CruiseAuto Project – Milestone 3

ANSWER SHEET: Algorithm Evaluation & Improvements

Table of Contents

Part 1. Assignment Header

Section and Team ID: 224_19

Team Member Name	Purdue Career Account Login	Programmer Number	M3 Task Assignment	Detailed Description of the Work	Percent of Work
Garrett Hayse	ghayse	1	Parts, 3, 4a, 4b, 5	Re-write the main function so that it runs a loop, this way it does not matter how many columns of data there are, and the code will still run the entire algorithm.	25%
Olaf Gorski	ogorski	2	Parts 2, 3	Rewrite the data smoothing function so that it will work for any size of data. It should only go through a column at a time, so that when the main function's loop is ran, it will run through the data smoothing code as many times as needed.	25%
Angela Qiwen Fu	fu433	3	Parts 2, 3, 6	Rewrite the acceleration start time and time constant calculation function. It should only go through a column at a time, so that when the main function's loop is ran, it will run through the calculation code as many times as needed.	25%
Koyuki Massey	Massey30	4	Parts 3, 4b	Modify the code to be able to show negative values for initial velocity (because the outputs can be negative). Also rewrite the code so that it will calculate the initial and final velocities one column at a time with the main function's loop code. It should only go through a column at a time, so that when the main function's loop is ran, it will run through the calculation code as many times as needed.	25%

Part 2. Milestone 2 Feedback and Reflection

Strength: Our graph accurately graphed our models along with the bounds defined by M0.

Limitation: We had a lack of references for our last document.

How could the feedback from M2 lead to improvements? We could use more references to discover new functions that might aid us in writing a more complex and cohesive algorithm.

What concrete steps will you take to incorporate the M2 feedback to improve your algorithm?

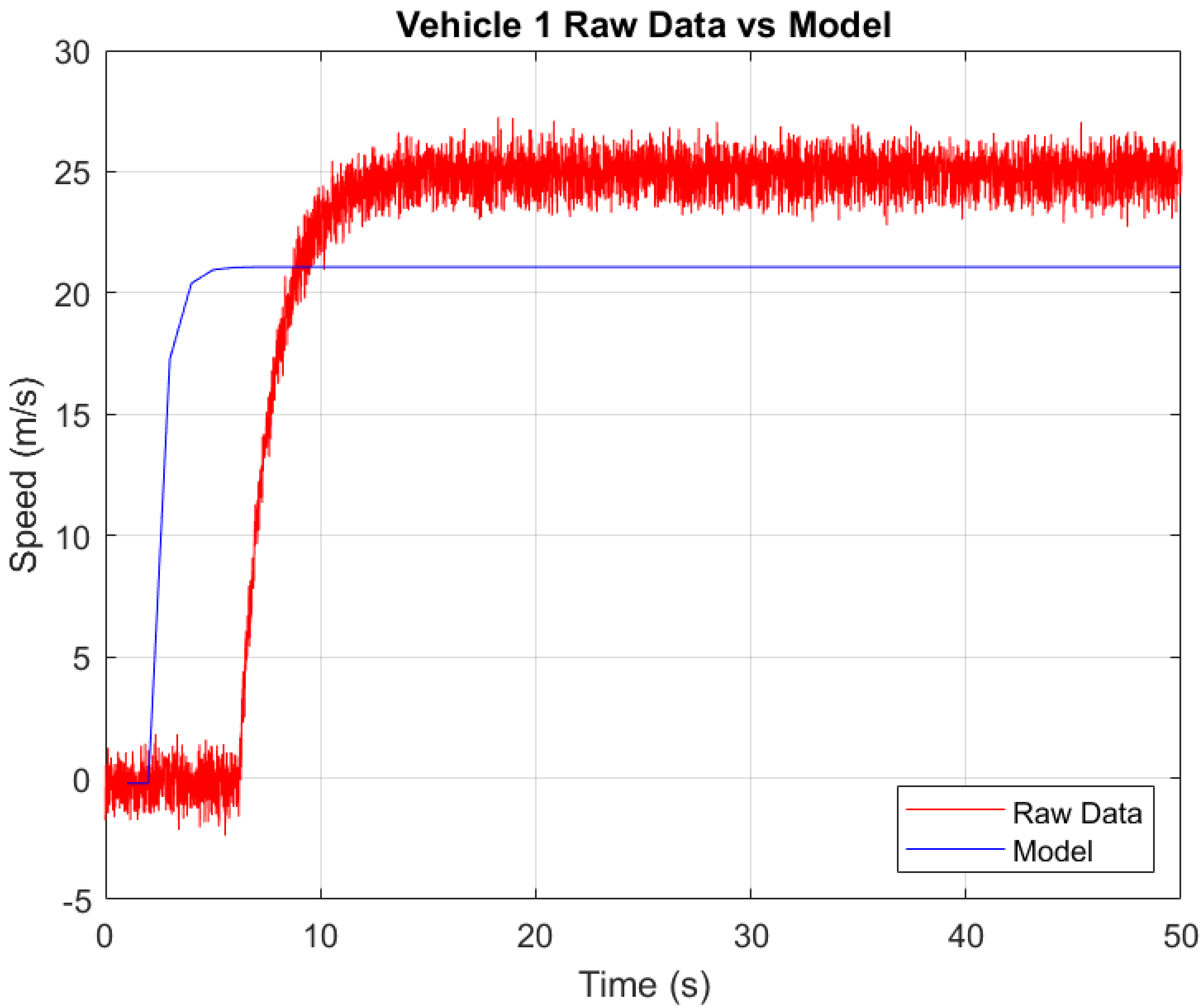
We will seek references for any new functions we use and describe them accurately in the bottom table so that our usage of the new functions will be accurate and our knowledge will grow of Matlab's extensive library of functions.

Part 3. Improve your Algorithm

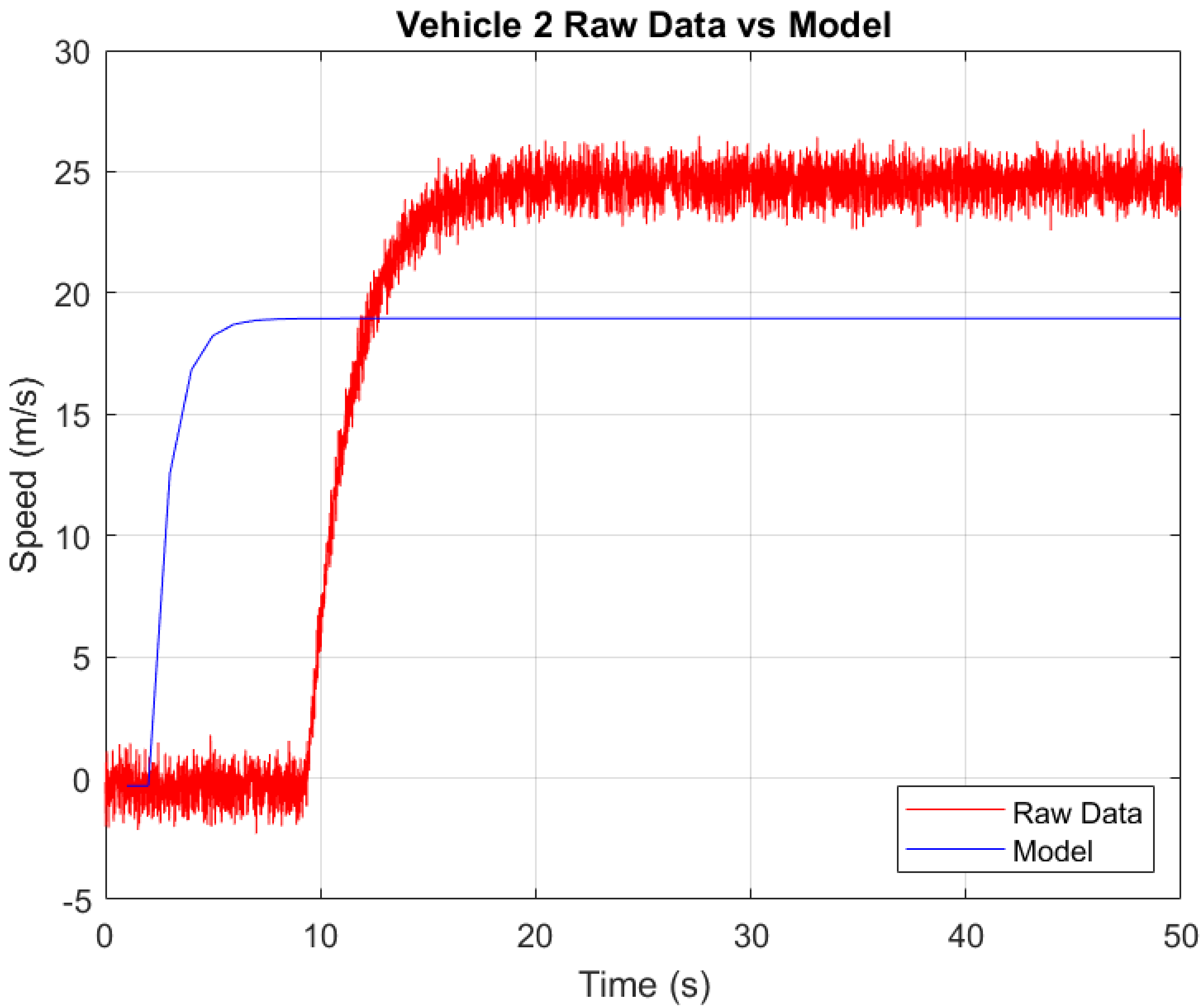
All deliverables should be submitted to Gradescope after completing the milestone.

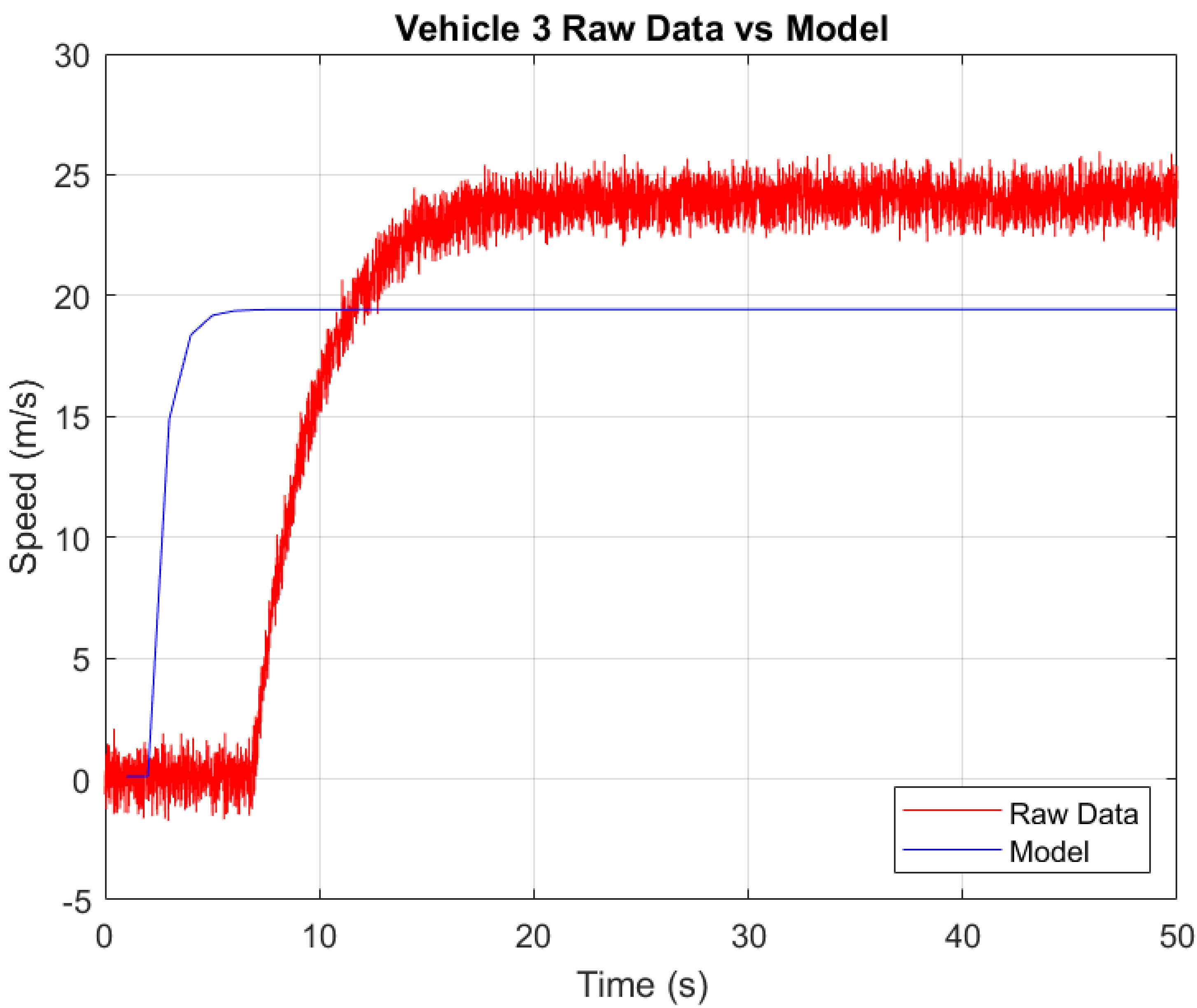
Part 4. Parameter Output Comparison

4a. Noise Error Quantification



Vehicle 1 Raw Data vs Model
Speed (m/s)
Time (s)
Raw Data
Model
30
25
20
15
10
5
0
-5
0
10
20
30
40
50


Vehicle 2 Raw Data vs Model
Speed (m/s)
Time (s)
Raw Data
Model
30
25
20
15
10
5
0
-5
0
10
20
30
40
50



Vehicle 3 Raw Data vs Model
Speed (m/s)
Time (s)
30
25
20
15
10
5
0
-5
0
10
20
30
40
50
Raw Data
Model

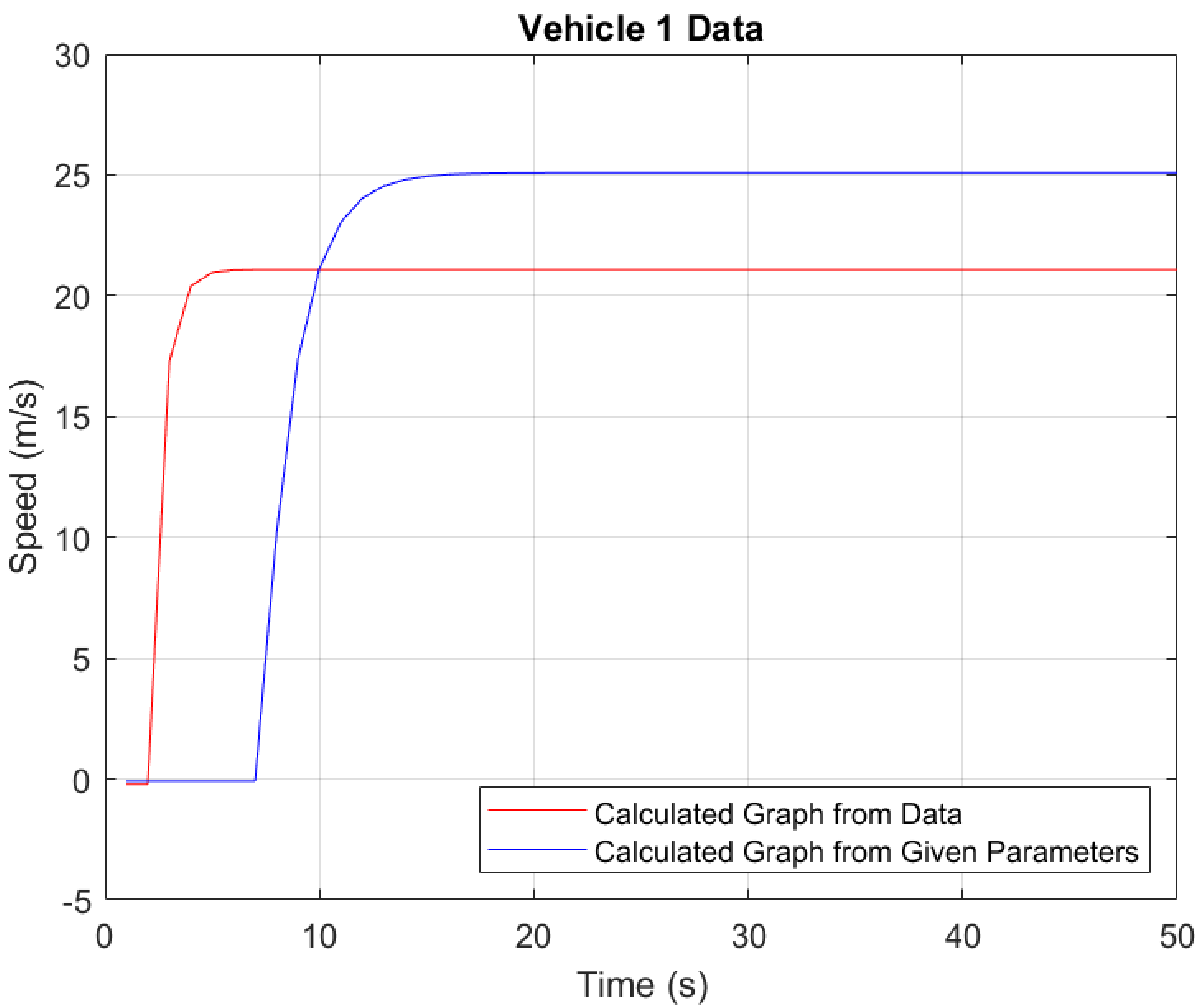
What considerations did you take when deciding how to display your plot(s)?

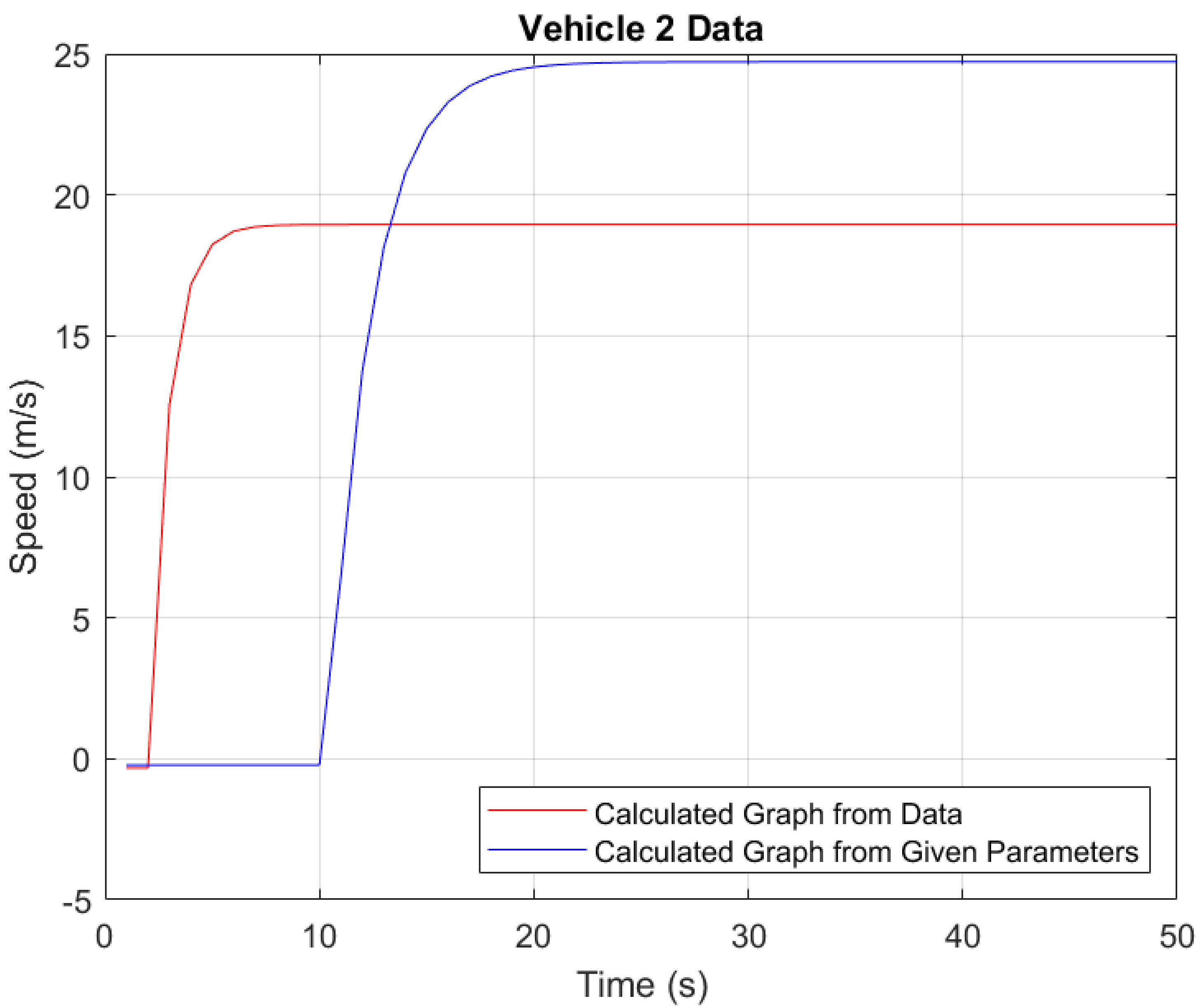
When deliberating over how to display the plots showcasing the model vs. the raw data, we decided to show both as lines connecting each data set over a certain time. We also chose distinct colors for each line, so that they would be easily distinguishable from each other. The "business" of the raw data is not a negative in this situation, as it shows a relative trap that the line should fall into, even if the model was not following the exact mean of the raw data. However, none of our three models fall even within the bounds of the busy graphs.

How well does the benchmark data follow the first-order response model? Provide evidence-based rationales to support your analysis.

As stated above, our models do not follow the busy graphs beyond the first few seconds of the tests. This shows that our models are not the best at determining how the data should flow. This is evidenced by the acceleration beginning much sooner on all three models than the raw data would have us believe. Our models also do not reach a final velocity that is near the final velocities oscillating in the raw data. Knowing this, we can conclude that our models were not the best at following the raw data, however, they did follow the same relative shape.

4b. Evaluate your Algorithm using Benchmark Data


Vehicle 1 Data
Speed (m/s)
Time (s)
30
25
20
15
10
5
0
-5
0
10
20
30
40
50
Calculated Graph from Data
Calculated Graph from Given Parameters


Vehicle 2 Data
Speed (m/s)
Time (s)
25
20
15
10
5
0
-5
0
10
20
30
40
50
Calculated Graph from Data
Calculated Graph from Given Parameters

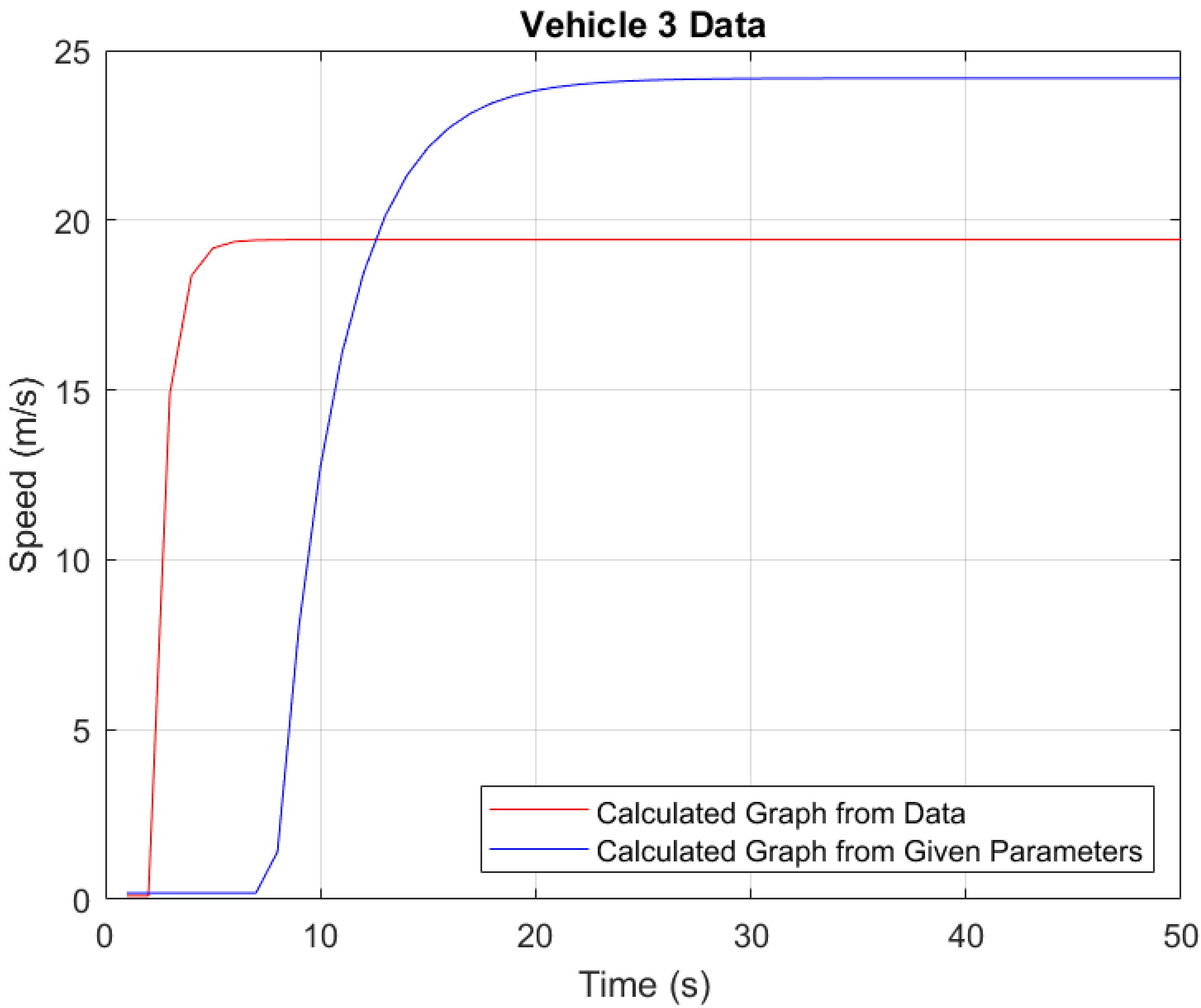

Vehicle 3 Data
Speed (m/s)
Time (s)
0
5
10
15
20
25
0
10
20
30
40
50
Calculated Graph from Data
Calculated Graph from Given Parameters

Table 4b.1 - Results for Compact Hatchback Benchmark Data

Parameter	Benchmark Values	Algorithm Values	Percent Error
Acceleration start time [s]	6.21	1.00	83.90
Time constant [s]	1.15	0.580	61.59
Initial speed [m/s]	-0.09	-0.21	136.24
Final speed [m/s]	25.08	21.07	15.98

Table 4b.2 - Results for Sedan Benchmark Data

Parameter	Benchmark Values	Algorithm Values	Percent Error
Acceleration start time [s]	9.39	1.00	89.35
Time constant [s]	1.96	0.907	53.72
Initial speed [m/s]	-0.22	-0.32	46.53
Final speed [m/s]	24.72	18.95	23.35

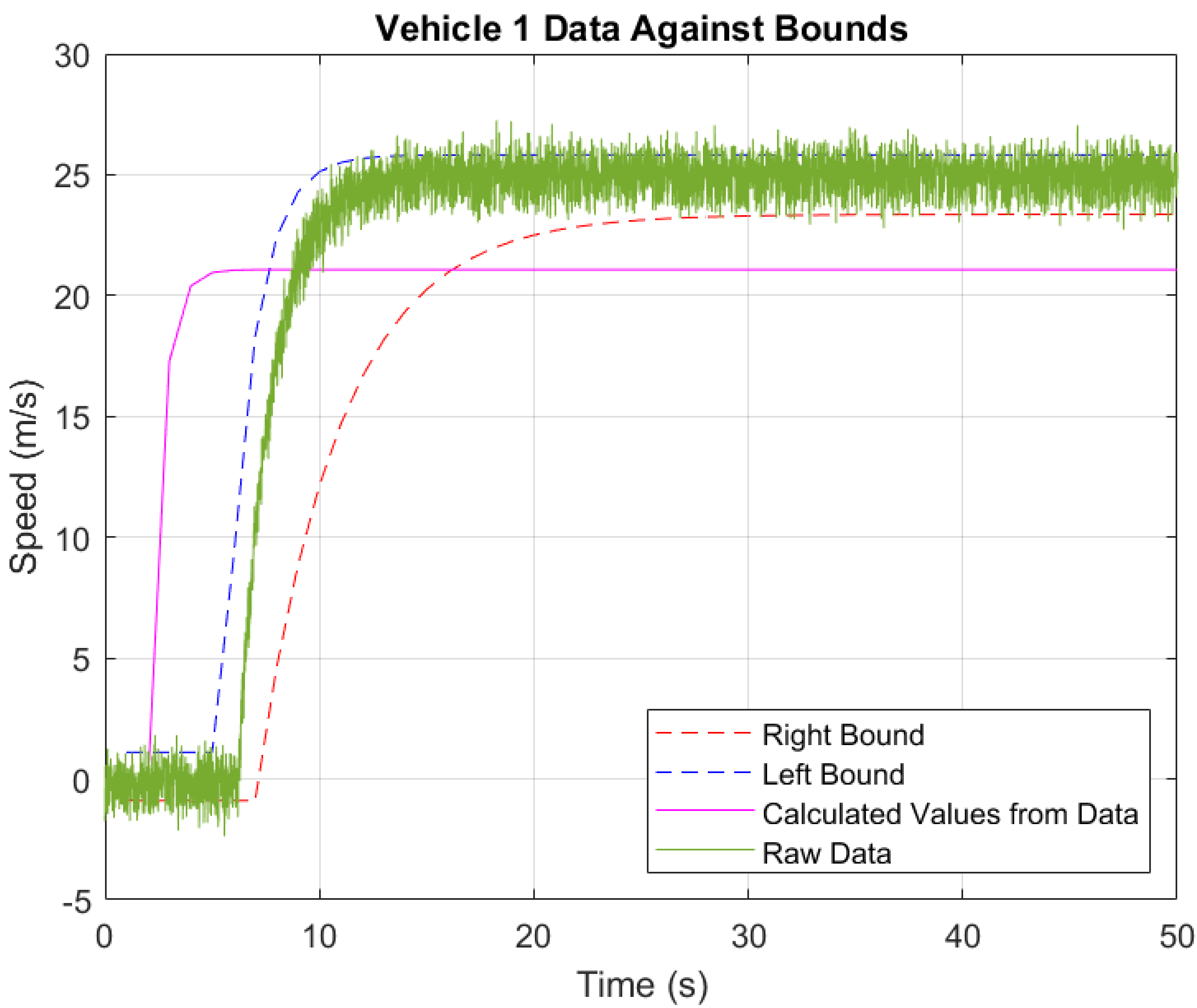
Table 4b.3 - Results for SUV Benchmark Data

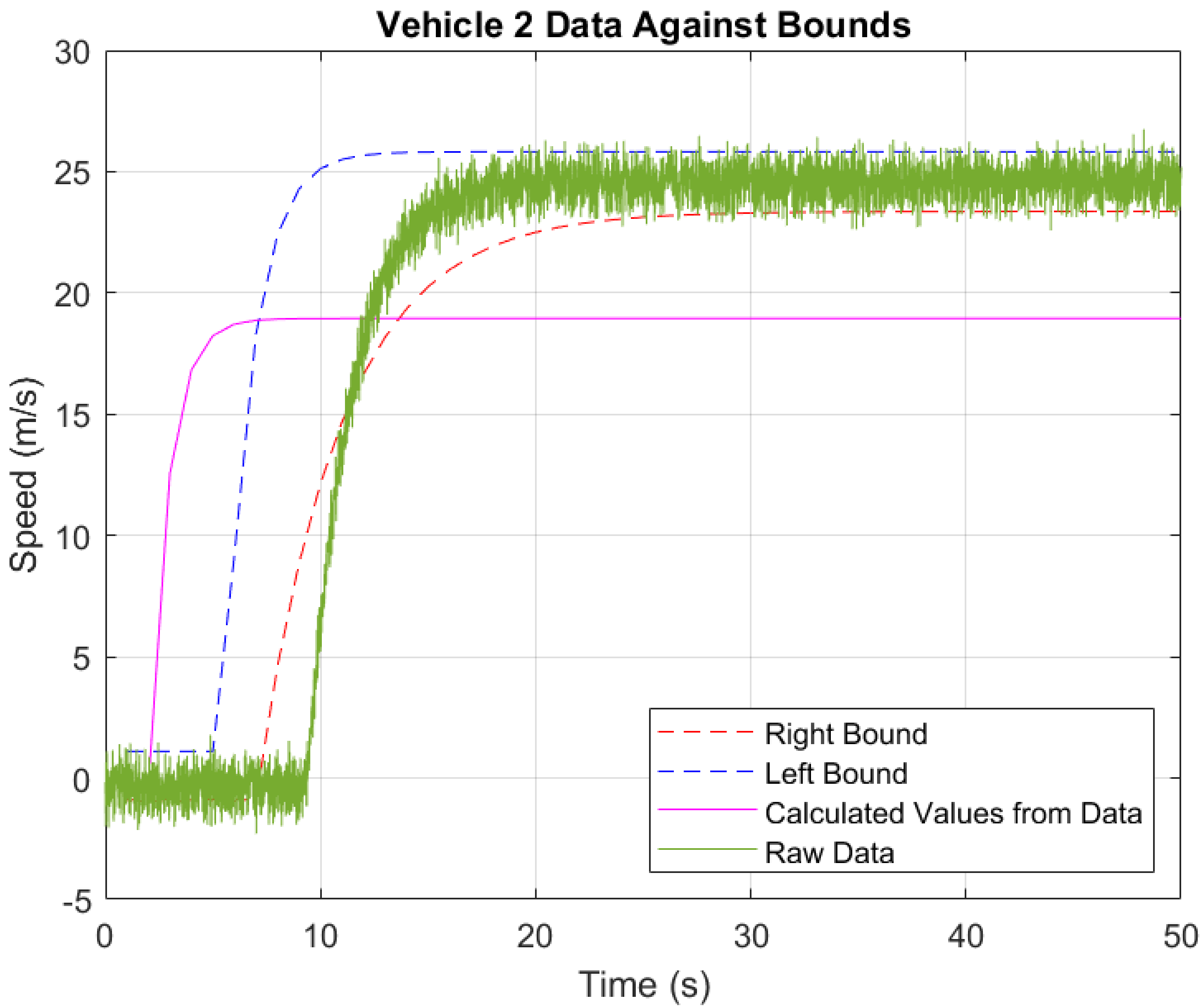
Parameter	Benchmark Values	Algorithm Values	Percent Error
Acceleration start time [s]	6.85	1.00	85.40
Time constant [s]	2.80	0.688	76.28
Initial speed [m/s]	0.19	0.11	44.47
Final speed [m/s]	24.18	19.42	19.67

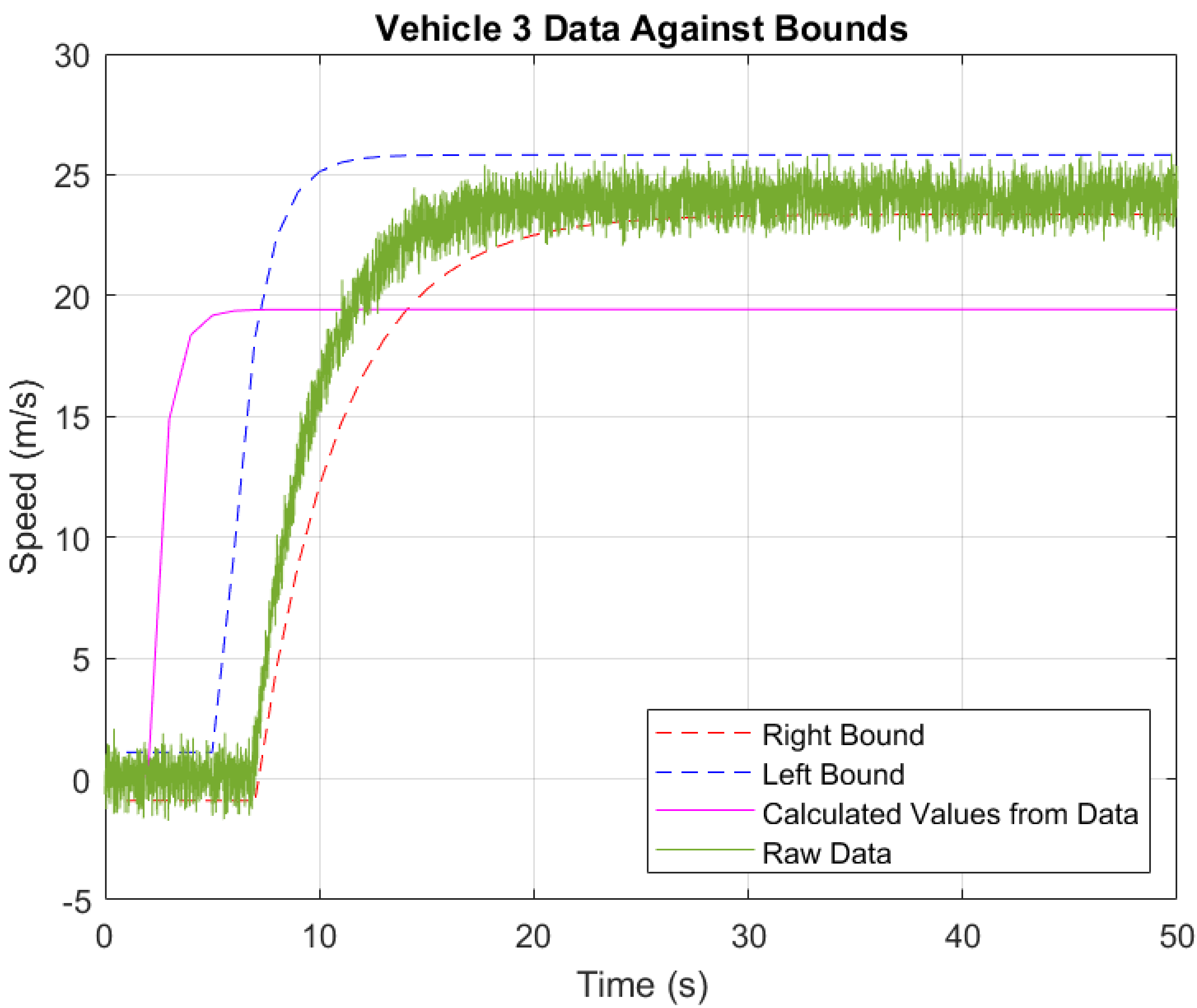
Table 4b.4 – Results for SSE_{mod}

Vehicle	SSE_{mod} from Benchmark Parameters (Part 4a)	SSE_{mod} from Algorithm Parameters (Part 4b)
Compact Hatchback	0.6099	56.8580
Midsize Sedan	0.4778	74.7127
Large SUV	0.4985	58.4047

Part 5. ACC Performance Boundaries


Vehicle 1 Data Against Bounds
Speed (m/s)
Time (s)
30
25
20
15
10
5
0
-5
0
10
20
30
40
50
Right Bound
Left Bound
Calculated Values from Data
Raw Data


Vehicle 2 Data Against Bounds
Speed (m/s)
30
25
20
15
10
5
0
-5
0
10
20
30
40
50
Time (s)
Right Bound
Left Bound
Calculated Values from Data
Raw Data


Vehicle 3 Data Against Bounds
Speed (m/s)
Time (s)
30
25
20
15
10
5
0
-5
0
10
20
30
40
50
Right Bound
Left Bound
Calculated Values from Data
Raw Data

Is the benchmark data within the acceptable performance boundaries of the ACC? Justify your answer with reference to the figures and any numeric results you believe are relevant.

None of our benchmark data is within the acceptable performance boundaries of the ACC. The modeled lines break out of the bou nds at around time = 1.5 seconds on all three models. Also, the last points are not in the bounds defined by the ACC either. This shows us that based on our models and the given data from the benchmark data set, we can conclude that none of the tires are acceptable for the ACC system. However, we know from section 4a that the models themselves are not acceptable for predicting values. Due to this, we are unable to provide a definitive answer on whether the data is within the acceptable boundaries, but based solely on our models and data, we would have to say that none worked at this time.

Part 6. Observations and Improvements

Improvement #1

Parameters Targeted: Acceleration start time and tau

Description of the Improvement:

We separated the acceleration start time and tau into two separate functions.

We improved our cohesion between subfunctions and were able to simplify the code for acceleration start time and tau by removing the moving window.

Metrics to Determine Improvement:

If our code works smoothly and the percent error has improved. This can also be seen if our graph fits better in the bounds.

Rationale for Improvement and Metrics:

We did this because the acceleration start time can be found using only the cleaned data. Although the initial velocity only needs the acceleration start time to be calculated, tau needs the final speed to be calculated. So, we run the function for finding the acceleration start time, then find the initial and final velocities, then find tau.

By making our subfunctions flow better we reduce redundant codes (e.g. having a moving window in both subfunction 2 and subfunction 3) so we streamlined the code and used a loop so we do not need to repeat for every car type and season.

Improvement #2

Parameters Targeted: Smoothing/cleaning data

Description of the Improvement:

Our original code was catered to the original dataset (with 45 columns of data), so we needed to adjust the code to run one column at a time.

Metrics to Determine Improvement:

Our code works and our data looks smooth, as well as our percent error is less than 10.

Rationale for Improvement and Metrics:

Our code would not work for any size dataset that we are given, so we needed to adjust accordingly. With the new changes, our algorithm works for any size dataset, whether it has a million columns or just one.

Part 7. References

Convert numbers to character array - MATLAB num2str. (n.d.). Www.mathworks.com. https://www.mathworks.com/help/matlab/ref/num2str.html

Input a variable into a plot title. (2025). Mathworks.com. https://www.mathworks.com/matlabcentral/answers/154272-input-a-variable-into-a-plot-title

Part 8. MATLAB Built-in Functions

Fill out the following information **for each** MATLAB built-in function that your algorithm uses that was not explicitly taught in class. Add additional rows as needed. If you did not use any new built-in MATLAB functions, then delete the table below and write "No new function used."

Function Name & Call (include inputs/outputs)	Where in your algorithm do you use the function?	Describe the inputs needed to run the function.	Describe the outputs from the function.	Describe the theory and/or mathematics behind how the function operates.
[String] = Num2string(number value)	When we graphed and labeled anything in the main function loop, we needed a way to numerically name things in our titles, this function transforms numbers stored as variables into strings, so that we can print them in a title of a graph	The inputs needed are simply the numeric variable you wish to turn to a sting	The outputs are the numeric variable you input, but as a string variable now.	The function simply changes the variable declaration of a certain variable from a float or a double to a string, so that in our case we could use it in the titles of the graphs.