' and 'Arrival Time'.
- Right Panel:** Displays 'Throughput' as '220/hr'. Below is a 'Blocks' section with a dropdown for 'Green Line' and a table with columns 'Block', 'Status', and 'Infrastructure'. The table lists 15 blocks (0 to D14) with their current status and infrastructure details.

	Block	Status	Infrastructure
1	0	Unoccupied	Yard
2	A1	Unoccupied	
3	A2	Unoccupied	STATION: ...
4	A3	Unoccupied	
5	B4	Unoccupied	
6	B5	Unoccupied	
7	B6	Unoccupied	
8	C7	Unoccupied	
9	C8	Unoccupied	
10	C9	Unoccupied	STATION: ...
11	C10	Unoccupied	
12	C11	Unoccupied	
13	C12	Unoccupied	
14	D13	Unoccupied	SWITCH (13-1...
15	D14	Unoccupied	

Figure 2.1.2

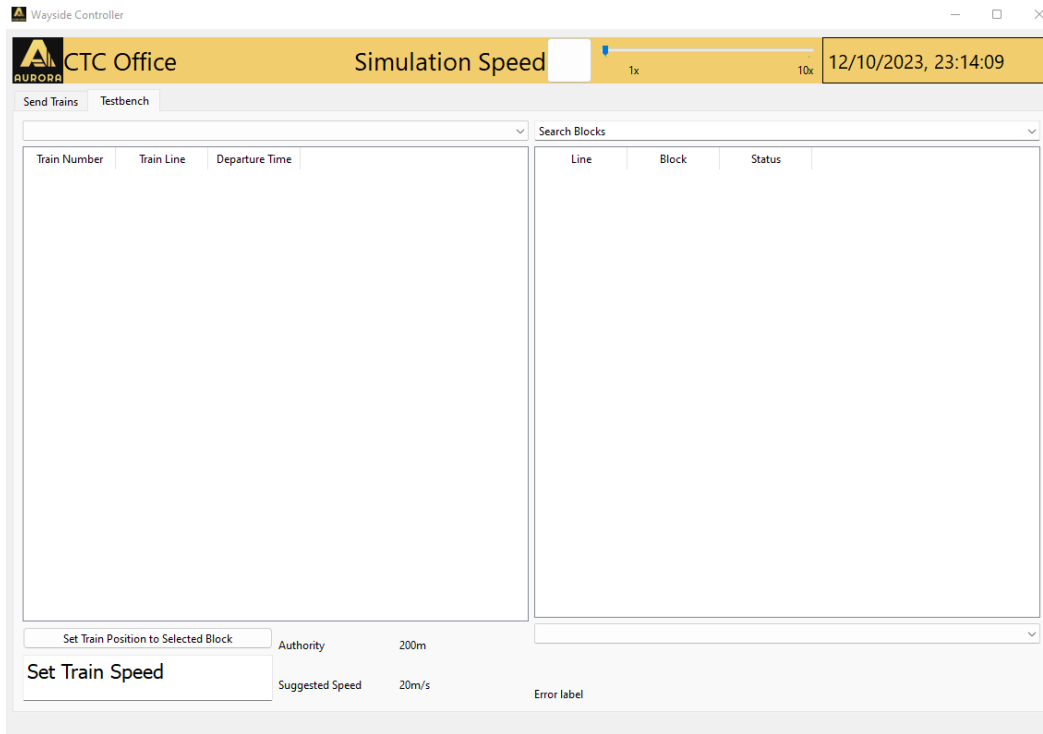


Figure 2.1.3

2.2 Wayside Controller

The Wayside Controller UI allows the user to control track logic, view/modify/load PLC programs, and view occupancy information for each of the five wayside controllers. The **Node Select** dropdown on the top panel (left of the pause button) allows the user to select which wayside controller to view or control. The far-right checkbox on the top panel is the **Manual Mode** switch.

The main tab in the Wayside Controller UI is the **Switch Control** tab. The table on the left shows all information about each switch including:

- **Block** column – Indicates the location of the switch
- **Primary Block** column – Indicates the switches primary connection
- **Secondary Block** column – Indicates the switches secondary connection
- **Current Connection** column – Indicates the switches current position

Note that there is no real distinction between primary and secondary switch positions; these were chosen arbitrarily based on the track map.

The **Switch Control** tab (figure 2.2.1) also contains a section for viewing, modifying, and uploading PLC programs for track logic. Each Wayside Controller loads three PLC programs. The **Selected Program** spin-box allows the user to cycle between the three programs. If a PLC program is loaded, clicking the **View File** button will open the PLC file in the Windows Notepad text editor so that the program may be conveniently modified. The software does **not** detect changes to the PLC file automatically, so for modifications to take effect, the user will have to use the **Upload PLC** button.

Clicking this button will open a Windows Explorer window in the PLC file location. Double-clicking one of the files will load that program into the wayside controller and its changes will immediately take effect.

The **Yard Return Mode** checkbox also appears on the Wayside Controller **Switch** tab. If the Wayside Controller's control region contains the Yard block (block 0), ticking this checkbox will immediately flip the switches that allow a train to return to the Yard.

Each of the tabs **Switch Control**, **Signal Control**, and **Crossing Control** show a table on the right that contains block information. This information includes:

- **Block ID** – Indicates block ID number
- **Section** – Indicates which letter-section the block is a part of
- **Status** – Indicates whether the block is under maintenance
- **Occupancy** – Indicates whether the block is occupied

Each of these tabs also has a graphic placed in the middle so the user may more easily understand the position of the track device (switch, signal, or crossing) currently selected. In **Manual Mode**, the **Toggle** button for each device is enabled and allows the user to manually change the state of the selected device. Note that in **Manual Mode**, the PLC program will **not** be executed.

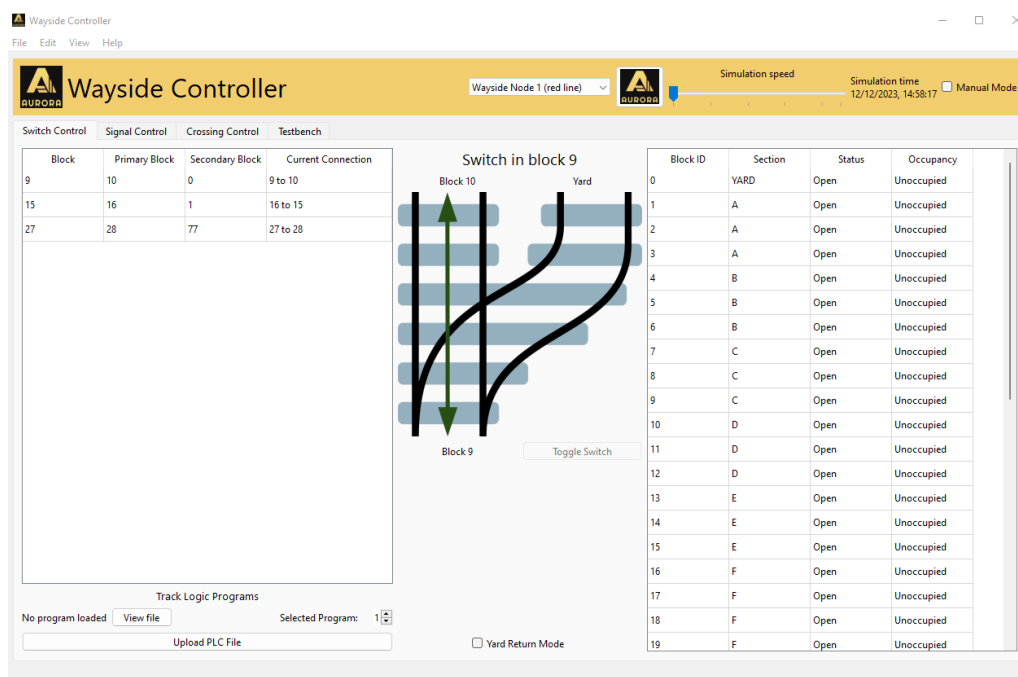


Figure 2.2.1

The **Signal Control** (figure 2.2.2) and **Crossing Control** (figure 2.2.3) tabs are very similar to each other and to the **Switch Control** tab. The leftmost table for both tabs indicates the block position and current state of each device.

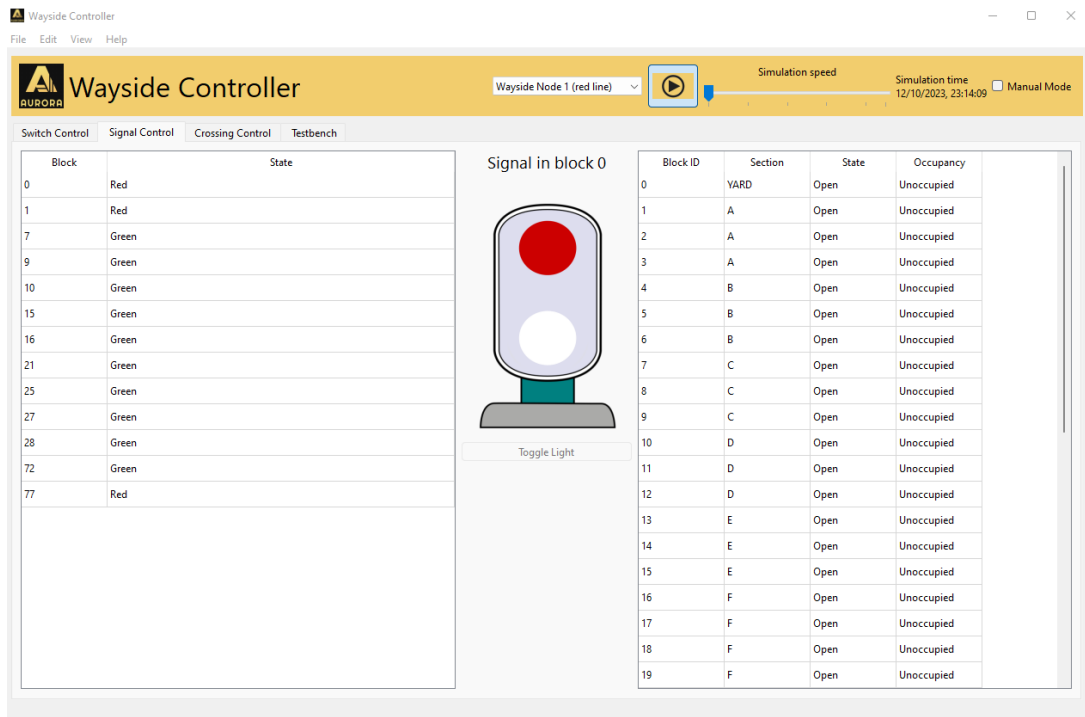


Figure 2.2.2

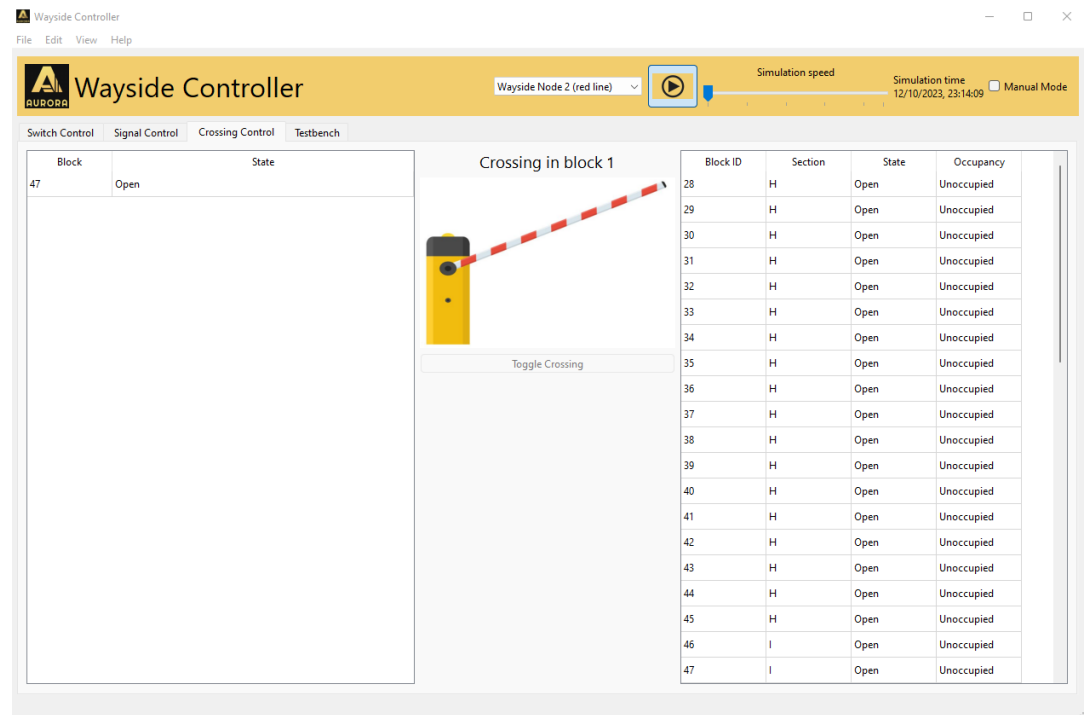


Figure 2.2.3

The Wayside Controller UI's **Testbench** tab allows the user to simulate certain inputs from the CTC Office and Track Model. This page is primarily intended for developer use. The only two inputs simulated are **Occupancy** and **Maintenance**. The table shows the same four columns on the other tab in addition to **Switch**, **Signal**, and **Crossing** columns. The **Authority** column shows the authority value being sent to the Track Model.

Wayside Controller

Wayside Node 1 (red line)

Simulation speed

Simulation time 12/12/2023, 17:32:55

Manual Mode

Switch Control Signal Control Crossing Control Testbench

Section YARD, Block 0

Device Inputs

☐ Occupy Block

☐ Place under maintenance

Block ID	Section	State	Occupancy	Switch	Signal	Crossing	Authority
0	YARD	Open	Unoccupied		Red		164 ft (CTC)
1	A	Open	Unoccupied		Red		164 ft (CTC)
2	A	Open	Unoccupied				164 ft (CTC)
3	A	Open	Unoccupied				164 ft (CTC)
4	B	Open	Unoccupied				164 ft (CTC)
5	B	Open	Unoccupied				164 ft (CTC)
6	B	Open	Unoccupied				164 ft (CTC)
7	C	Open	Unoccupied		Green		245 ft (CTC)
8	C	Open	Unoccupied				245 ft (CTC)
9	C	Open	Unoccupied	9 to 10	Green		245 ft (CTC)
10	D	Open	Unoccupied		Green		245 ft (CTC)
11	D	Open	Unoccupied				245 ft (CTC)
12	D	Open	Unoccupied				245 ft (CTC)
13	E	Open	Unoccupied				229 ft (CTC)
14	E	Open	Unoccupied				196 ft (CTC)
15	E	Open	Unoccupied	16 to 15	Green		196 ft (CTC)
16	F	Open	Unoccupied		Green		164 ft (CTC)
17	F	Open	Unoccupied				656 ft (CTC)
18	F	Open	Unoccupied				1312 ft (CTC)
19	F	Open	Unoccupied				1312 ft (CTC)

Figure 2.2.4

2.3 Track Model

The Track Model UI window is the hub of our software, so our team spent a lot of time making this window informative and intuitive.

The **Track Map** tab (figure 2.3.1) shows all block-related information for the system. The map placed on the left of the tab is fully interactive; the user may zoom, pan, and select blocks to view their information. The **Red Line** and **Green Line** buttons above the map toggle the view for each of the rail lines so the user can view either or both lines. The blocks on the map are numbered according to their IDs and clicking on a block will update the information boxes in the top right of the window. The map itself is color coded to indicate various states and infrastructure for each block. The meanings of these colors are clearly explained by the **Color Key** shown in the bottom right of the window.

The **Faults on Selected Block** box simply indicates whether the selected block is experiencing each of the three faults, which are **Broken Rail**, **Track Circuit Failure**, and **Power Failure**. If any of these faults are active, the block will appear as occupied to the Wayside Controller and CTC Office.

The **Block Information** box shows a plethora of information about the selected block. This information consists of:

- **Section** – indicates the section letter of the selected block
- **Authority** – shows the authority of the selected block in feet
- **Occupancy** – shows a true/false value for whether the block is currently occupied
- **Underground** – indicates if the block is underground: *0* means the block is above ground
- **Block** – shows the ID number of the selected block matching the number seen on the map
- **Block Length** – shows the length of the block in feet
- **Block Grade** – shows the grade of the block as a percentage
- **Max Speed Limit** – indicates the absolute speed limit of the block
- **Elevation** – shows the elevation of the block relative to its neighbors
- **Cumulative Elevation** – shows the total elevation of the block relative to a set ground point
- **Temperature** – shows the temperature of the rails in the selected block
- **Heaters** – indicates if the heaters on the selected block are enabled
- **Throughput** – shows the number of passengers per hour if the block is a station
- **Total Passengers** – shows the total number of passengers since the simulation has started if the block is a station

The **Stations/Devices** box shows infrastructure and station-related information for the selected block. If the block does not contain the device or station, its related information is marked as *N/A*. The station-related information contains:

- **Station ID** – number identifier for the selected station
- **Station Name** – name of the selected station
- **Disembarking** – number passengers exiting the train (shown as *N/A* if the block is unoccupied)
- **Boarding** – number of passengers boarding the train (shown as *N/A* if the block is unoccupied)
- **Ticket Sales** – number of tickets sold at the station since the simulation started
- **Exit Side** – indicates which side of the train passengers may board and exit from

The rest of the information in the **Stations/Devices** box is contains information about any other devices placed on the block:

- **Beacon 1** – unencoded beacon package for the beacon placed on the block
- **Beacon 2** – unencoded beacon package for the secondary beacon placed on the block (appears as *None* if the block has only one beacon)
- **Switch ID** – numeric identifier for the selected block's switch
- **Switch Connections** – indicates which two blocks are currently bridged by the switch
- **Crossing ID** – numeric identifier for the selected block's crossings
- **Crossing State** – indicates whether the selected crossing is open or closed
- **Signal ID** – numeric identifier for the selected block's signal
- **Signal State** – indicates if the selected signal is green or red
- **Polarity** – shows the polarity of the selected block. *0* and *1* indicate opposite polarities

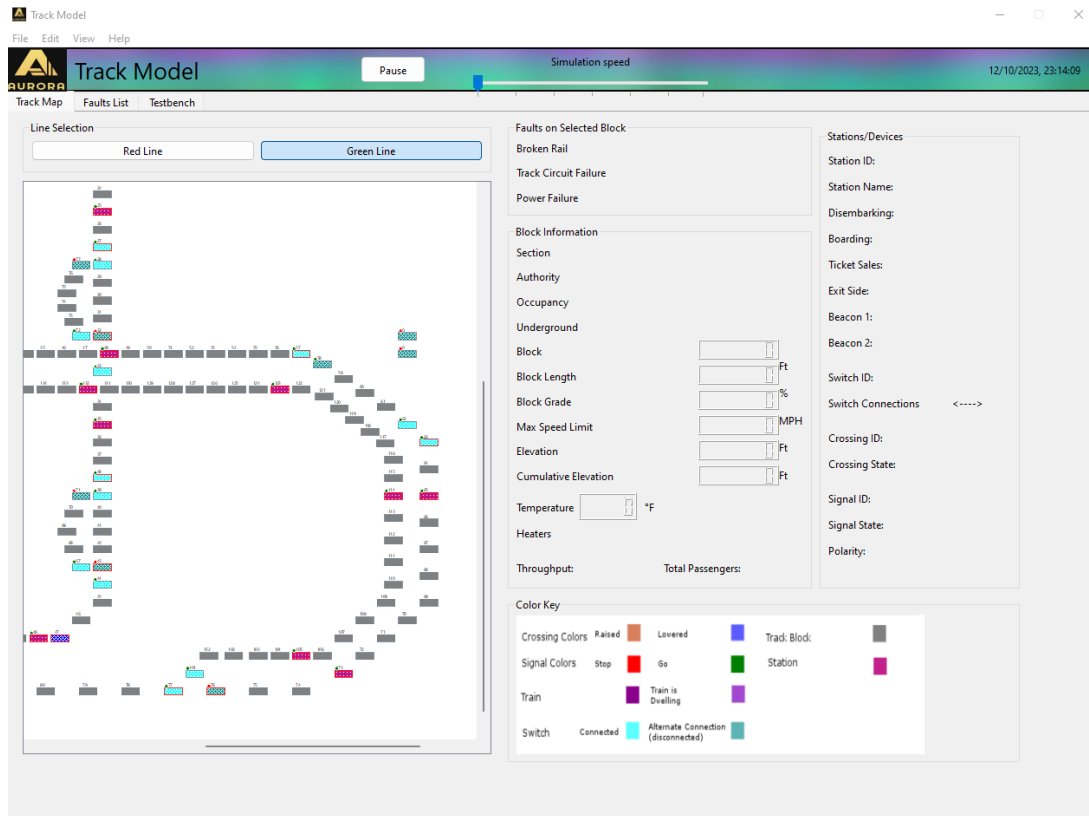


Figure 2.3.1

The Track Model UI's **Faults List** tab (figure 2.3.2) exists so the user has immediate access to all track fault information for each block. The table contains all blocks from both lines (indicated by the **Rail Line** column) and shows the status of each block's faults. If the table cell for a block is blank, the block is operating normally.

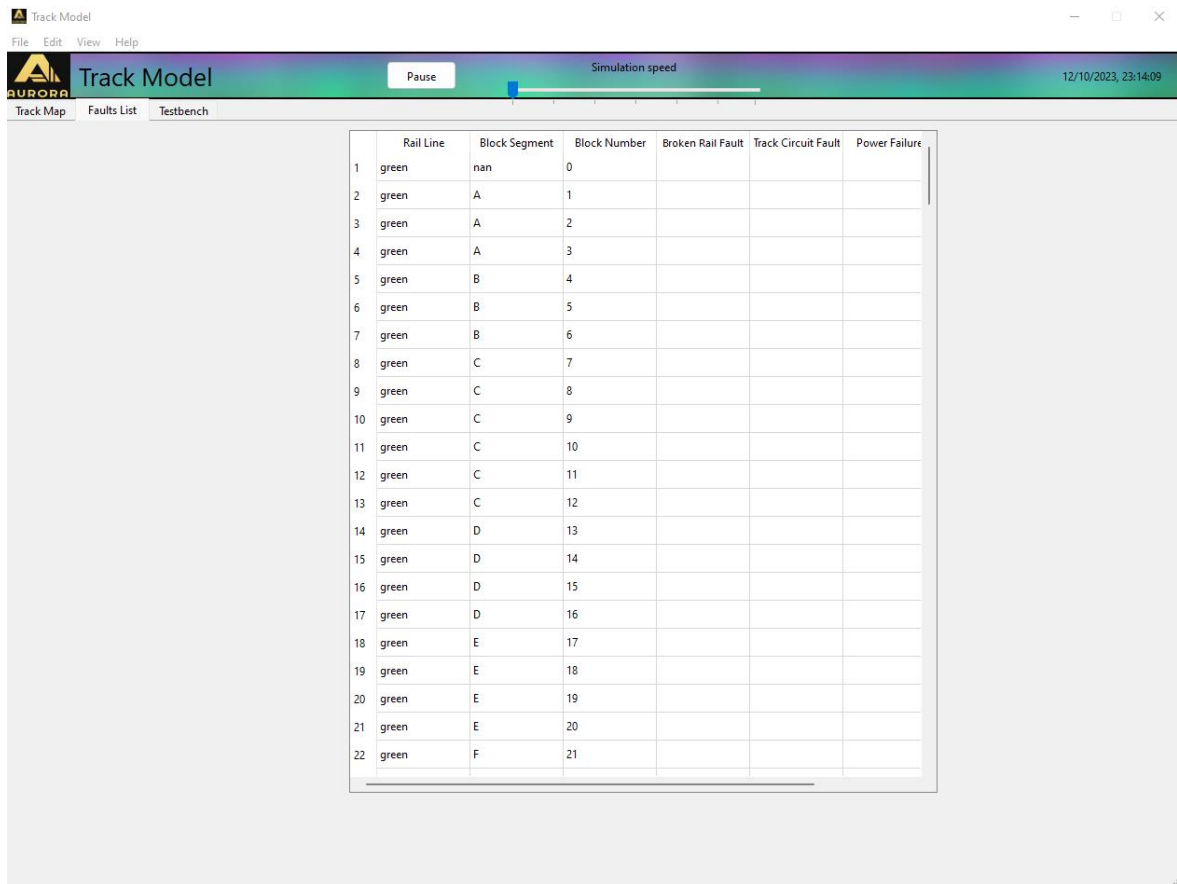


Figure 2.3.2

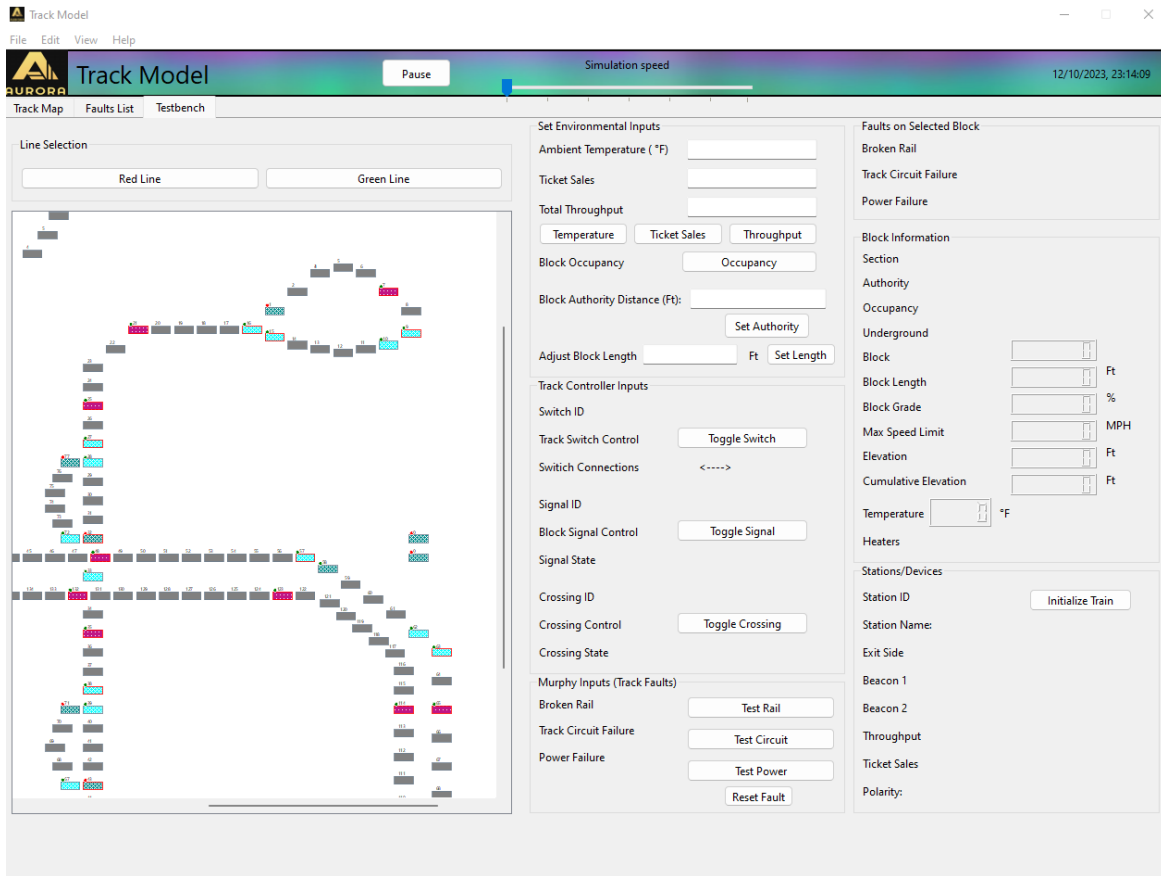


Figure 2.3.3

2.4 Train Model

The Train Model UI primarily allows the user to access information about each train. It also includes buttons so the user may trigger faults and engage the emergency brake. To select a train, the user uses the text field in the top panel to enter the ID of the train they wish to view and clicks the button left of the field corresponding to the line where the train is located. Upon doing so, the information in window will begin actively updating according to the selected train.

The **Train Model Information** tab (figure 2.4.1) contains all the information about the train model. The table in the top left shows:

- **Authority** – actively updated authority value in feet for the train
- **Power** – current power command from Train Controller in watts sent to the train engine
- **Current Speed** – current speed of the train in mph
- **Commanded Speed** – speed command sent by Train Controller in mph
- **Acceleration** – current acceleration of the train in feet per square second
- **Force** – horizontal net force on the train model in pounds accounting for engine, brakes, friction, and gravity
- **Tunnel/Underground** indicates if the train is underground
- **Block Grade** – grade of the current block as a percentage

The **Door State** table shows whether the doors on the left and right of the train are open or closed. The **Lights State** table indicates whether the interior and exterior lights are on or off. The **Brake State** table shows if the service and emergency brakes are engaged or disengaged. Shockingly, the big red button below the **Brake Table** labelled **Emergency Brake** triggers the emergency brake.

The box on the right side of the window contains more train-related information. The very top of this box shows any announcements on the passenger information system (PIS). Immediately below the announcement is fault information. There are buttons to trigger each fault type, a **Reset Faults** button to resume normal operation, and a **Failure Modes** table indicating whether each potentially faulty train part is functional or faulty. The **Train Information** table contains more train model-related data:

- **Crew Count** – number of crew members aboard the train
- **Passenger Count** – number of passengers aboard the train
- **Temperature** – cabin temperature of the train in degrees Fahrenheit
- **Weight** – total weight of the train in pounds (approximated using crew and passenger counts)
- **Length** – length of the train in feet
- **Width** – width of the train in feet
- **Height** – height of the train in feet

The screenshot shows the 'Train Model' software interface. At the top, there's a header with 'Train Model' and buttons for 'Green Line', 'Blue Line', and 'Red Line'. Below this, the interface is divided into several sections:

- Train Model Information**: A table listing various parameters like Authority, Power, Current Speed, Commanded Speed, Speed Limit, Acceleration, Force, Tunnel/Underground, and Block Grade.
- Door State**: A table showing the status of the Right and Left doors.
- Lights State**: A table showing the status of Internal and External lights.
- Brake State**: A table showing the status of Emergency and Service brakes.
- Emergency Brake**: A large red button with the text 'Emergency Brake'.
- Announcements**: A section with buttons to trigger faults for Train Engine, Brake, and Signal Pickup.
- Reset Faults**: A button to reset the faults.
- Failure Modes**: A table showing the status of Train Engine, Train Brake, and Signal Pickup.
- Train Information**: A table listing train-specific data such as Crew Count, Passenger Count, Temperature, Weight, Length, Width, and Height.

Figure 2.4.1

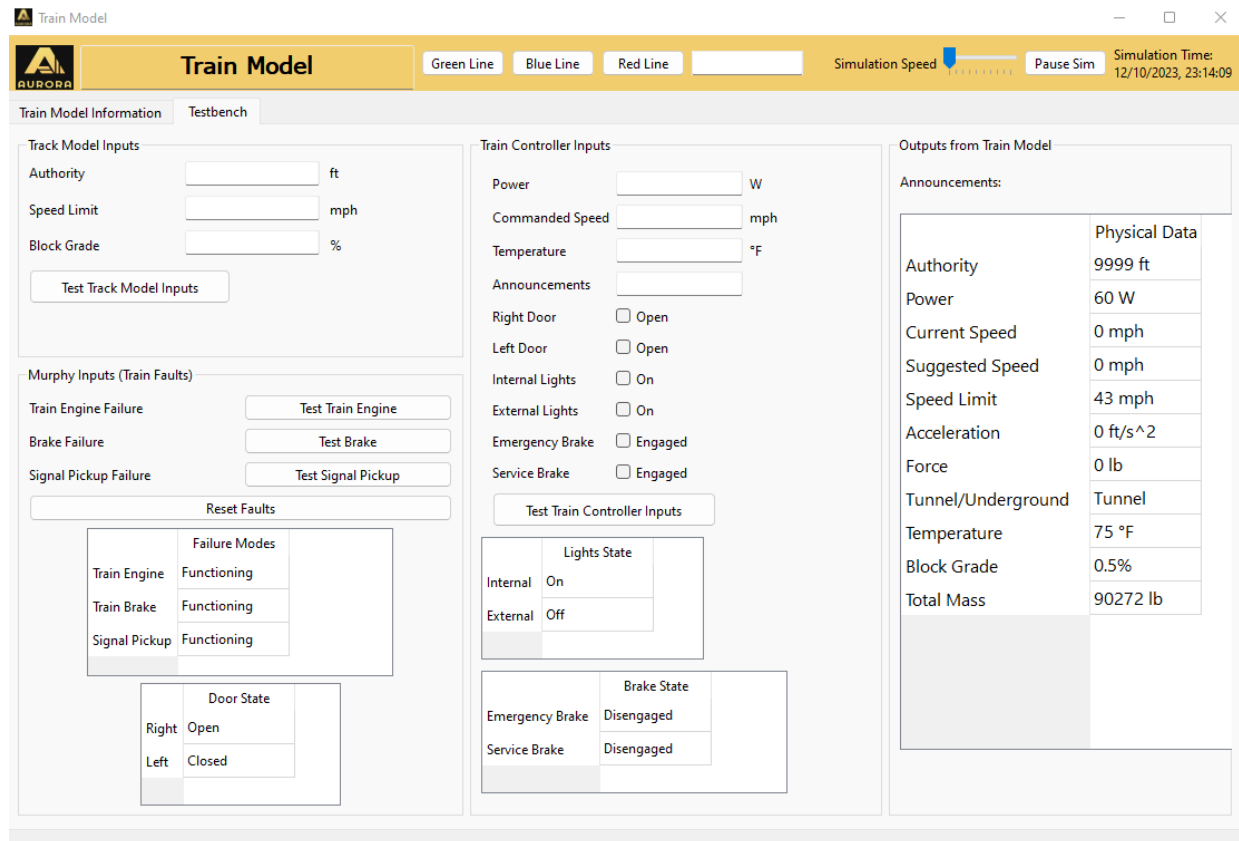


Figure 2.4.2

2.5 Train Controller

The Train Controller UI window contains much of the same information as the Train Model UI but offers control options for the train's driver and engineer.

On the **Main** tab (figure 2.5.1), the scheme for selecting a train is identical to that of the train model: the user uses the text field to right of the **Green Line** and **Red Line** buttons to enter the ID of the train they wish to view and clicks the button corresponding to the train's line. The radio button in the top right labelled **Manual** allows the user to switch between automatic and manual mode. The remainder of the **Main** tab's widgets are sorted into group boxes.

The **Driver Control** box contains speed information. It shows the following speeds in mph:

- **Current Speed** – current speed of the train observed from the train model
- **Speed Limit** – speed limit of the train's current block
- **Commanded Speed** – speed command used for power calculation
- **Suggested Speed** – speed suggestion sent by the CTC Office

In manual mode, the driver can manually change the speed command using slider underneath the **Command Speed** indicator.

The **Engineer Control** box contains information related to power and the PI Controller. The power command being sent to the train model is viewed at the top of this box. Below are indicators and sliders

for the gain values (proportional and integral respectively) for the PI Controller. In manual mode, the engineer may use the sliders to adjust the values of K_p and K_i .

The **Station Control** box shows stop-related information. This includes the train's actively updated authority, current station, next station, and announcement. In manual mode, the user can manually send an announcement to the PIS.

The boxes below **Station Control** allow the user to and/or control doors, lights, cabin temperature, and faults. All control buttons are only usable in manual mode.

The **Brakes** box allows the user to view the states of the emergency and service brakes. In manual mode, the user can manually engage the service brake using the **Service Brake** button. The **Emergency Brake** button is enabled regardless of manual or automatic mode.

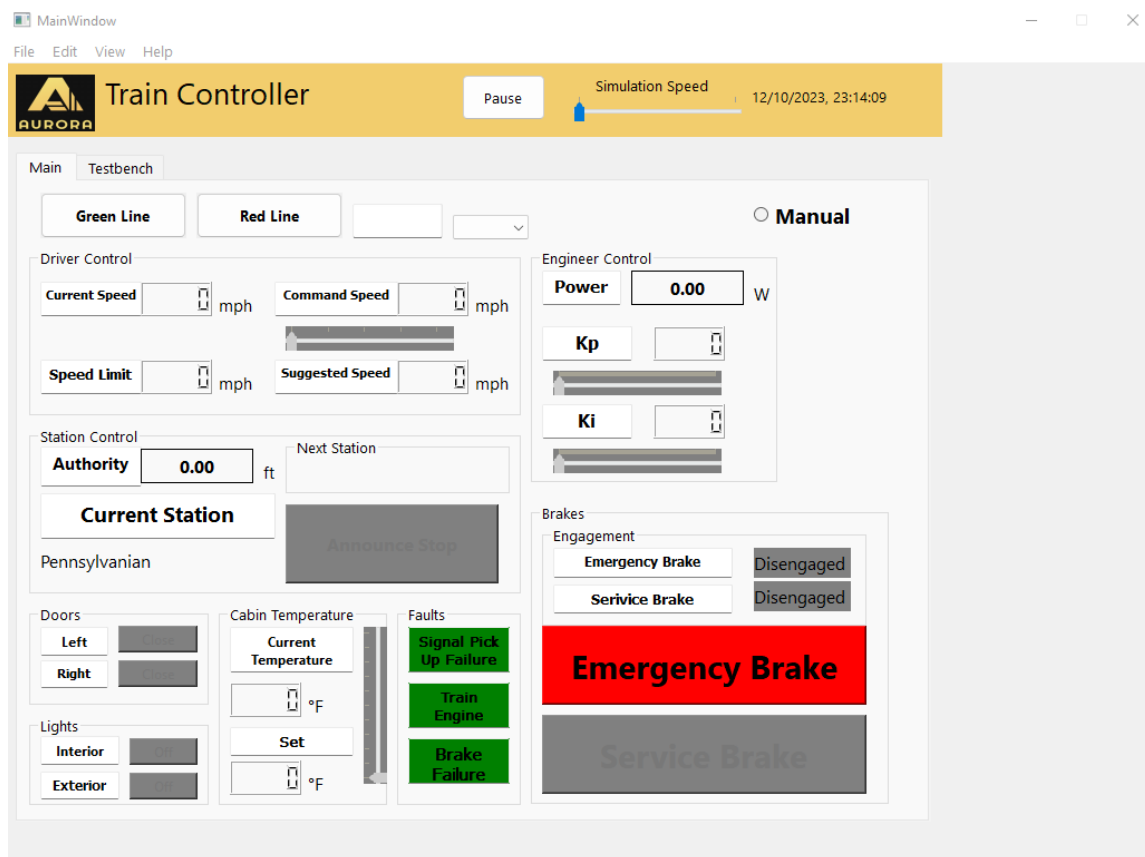


Figure 2.5.1

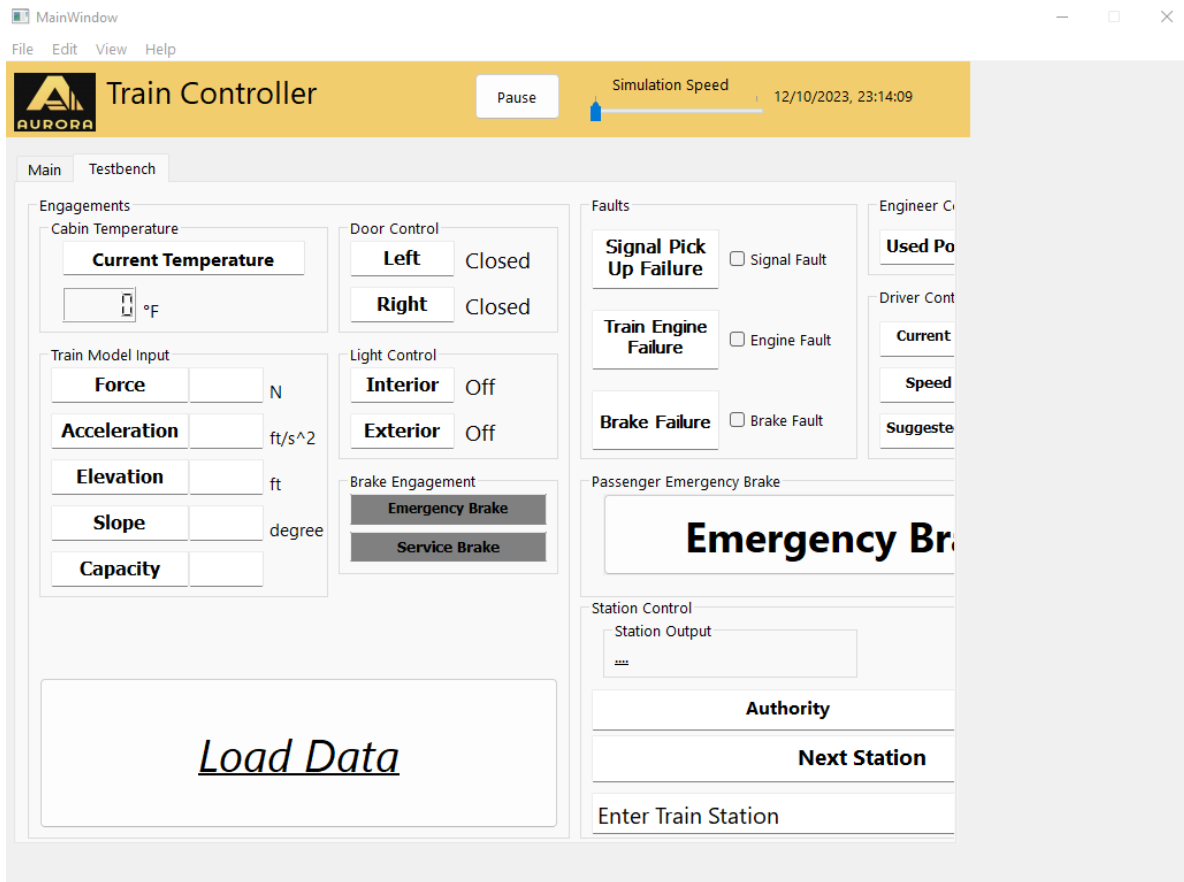


Figure 2.5.2