RWR 4013

Digital Twins for Smart Cities

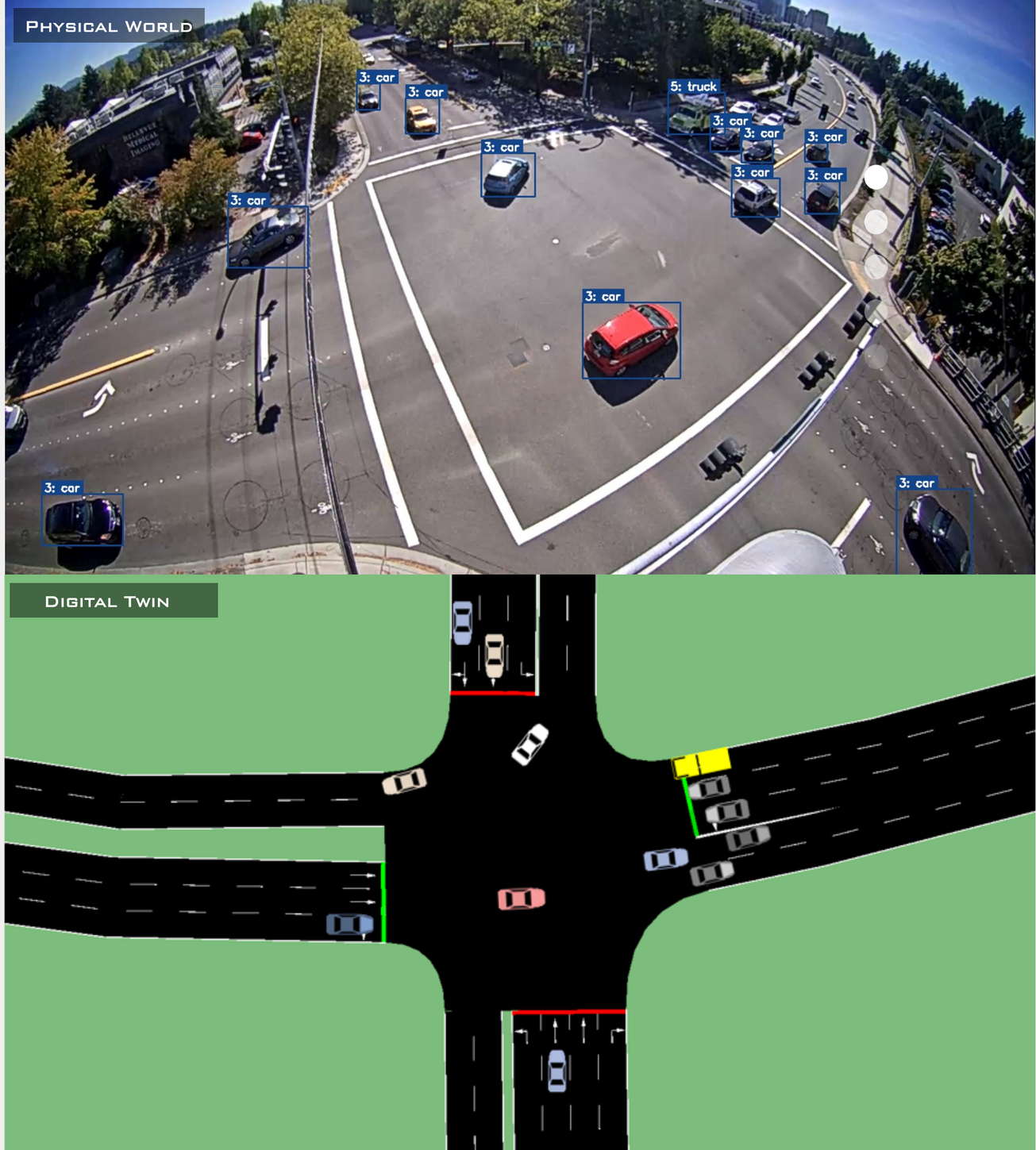
Dr. Ahmad Mohammadi

Week 7 | Session 2:
Simulation Calibration

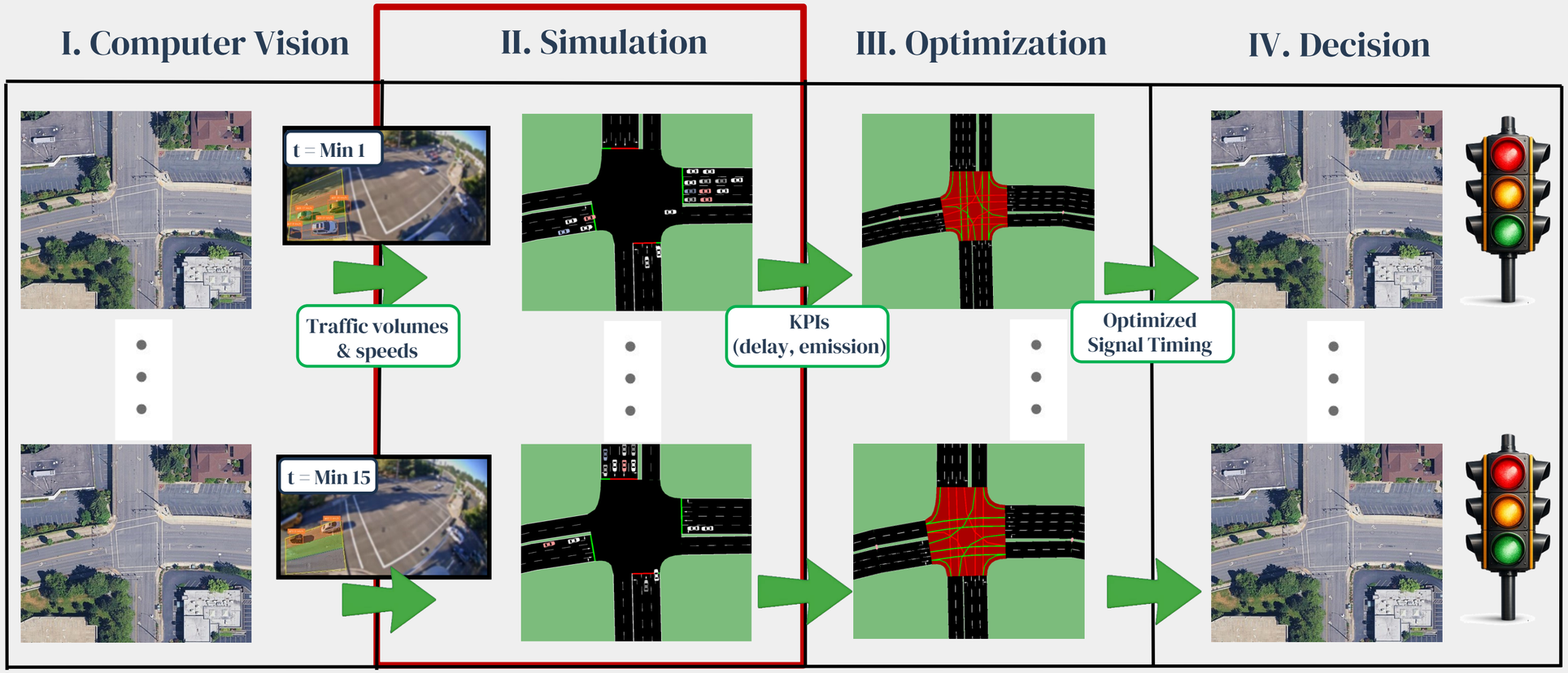
Fall 2026

RoadwayVR

roadwayvr.github.io/DigitalTwinsforSmartCities

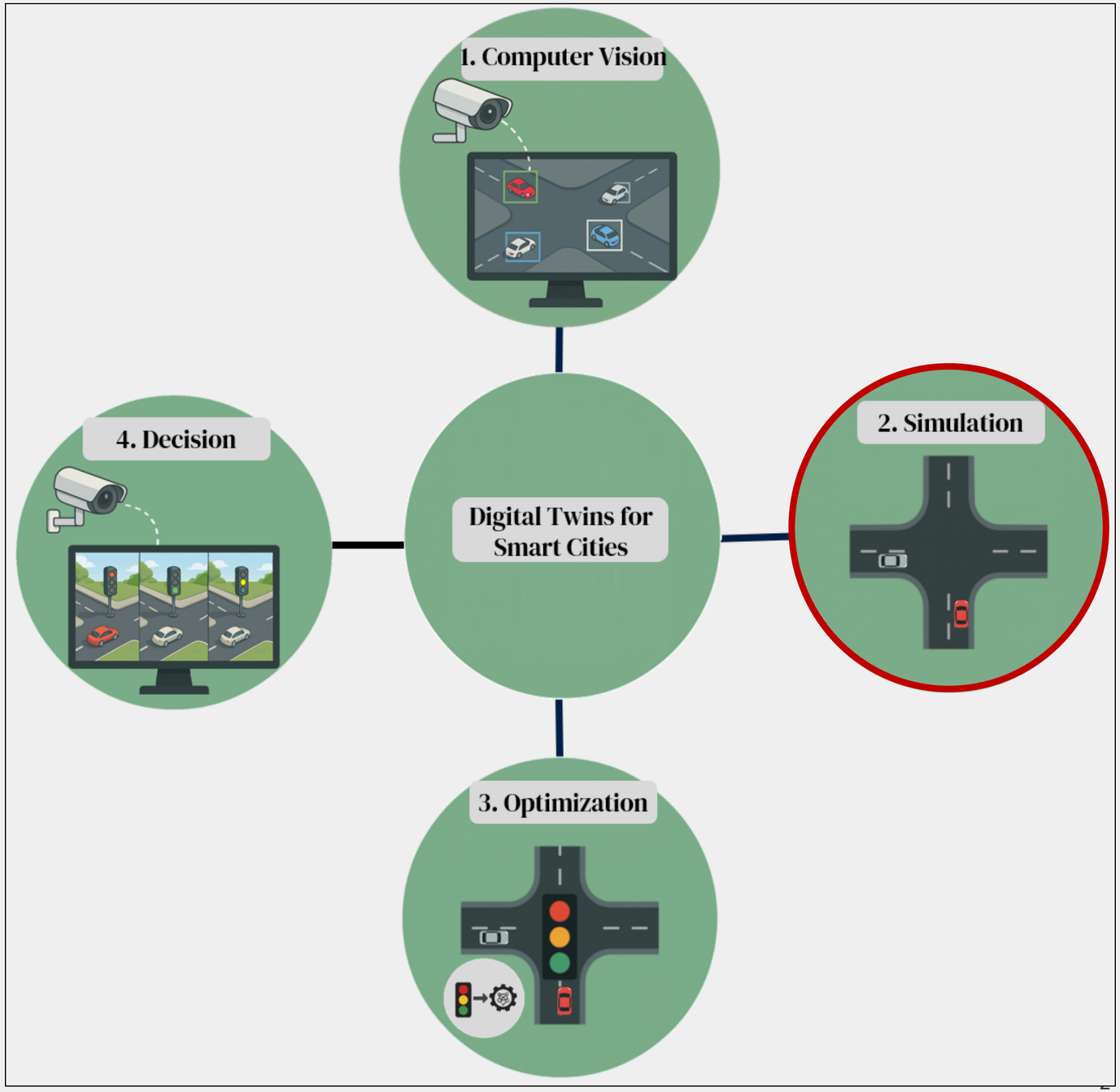


Overview of Course Syllabus in One Shot



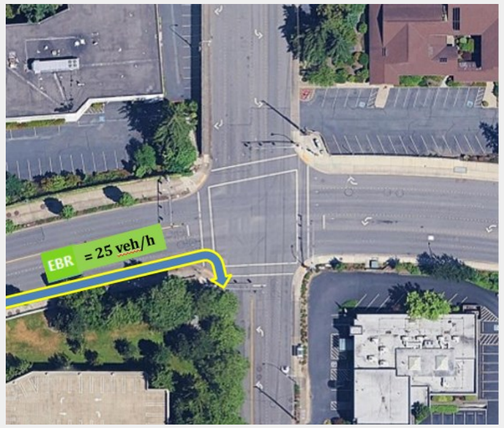
Agenda

- ❑ Simulation Calibration
1. Road Network Development
2. Traffic Signal Timing
3. Traffic Movement
4. Traffic Volume
5. Traffic Speed



Traffic Movement & Volume Calibration

- ❑ Download Week7b.Material.zip
- ❑ Extract it
- ❑ You would observe each Traffic Movement & Volume on top of the GIS map



Traffic Movement & Volume Calibration

Task: Assign each observed traffic movement and volume to the simulation.

1. Open SUMODT.netecfg

2. On the top bar, select Demand.

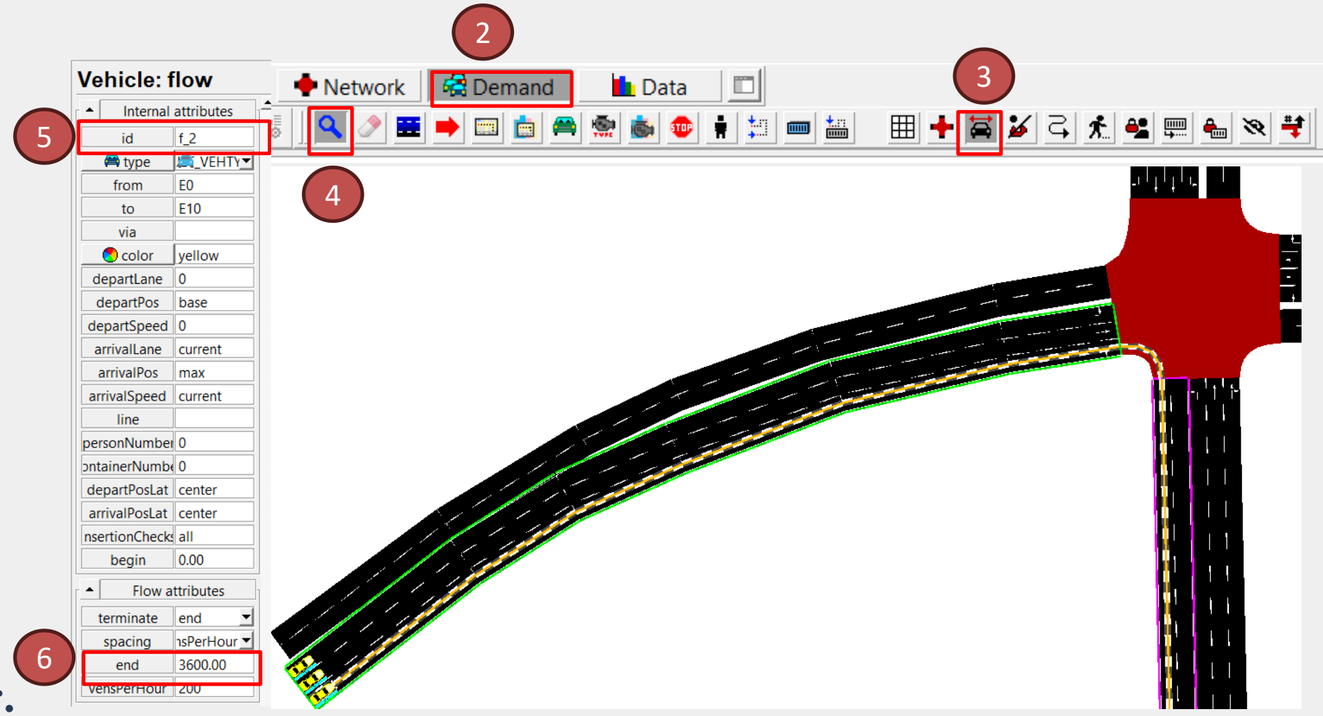
3. Select Vehicles Spread...

4. Select the Magnifier tool.

5. Start from the eastbound approach

→ Select the car in the rightmost lane.

6. In the left panel, read the flow ID and volume per hour.



Quiz

Q: What is the traffic flow for f2, if it is defined as **200 (veh/h)**? Select the most proper response.

A) It generates **exactly 200 vehicles every hour**, no more no less.

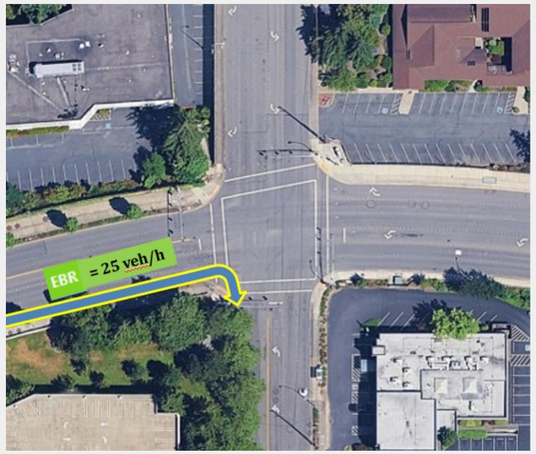
B) It generates **200 vehicles randomly in each hour**, meaning the model tries to average 200 but the exact count can vary.

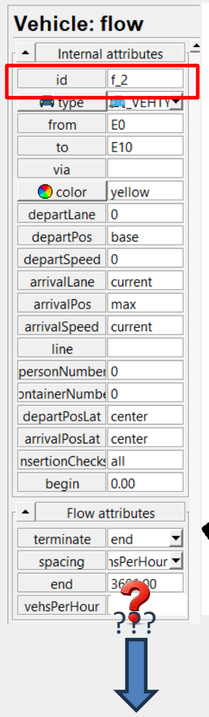
C) It generates **200 vehicles each minute** (so 12,000 vehicles per hour).

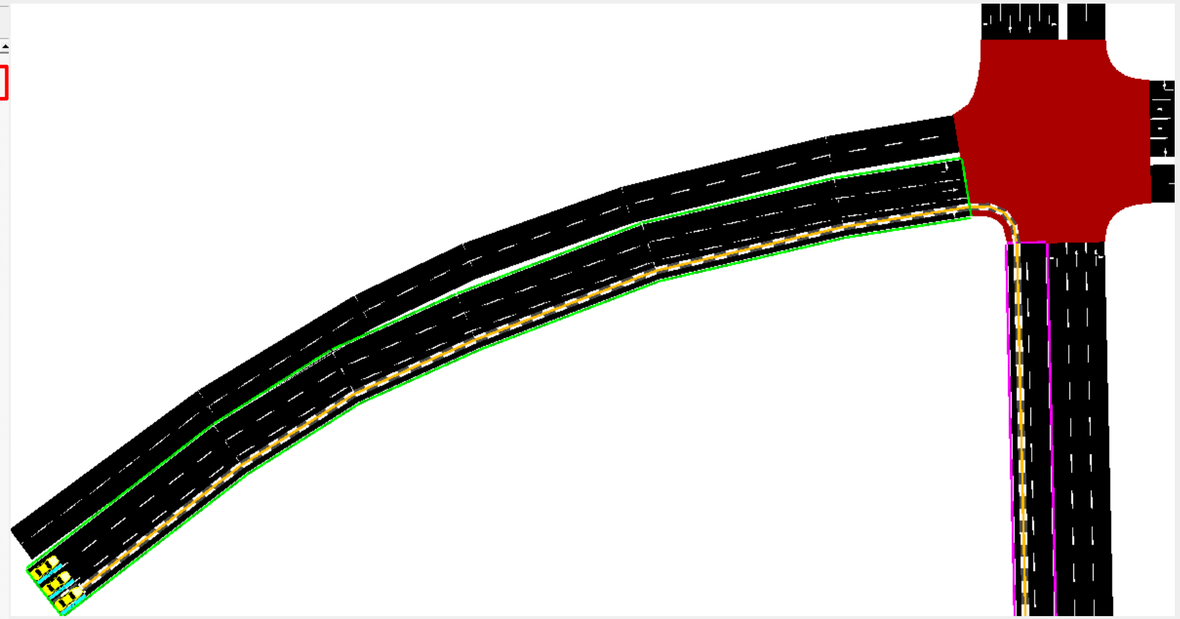
D) It generates **200 vehicles total for the whole simulation**, regardless of simulation duration.

Traffic Movement and Volume Calibration

7. Read the traffic volume from the real-world image on the slide, then update the traffic volume in NetEdit.

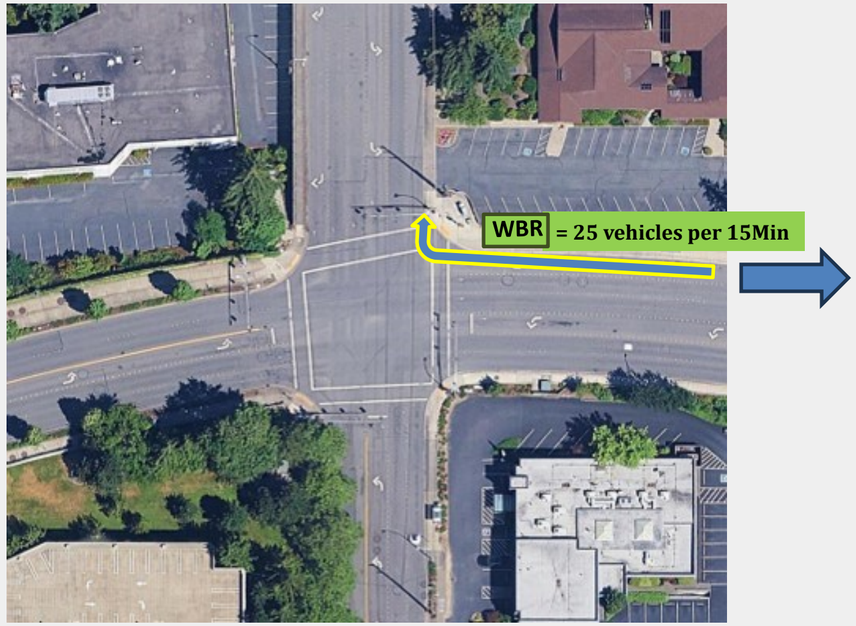


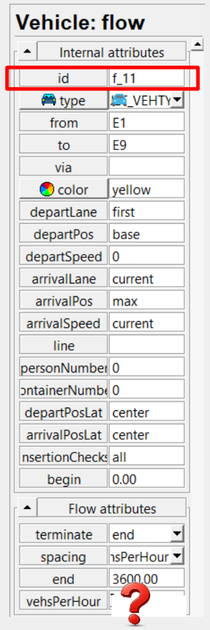


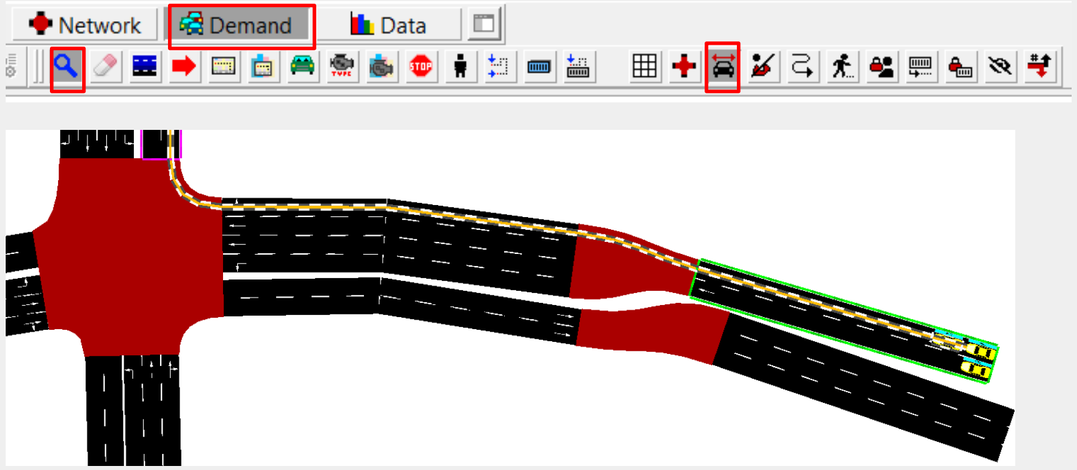


Traffic Movement and Volume Calibration

8. Make sure you select: Demand → Vehicles Spread… → Magnifier







???

9. Repeat this process to assign the observed (real-world) volumes to the remaining simulated flows.

Deliverables

❑ Complete volume assignment for all movements (real-world → simulation).

❑ Upload the final calibrated input file(s) to the course website.

Traffic Volume Calibration (using GEH)

Question: Can we calculate GEH using traffic volume and movement in real-world images and simulation in previous slides?

GEH Formula:

$$GEH = \sqrt{\frac{2(M-C)^2}{M+C}}$$

$M = Simulated\ Traffic\ Volume\ (veh/h)$

$C = Observed\ Traffic\ Volume\ (veh/h)$

Interpretation:

$GEH < 5$	$Good\ match$
$5 \leq GEH < 10$	$Needs\ investigation$
$10 \leq GEH$	$Likely\ mismatch\ (check\ data, mapping, or\ model\ settings)$

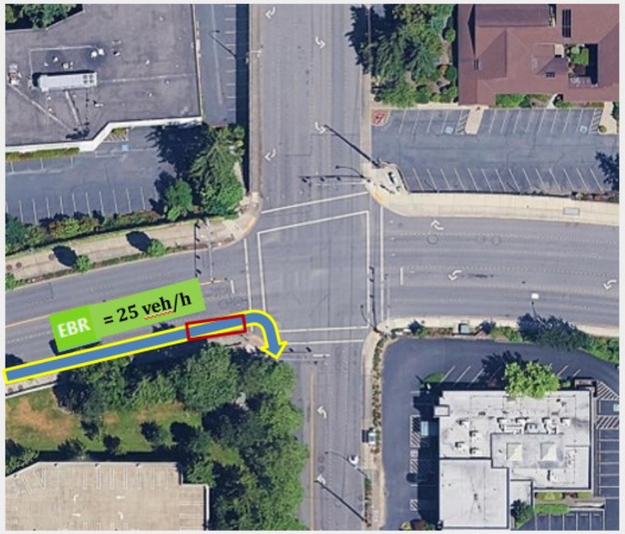
Traffic Volume Calibration using GEH

1. We cannot compute GEH from the previous slides because we only assigned input demand (e.g., f2),

not the measured simulated volume at the red box.

2. We need to run simulation and then collect traffic volume in red box from SUMO

3. Then, calculate GEH

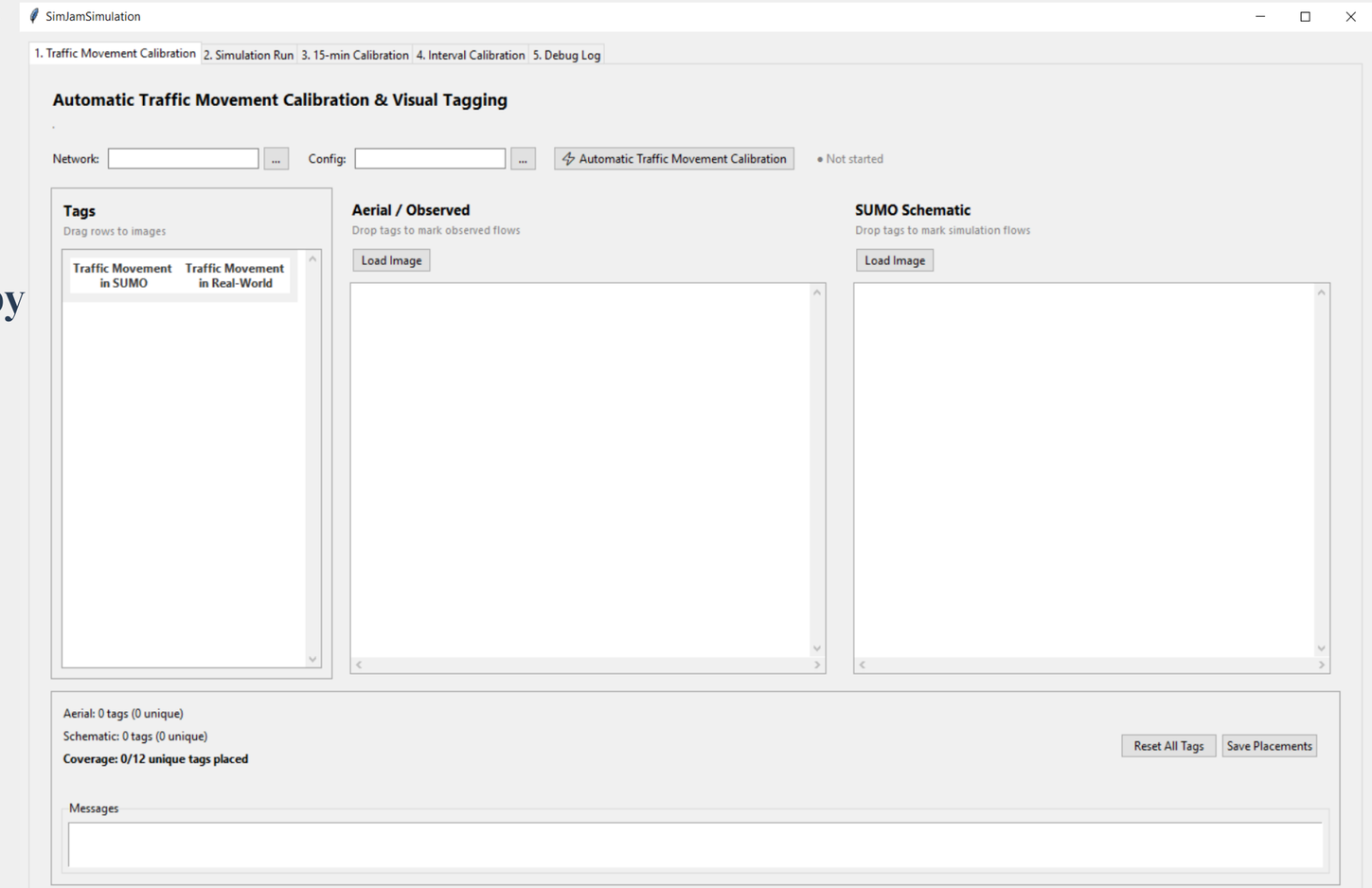


EBR (25 veh/h) = f2 (25 veh/h)

Traffic Volume Calibration using GEH

5. For this course, we created an application so it can automatically collect traffic volume from red boxes from SUMO and calculate GEH

6. In Week7b.Material → 7. Folder "SimJamCalibration" → Run SimJamSimulation.py

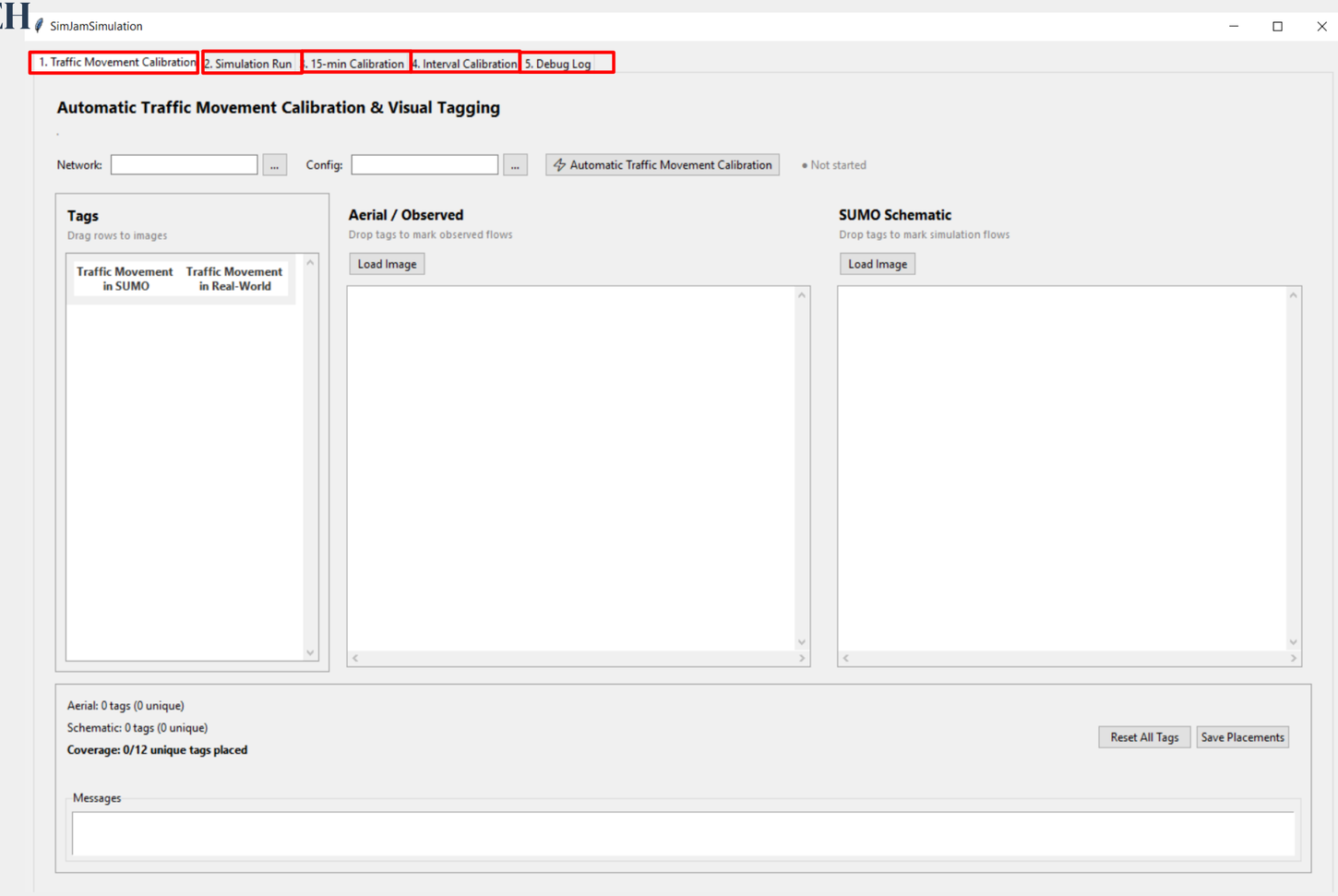


SimJamSimulation App

SimJamSimulation App

1. The SimJamSimulation app automatically perform

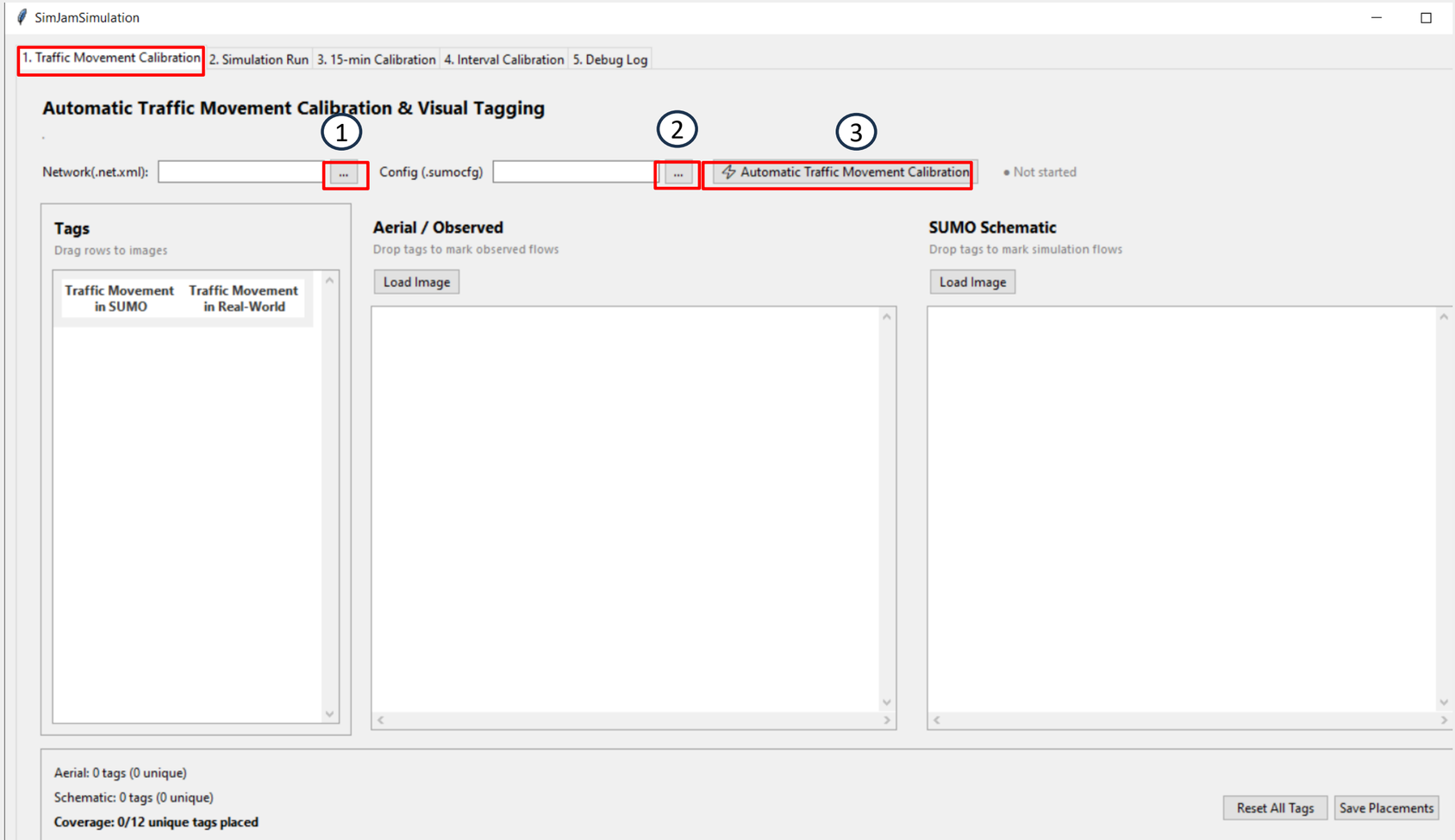
Traffic Movement & Volume Calibration using GEH



Traffic Movement Calibration

2. In Traffic Movement Calibration Tab → Select Sumo Network → Select Sumo Visualization Interface (.sumocfg)

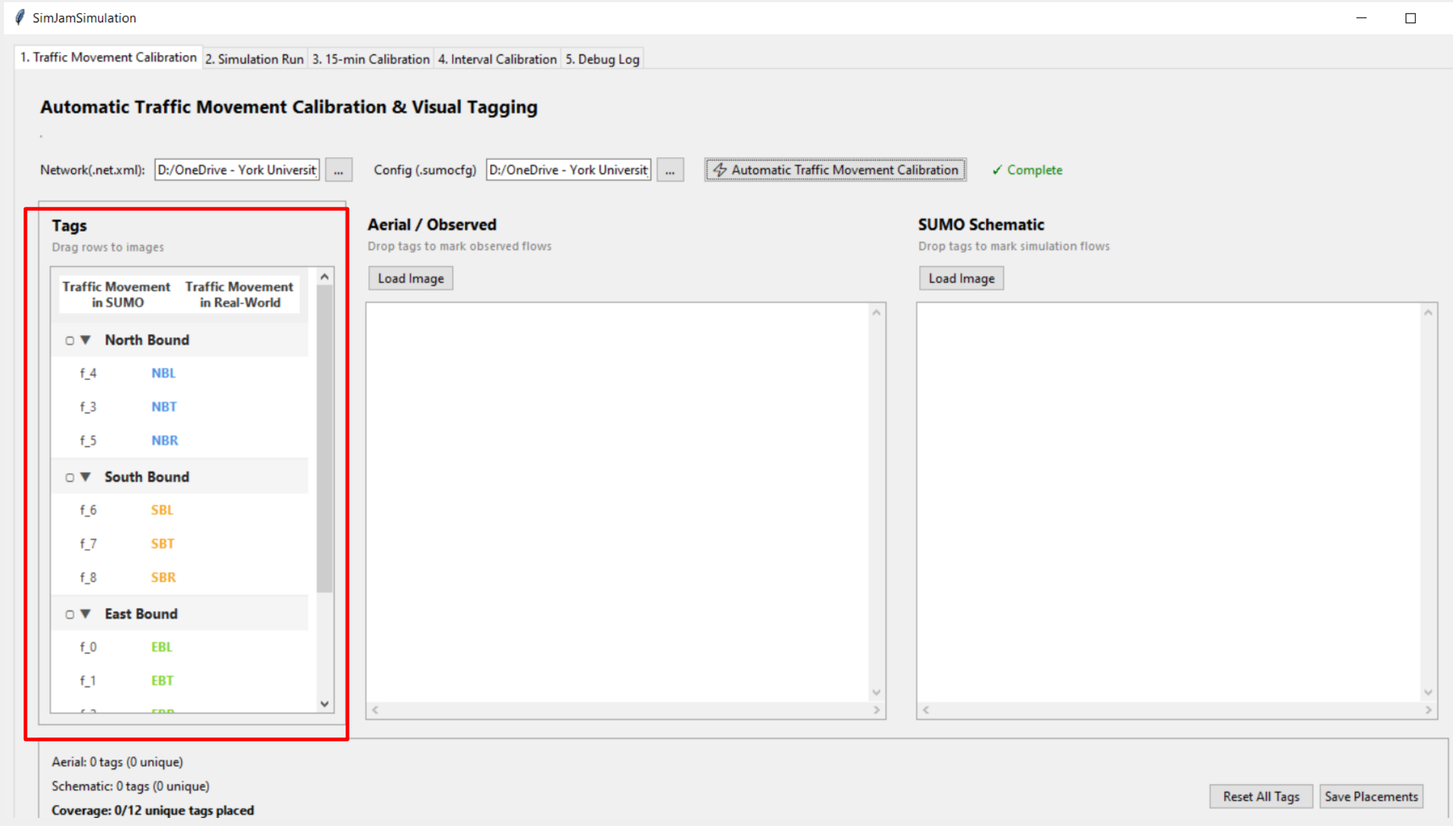
→ Click Automatic “Traffic Movement Calibration”



Traffic Movement Calibration

3. Traffic Movement Calibration is automatically performed

- The tool automatically maps observed movements (e.g., NBL, NBT, NBR) to SUMO flow IDs (e.g., f_4, f_3, f_5).
- Check the mapping in the Tags panel (red box).



Traffic Movement Calibration

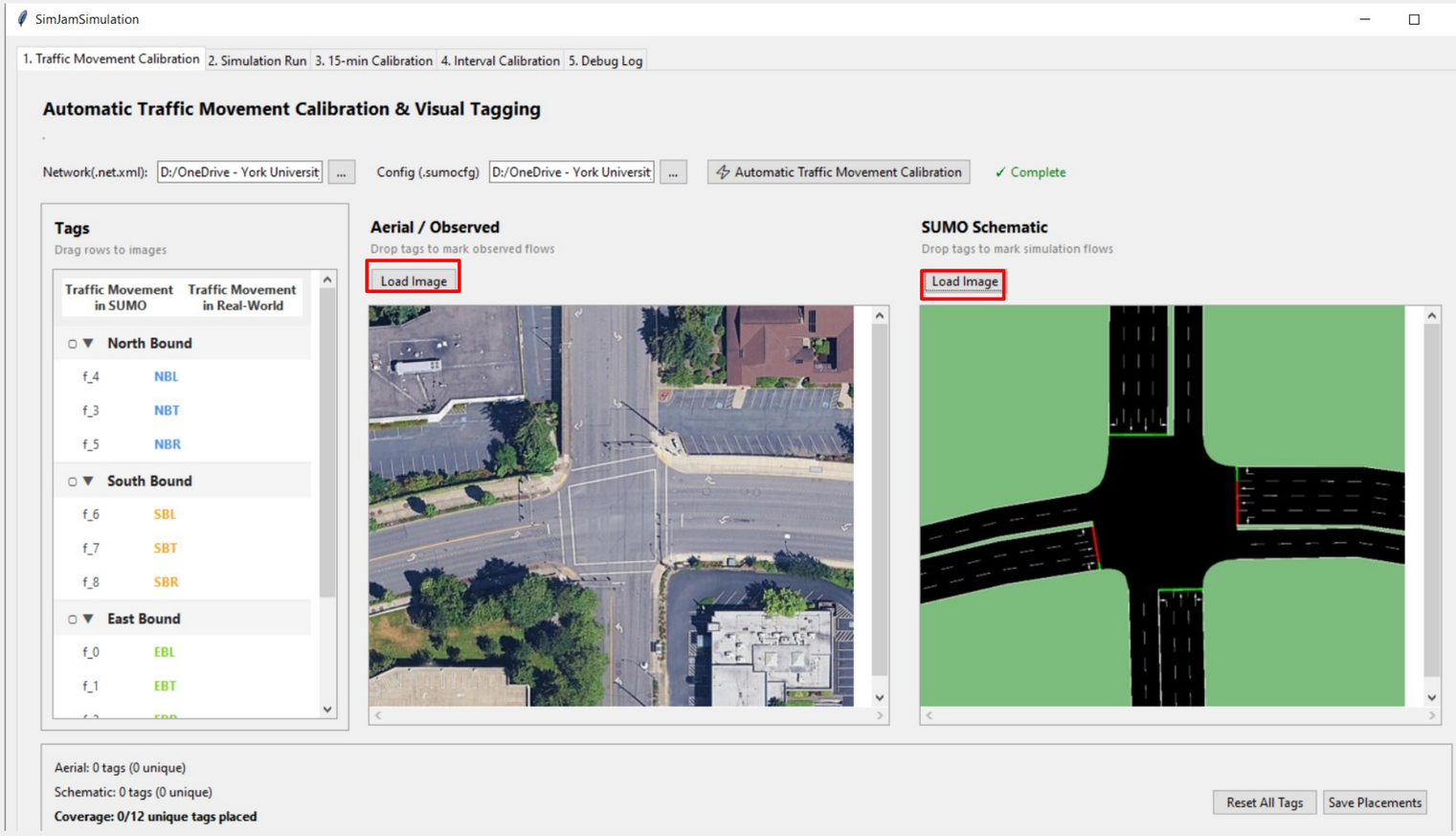
4. Open SUMODT.cfg → Zoom to the intersection → Switch to the real-world view → Take a screenshot → Save

5. Open StudyArea.tif → Zoom to the same area → Take a screenshot → Save

6. In the app, load both images:

Aerial/Observed: load the real-world screenshot

SUMO Schematic: load the SUMO screenshot

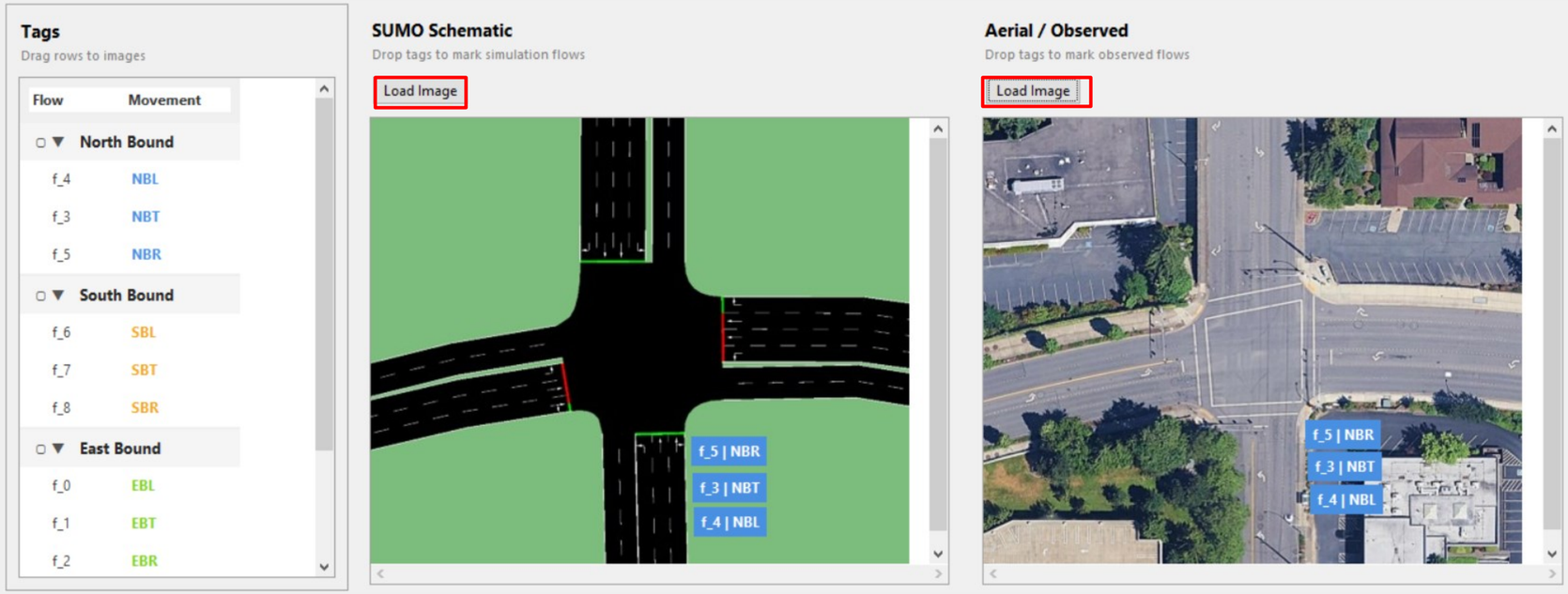


Deliverables

7. Drag and drop each tag onto the correct location in both images.

8. Repeat until all directions/movements are assigned.

9. When finished, take a screenshot like the example below and submit it (make sure every tag is assigned)



Traffic Volume Calibration using GEH

1. Click Browse and select the 15-min Observed Data file (.csv)

2. Click Browse and select the SUMO Network file (.net.xml)

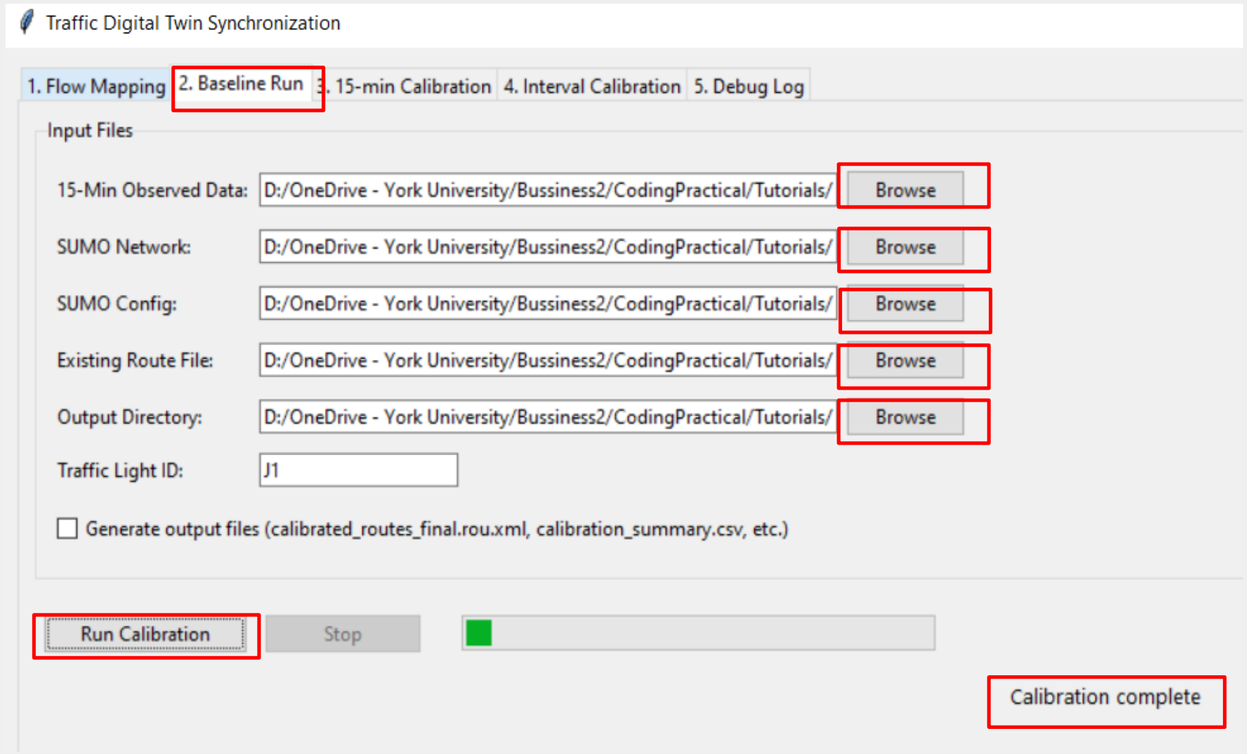
3. Click Browse and select the SUMO Config file (.sumocfg)

4. Click Browse and select the Route File (.rou.xml)

5. Click Browse and select the Output Folder (create a new folder first, if needed)

6. Enter the Traffic Light ID: J1

7. Click Run Calibration → confirm you see “Calibration complete”



Traffic Volume Calibration using GEH

1. Open the “15-Min Calibration” tab.

2. The app automatically copies the observed 15-minute volumes into the simulation inputs for each movement.

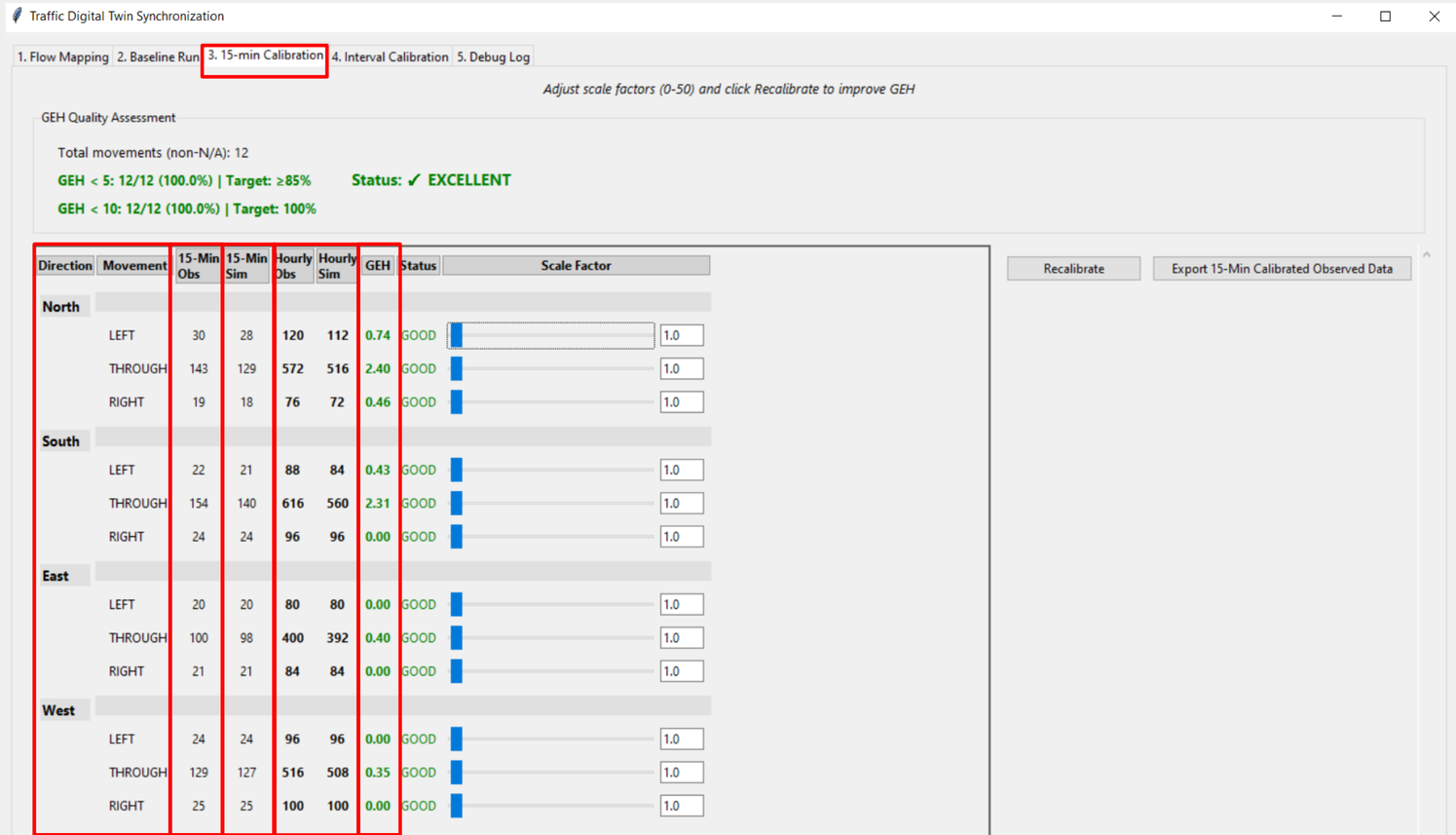
3. The first two columns list the traffic movements (e.g., NBL, EBT).

4. The third column shows the observed 15-minute volume (collected from video).

5. The fourth column shows the simulated 15-minute volume for each movement.

6. The next column shows the hourly volumes (Observed and Simulated), converted from the 15-minute values.

7. The final column shows the GEH for each movement.



Direction	Movement	15-Min Obs	15-Min Sim	Hourly Obs	Hourly Sim	GEH	Status	Scale Factor
North								
	LEFT	30	28	120	112	0.74	GOOD	1.0
	THROUGH	143	129	572	516	2.40	GOOD	1.0
	RIGHT	19	18	76	72	0.46	GOOD	1.0
South								
	LEFT	22	21	88	84	0.43	GOOD	1.0
	THROUGH	154	140	616	560	2.31	GOOD	1.0
	RIGHT	24	24	96	96	0.00	GOOD	1.0
East								
	LEFT	20	20	80	80	0.00	GOOD	1.0
	THROUGH	100	98	400	392	0.40	GOOD	1.0
	RIGHT	21	21	84	84	0.00	GOOD	1.0
West								
	LEFT	24	24	96	96	0.00	GOOD	1.0
	THROUGH	129	127	516	508	0.35	GOOD	1.0
	RIGHT	25	25	100	100	0.00	GOOD	1.0

Traffic Volume Calibration using GEH

8. Status column: shows the GEH result for each movement. A movement is Good when GEH < 5.

9. GEH Quality Assessment: summarizes overall calibration quality. The target is at least 85% of movements with GEH < 5.

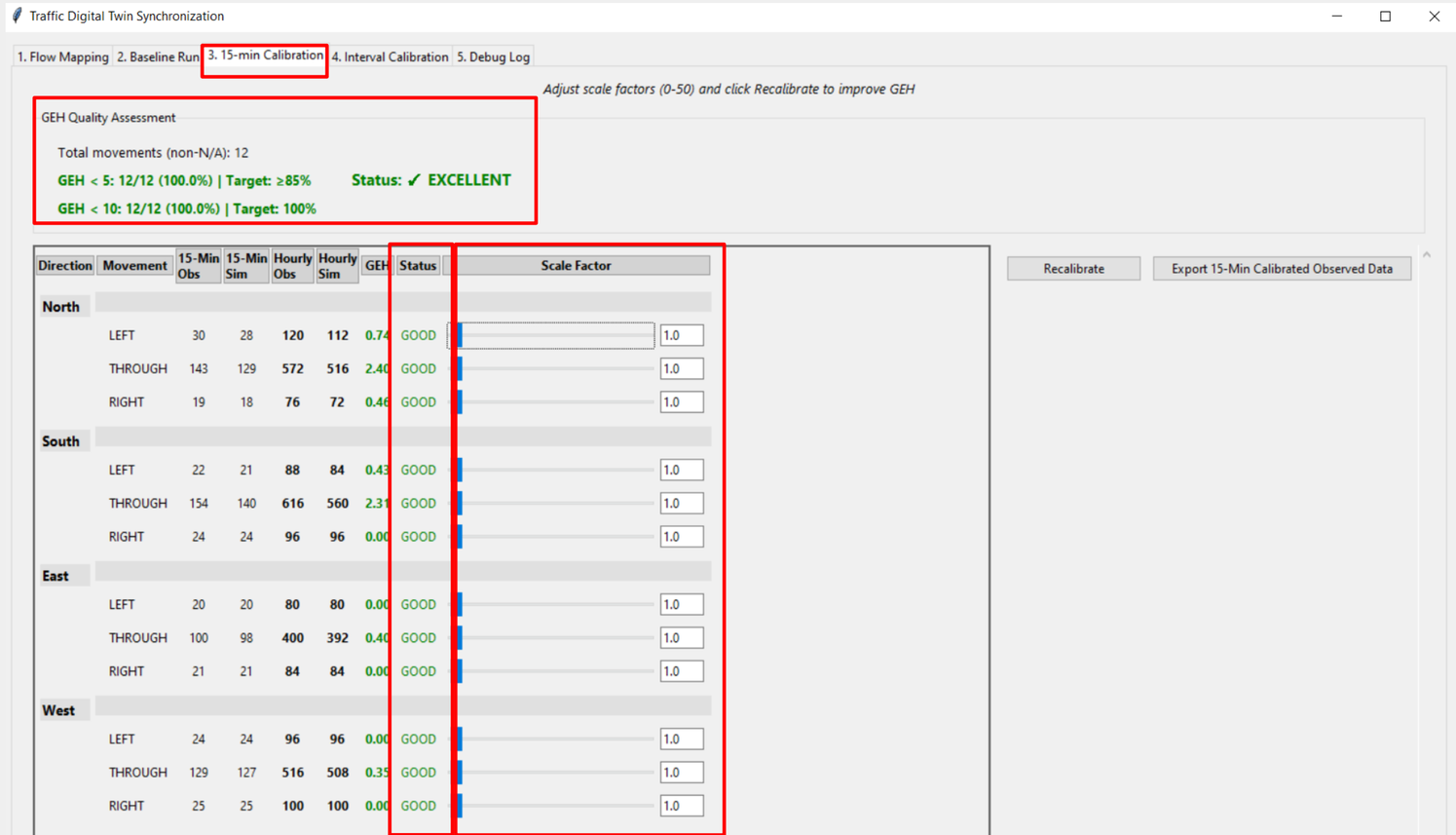
10. If any movement has GEH ≥ 5, do this:

I. Compare Hourly Observed vs Hourly Simulated volume for that movement.

II. If Simulated > Observed, reduce the Scale Factor (set < 1) and click Recalibrate.

III. If Simulated < Observed, increase the Scale Factor (set > 1) and click Recalibrate.

IV. Repeat steps I–III until the movement reaches Acceptable or Excellent GEH.



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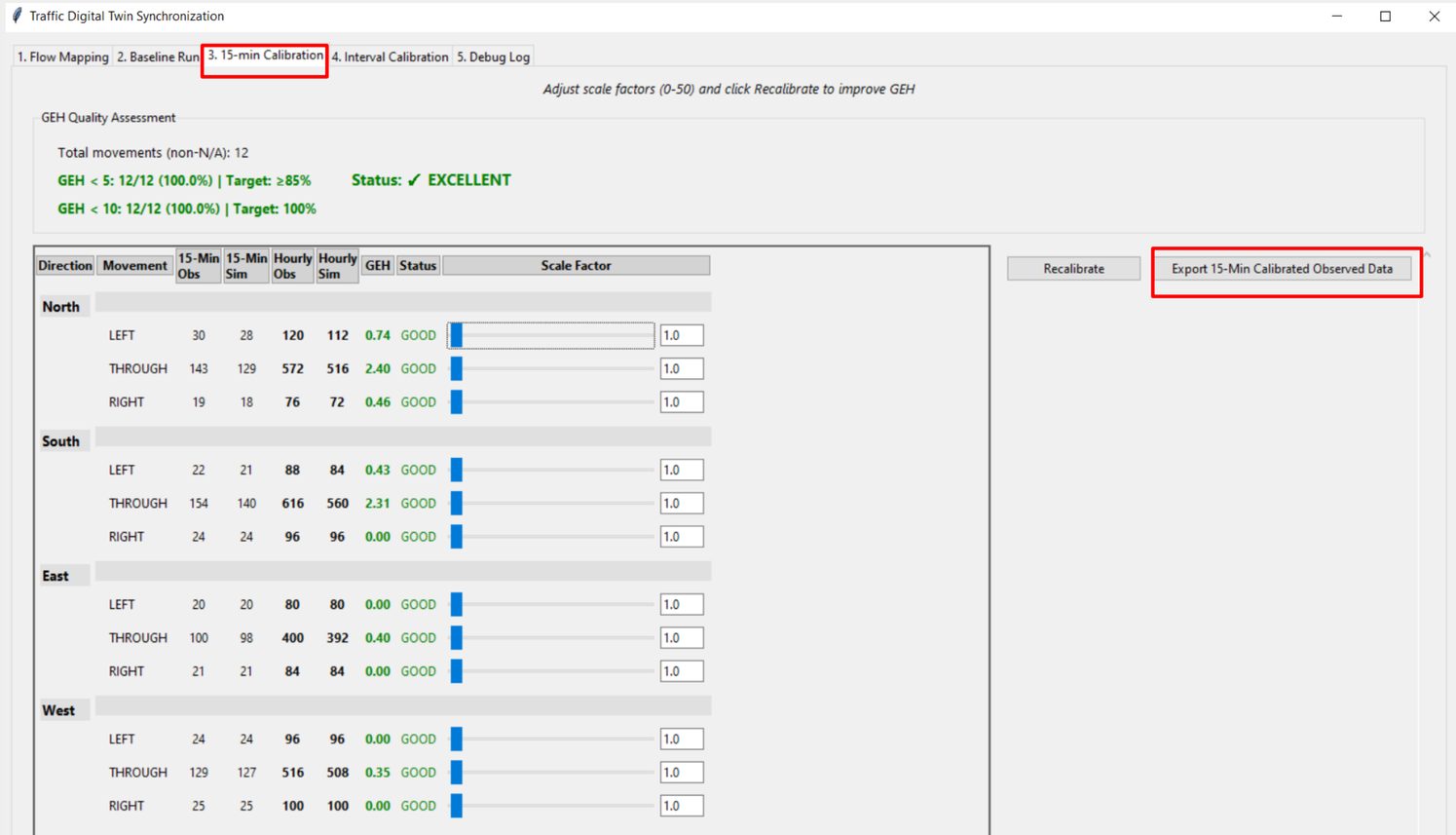
	RIGHT	25	25	100	100	0.00	GOOD	1.0

Traffic Volume Calibration using GEH

11. Once you are satisfied with the results, click **“Export 15-Min Calibrated Observed Data.”**

12. This **creates a CSV** file containing **the calibrated 15-minute traffic volumes** (by movement) for use in the simulation.

13. **See the next slide** for how to use/import the exported file



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	RIGHT	25	25	100	100	0.00	GOOD	1.0

Traffic Volume Calibration (using GEH)

14. Compare the two files

- **Left:** 15-Min Observed Data.csv (raw counts from video)
- **Right:** 15-Min Calibrated Data.csv (exported after GEH calibration)

"15-Min Observed Data.csv"

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Minute	NBL	NBT	NBR	SBL	SBT	SBR	EBL	EBT	EBR	WBL	WBT	WBR
2	All	30	143	19	22	154	24	20	100	21	24	129	25
3													
4													
5													
6													
7													
8													
9													
10													
11													
12													
13													
14													
15													
16													

Exported "15-Min Calibrated Data.csv"

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Minute	NBL	NBT	NBR	SBL	SBT	SBR	EBL	EBT	EBR	WBL	WBT	WBR
2	All	30	143	19	22	154	24	20	100	21	24	129	25
3													
4													
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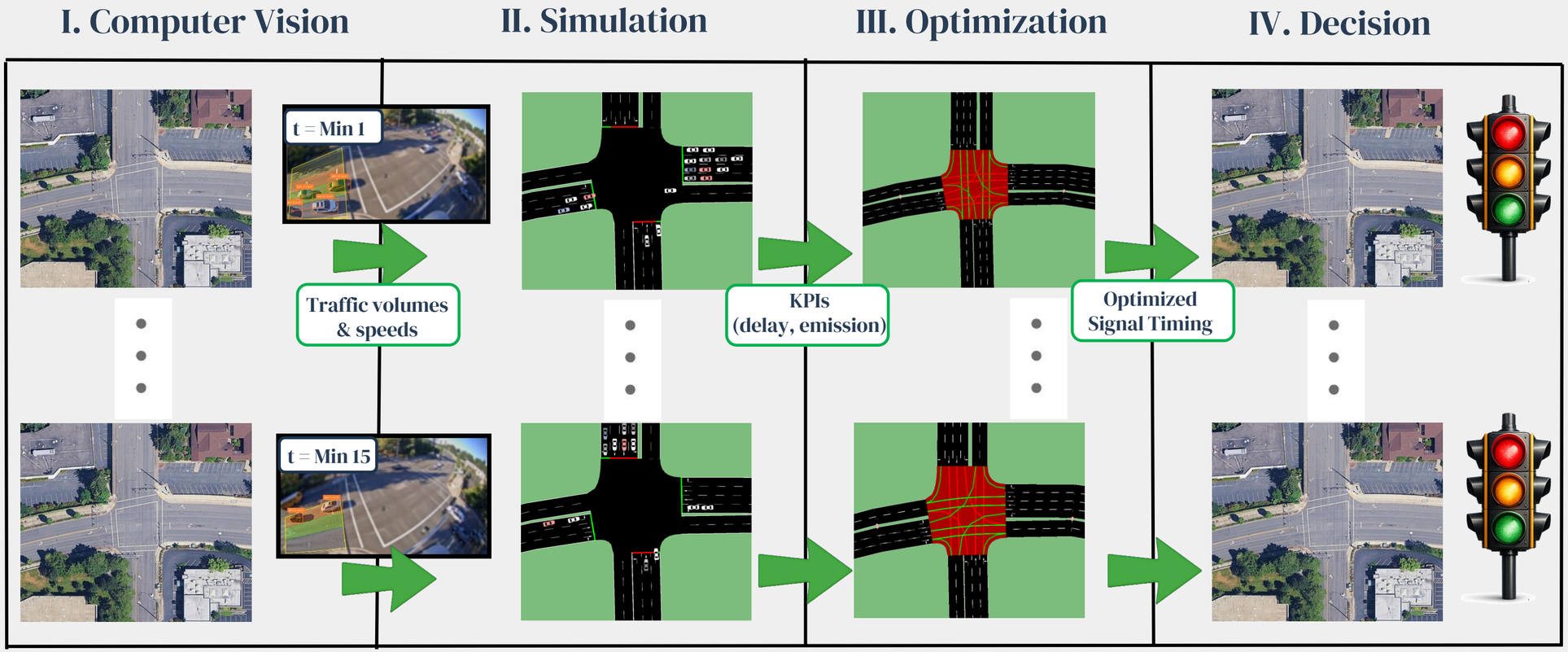
16													

Traffic Volume Calibration using GEH

15. Next: calibrate minute-by-minute Traffic Volume (interval calibration), not only 15-minute totals.



Traffic Volume Calibration using GEH

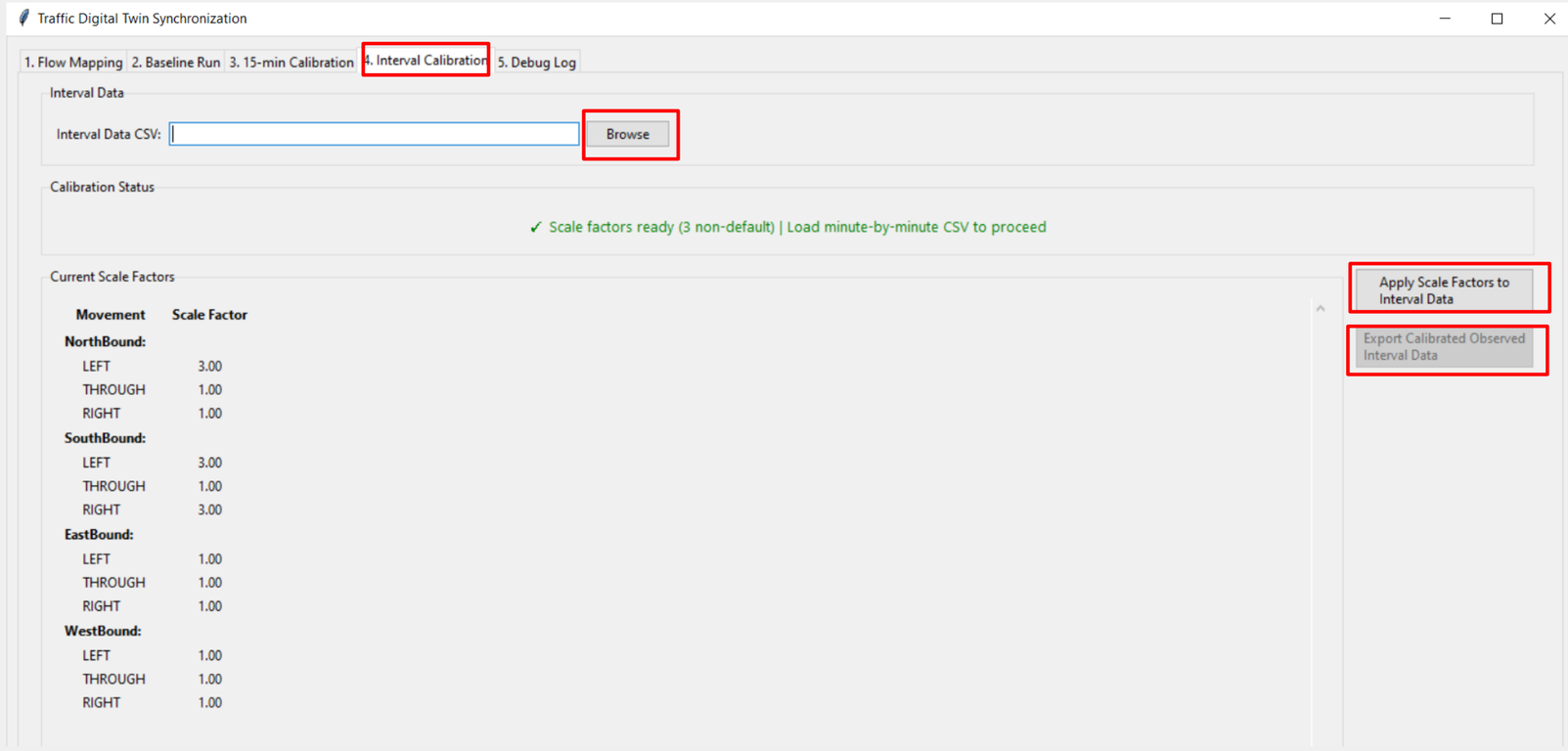
1. Open the “Interval Calibration” tab.

2. Under Interval Data → Click Browse → Select “Interval Observed Data.csv”

3. Check “Apply Scale Factors to Interval Data”

4. Click “Export Calibrated Observed Interval Data”

5. This step multiplies each movement’s minute-by-minute demand by its scale factor to generate calibrated interval volumes for the simulation.



Traffic Volume Calibration using GEH

- ❑ Compare the two files (before vs after calibration).

- **Left: Original "Interval Observed Data.csv"** (raw minute-by-minute counts)
- **Right: Exported "Calibrated Interval Observed Data.csv"** (after applying scale factors)
- The exported file preserves the time pattern but adjusts each movement to match the calibrated 15-minute totals.

"Interval Observed Data.csv"

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Minute	NBL	NBT	NBR	SBL	SBT	SBR	EBL	EBT	EBR	WBL	WBT	WBR
2	1	2	15	1	1	10	2	1	6	1	1	6	1
3	2	3	16	1	1	11	2	1	4	1	1	7	2
4	3	1	9	1	2	9	1	1	5	3	2	8	1
5	4	2	4	1	3	8	2	1	4	1	3	8	2
6	5	3	13	1	1	10	1	2	7	3	2	6	2
7	6	1	12	2	2	12	2	2	10	1	1	12	2
8	7	2	7	1	2	13	1	1	8	1	2	8	2
9	8	3	9	1	1	11	2	2	8	1	1	5	1
10	9	2	5	2	1	10	2	1	6	1	2	10	2
11	10	1	1	2	1	11	2	1	8	1	2	11	1
12	11	2	10	2	1	9	1	2	6	1	1	8	3
13	12	2	11	1	1	12	2	1	8	1	1	12	2
14	13	3	5	1	1	10	1	2	6	3	2	10	2
15	14	1	14	1	2	8	2	1	7	1	1	9	1
16	15	2	12	1	2	10	1	1	7	1	2	9	1

Exported "Calibrated Interval Observed Data.csv"

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Minute	NBL	NBT	NBR	SBL	SBT	SBR	EBL	EBT	EBR	WBL	WBT	WBR
2	1	2	15	1	1	10	2	1	6	1	1	6	1
3	2	3	16	1	1	11	2	1	4	1	1	7	2
4	3	1	9	1	2	9	1	1	5	3	2	8	1
5	4	2	4	1	3	8	2	1	4	1	3	8	2
6	5	3	13	1	1	10	1	2	7	3	2	6	2
7	6	1	12	2	2	12	2	2	10	1	1	12	2
8	7	2	7	1	2	13	1	1	8	1	2	8	2
9	8	3	9	1	1	11	2	2	8	1	1	5	1
10	9	2	5	2	1	10	2	1	6	1	2	10	2
11	10	1	1	2	1	11	2	1	8	1	2	11	1
12	11	2	10	2	1	9	1	2	6	1	1	8	3
13	12	2	11	1	1	12	2	1	8	1	1	12	2
14	13	3	5	1	1	10	1	2	6	3	2	10	2
15	14	1	14	1	2	8	2	1	7	1	1	9	1
16	15	2	12	1	2	10	1	1	7	1	2	9	1

Step 3 (15 Min Calibration)

- ❑ **Now, we have two calibrated CSV files ready for simulation:**
- **Left:** 15-Min Calibrated Volumes (by movement)
- **Right:** Calibrated Interval Volumes (minute-by-minute)

Exported “15-Min Calibrated Observed Data.csv”

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Minute	NBL	NBT	NBR	SBL	SBT	SBR	EBL	EBT	EBR	WBL	WBT	WBR
2	All	30	143	19	22	154	24	20	100	21	24	129	25
3													
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14													
15													
16													

Exported “Calibrated Interval Observed Data.csv”

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Minute	NBL	NBT	NBR	SBL	SBT	SBR	EBL	EBT	EBR	WBL	WBT	WBR
2	1	2	15	1	1	10	2	1	6	1	1	6	1
3	2	3	16	1	1	11	2	1	4	1	1	7	2
4	3	1	9	1	2	9	1	1	5	3	2	8	1
5	4	2	4	1	3	8	2	1	4	1	3	8	2
6	5	3	13	1	1	10	1	2	7	3	2	6	2
7	6	1	12	2	2	12	2	2	10	1	1	12	2
8	7	2	7	1	2	13	1	1	8	1	2	8	2
9	8	3	9	1	1	11	2	2	8	1	1	5	1
10	9	2	5	2	1	10	2	1	6	1	2	10	2
11	10	1	1	2	1	11	2	1	8	1	2	11	1
12	11	2	10	2	1	9	1	2	6	1	1	8	3
13	12	2	11	1	1	12	2	1	8	1	1	12	2
14	13	3	5	1	1	10	1	2	6	3	2	10	2
15	14	1	14	1	2	8	2	1	7	1	1	9	1
16	15	2	12	1	2	10	1	1	7	1	2	9	1

Thank You