# 4. Validation

## 4.1 Approach

To validate our model and simulation program we have followed the two-step approach

**Face Validity** – Results appeared to be reasonable for our team members. The real-world data we have collected manually from the node.

**Quality of the simulation output** - Compared the results of real and simulated system data using input-output transformations

## 4.2 Variables of interest

We have considered two variables to validate the model and the simulation program. They are

**Time in the node** – Time between arrival and departure of vehicles. This is the duration of time when a vehicle enters any intersection of the node and enter the destination road.

**Queue length** – Number of vehicles waiting in each signal when the signal just turns green from red.

## 4.3 Data

### 4.3.1 Data from the real-world system

Average time spent in the node by vehicles: 58 seconds

Here, the Mean queue length is the mean number of vehicles waiting in each signal when the signal just turns green from red.

| Street | Mean Queue Length |
|---|---|
| Herder Straße | 1.57 |
| Ebendorfer Straße | 3.55 |
| Olvenstedter Straße (West) | 2.0 |
| Gerhart-Hauptmann Straße | 3.13 |
| Olvenstedter Straße (South) | 1.59 |

Table 17: Real World data

### 4.3.2 Data from the simulation model

Confidence intervals for all the streets using student t-distribution is mentioned in the below table. The first table contains the intervals for the queue length of each street while the second one contains the average time spent by vehicles inside the node - from reaching the intersection to entering their destination street after crossing through the intersection. Confidence level is 99%:

| Street | Lower Bound | Upper Bound |
|---|---|---|
| Herder Straße | 1.556 | 1593 |
| Ebendorfer Straße | 3.509 | 3.589 |
| Olvenstedter Straße (West) | 2.01 | 2.152 |
| Gerhart-Hauptmann Straße | 2.974 | 3.156 |
| Olvenstedter Straße (South) | 1.468 | 1.632 |

Table 18: Confidence interval for average queue lengths for each street.

| Upper Bound | Lower Bound |
|---|---|
| 53.23 | 58.651 |

Table 19: Confidence interval for average time spent by vehicles in the node

### 4.3.3 Comparison of the real and simulated data

The below depicted graphs show the comparison between the real world system and the validated system. The compared variables are average queue length for each road and average time spent by vehicles in the node

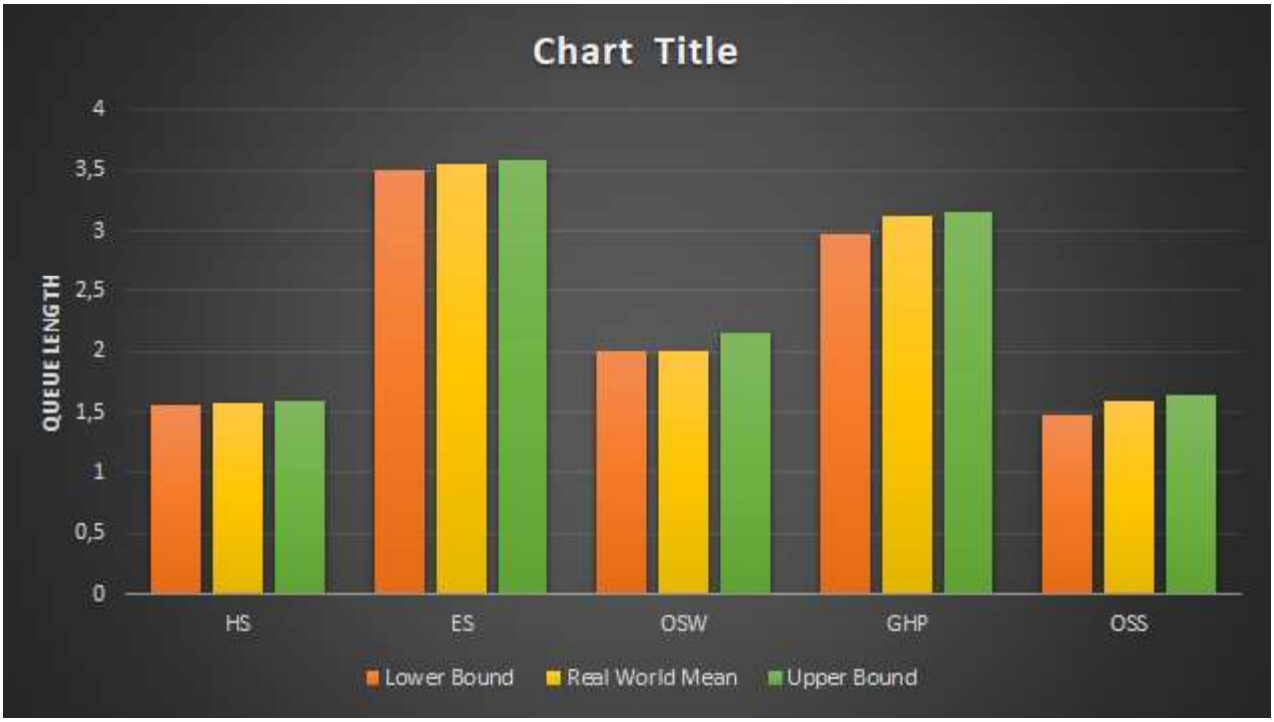


Figure 30: Average queue length for each of the roads. The upper bound, lower bound and mean value.

In comparison of queue length between Real world data and simulated data, it can be seen that the real-world data is well in the limit of upper bound and lower bound of confidence intervals.

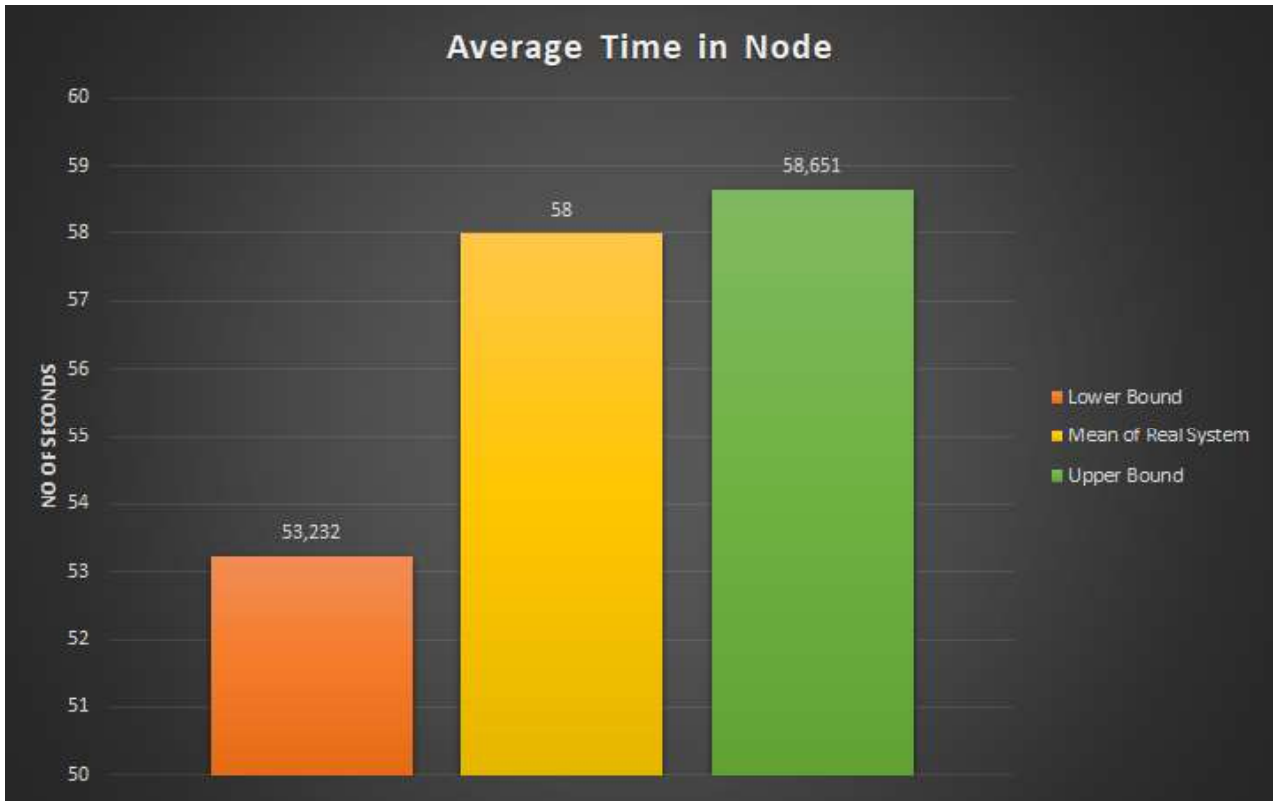


Figure 31: Average time spent by vehicles inside the node. The upper bound, lower bound and mean value.

The real-world average is 58 which is well inside the limit of lower bound and upper bound of 53.232 and 58.651 respectively.

## 4.4 Statement of Confidence

The statement of confidence was obtained after running the simulation for a number of replications for a predefined amount of time for each replication.

Total number of replications: 100

Total time per simulation run: 3599 (maximum allowed in Learning version of Anylogic)

Confidence level: 99%

Model validation status: OK