Capacity, Capacity Drop and Relation of Capacity to the Path Width in Bicycle Traffic

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HIGHLIGHTS

- A controlled bottleneck experiment is performed to study the aggregated cycling movements before and after the onset of congestion.
- We quantitatively describe the relation between path width and capacity.
- We illustrate the existence of the capacity drop phenomenon in bicycle flow.
- A qualitative analysis illustrates that the cyclist configuration at different path widths shows resemblance to a merging process.

BACKGROUND

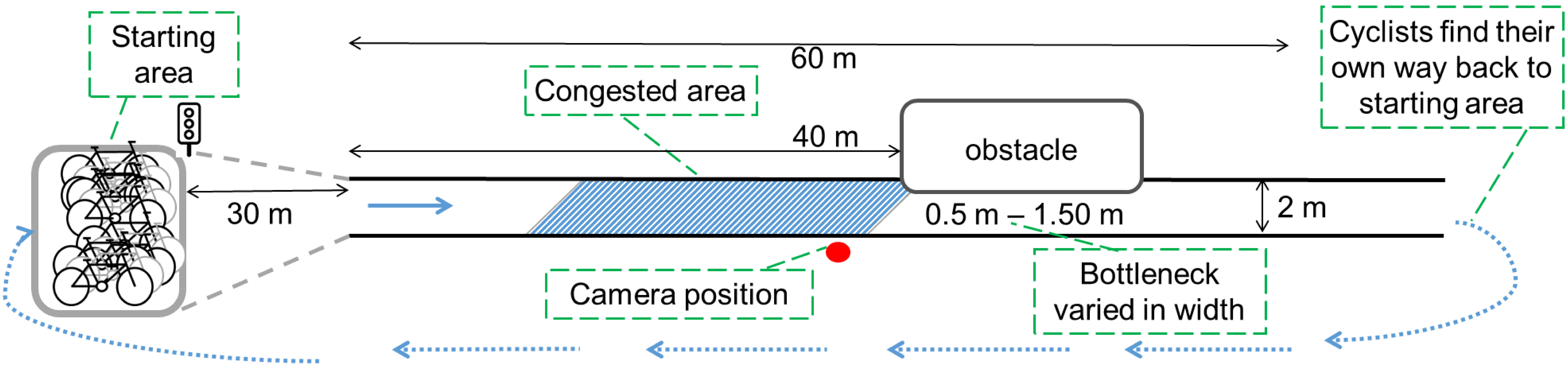
Understanding of bicycle flow dynamics is progressing slowly:

- Previous research has lead to a **wide variety** in reported capacity values of bicycle paths but it is unclear if these differences are related to different **path width**.
- Bicycle traffic flow dynamics of **single file** bicycle flow shows strong resemblance to motorized traffic flow dynamics but little is known when cyclists are **side-by-side**.
- The **capacity drop** phenomenon has not yet been observed in bicycle traffic flow.

Insights are gathered by studying the bicycle flow movements in a bottleneck experiment where cyclists can move alongside.

EXPERIMENT SET-UP

- Participant start cycling as a group and are instructed to cycle `as normal'.
- The 2m wide cycle path is obstructed by a mattress that narrows the path from one side and created a bottleneck.
- The bottleneck width is varied between 0.50-1.50 m by changing the position of the mattress.
- The order of the five scenarios is randomized but each one consists of three consecutive runs.



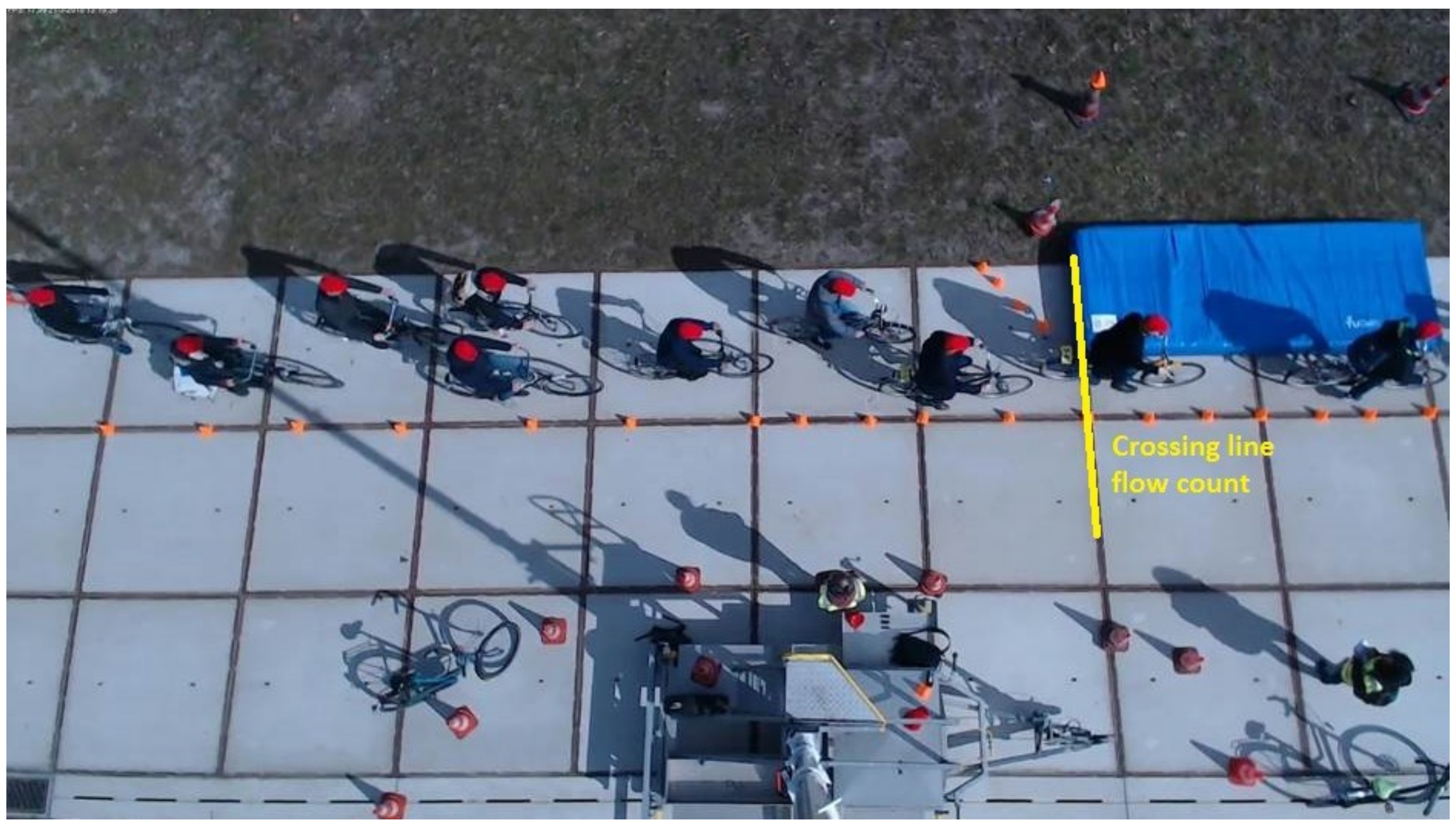
SCENARIOS

Run #	Scenario name	Bottleneck width (m)	Participant #	Duration (sec)
1	150-1	1.50	34	27
2	150-2	1.50	34	22
3	150-3	1.50	34	21
4	75-1	0.75	34	36
5	75-2	0.75	34	35
6	75-3	0.75	34	38
7	100-1	1.00	34	31
8	100-2	1.00	34	30
9	100-3	1.00	34	31
10	125-1	1.25	34	27
11	125-2	1.25	34	28
12	125-3	1.25	31	20
13	50-1	0.50	35	52
14	50-2	0.50	34	47
15	50-3	0.50	-	canceled

DATA

A camera at 11m height record the bicycle movements from a near top-down angle.

One-second flow counts are manually retrieved at the entrance of the bottleneck (yellow line).



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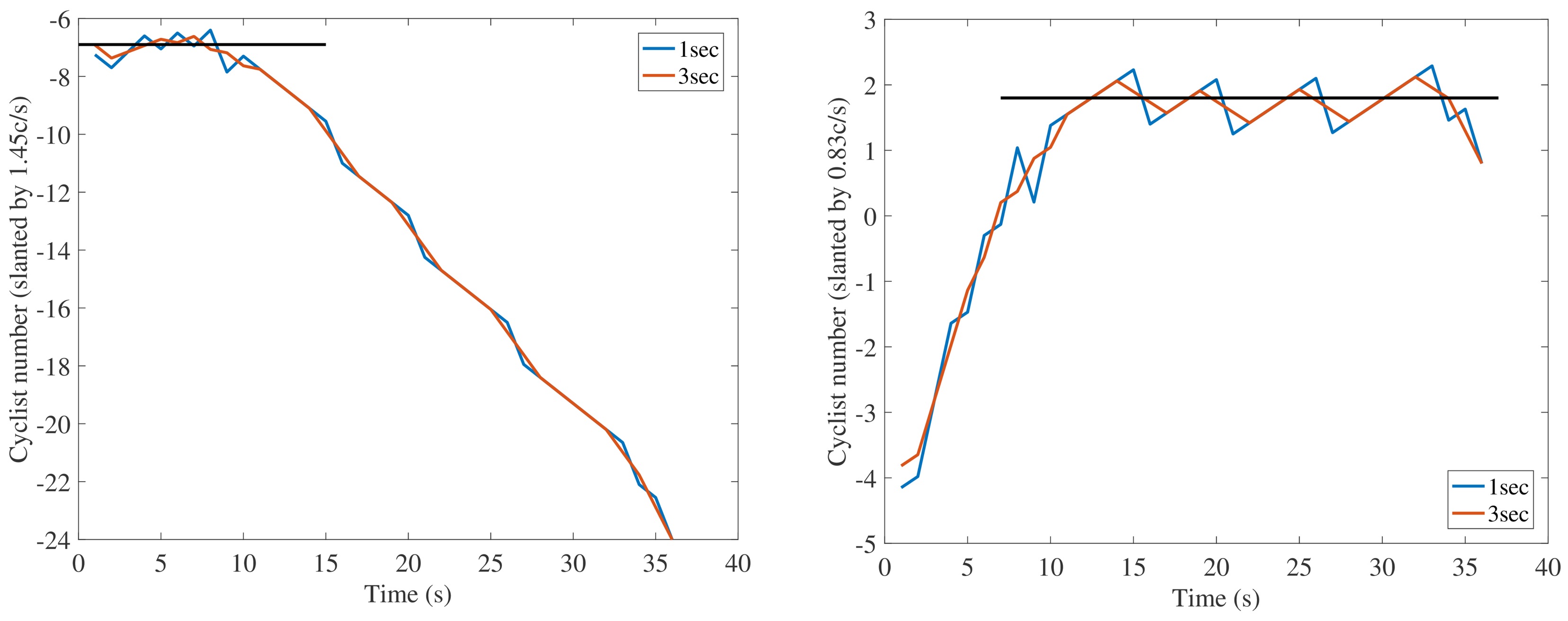
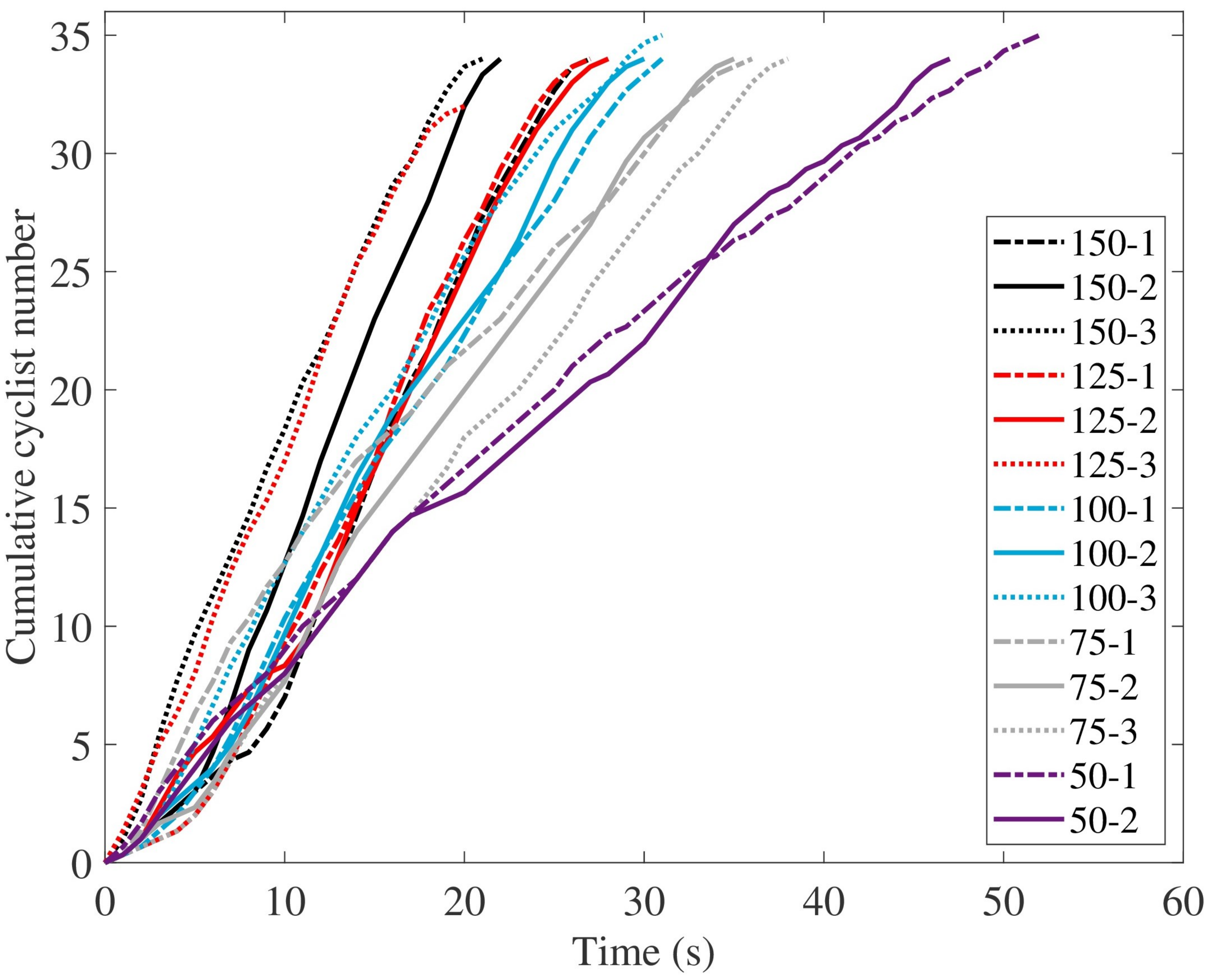
DATA ANALYSIS

- Slanted cumulative curves are used to estimate the maximum flow before and after the onset of congestion.
- Cyclist configuration while passing the bottleneck is analysed qualitatively.
- Regression analysis is used to quantify the relation between path width and capacity.



RESULTS

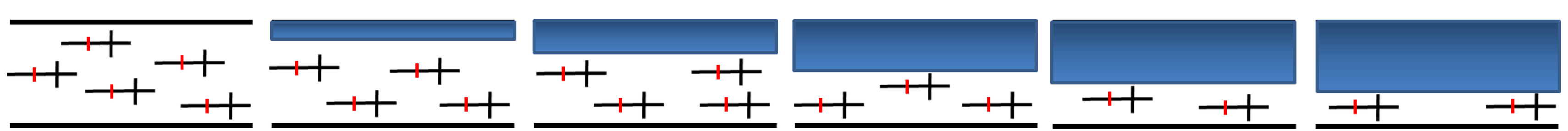
Run duration increases when bottleneck width decreases. It takes more time for all cyclists to pass the bottleneck entrance.
→ Average flow rate decreases when path width decreases.



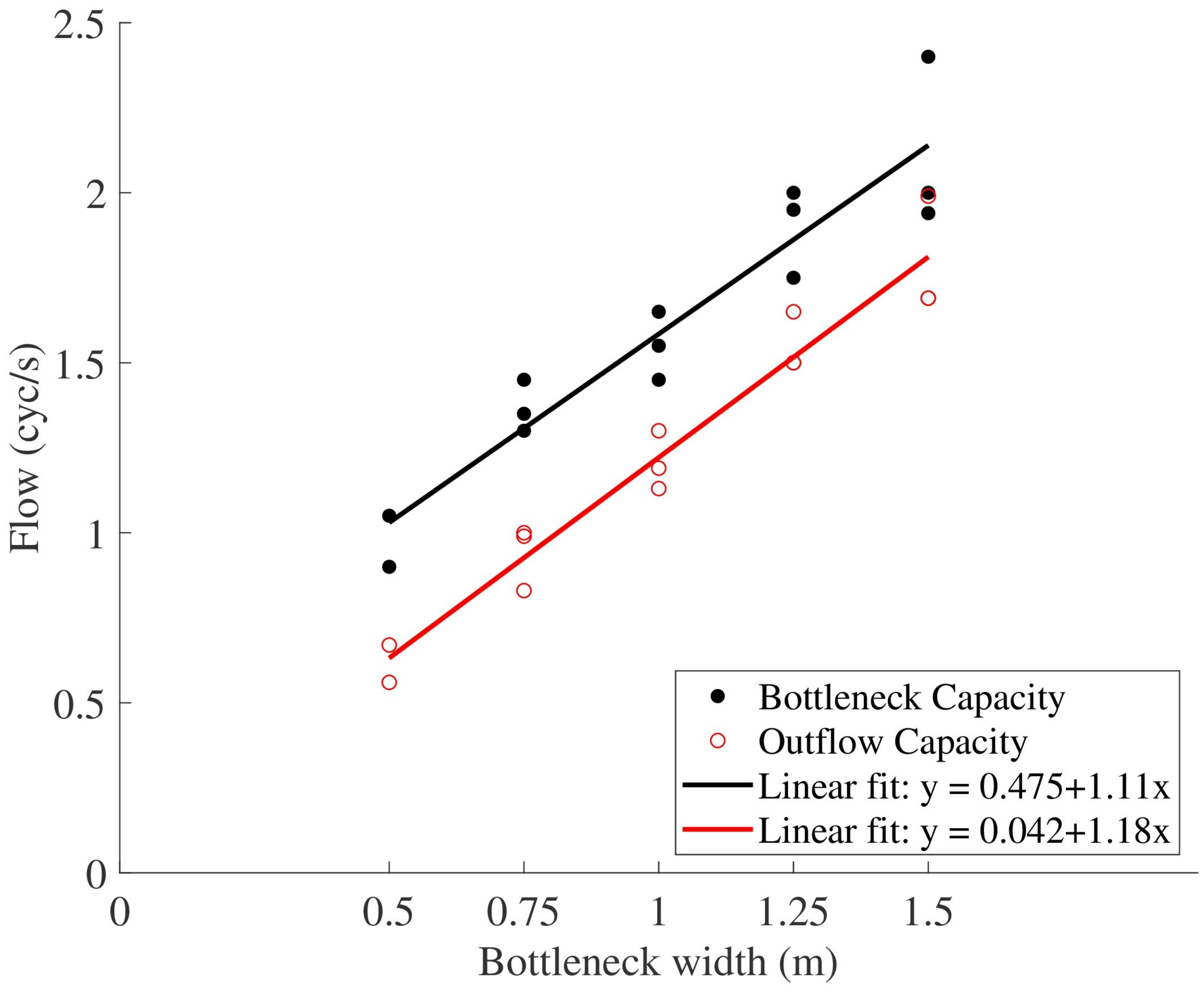
CONFIGURATION

Cyclists use the available space differently depending on path with by forming multiple effective sublanes when space allows.
The lateral distance between effective sublanes descreases until the path width does not allow cyclists to cycle alongside. As a result, the longitudinal distance between cyclists increases.

- In snapshots, the configurations resemble a merging process.



CAPACITY AND CAPACITY DROP



- Capacity is linearly and positively related to path width for widths between 0.50 and 1.50m.
  $Flow_{cap}$ (cyc/s) = 0.475 + 1.11 * path width (m)
- Maximum queue discharge rate is linearly and positively related to path width for widths between 0.50 and 1.50m.
  $Flow_{out}$ (cyc/s) = 0.042 + 1.18 * path width (m)
- Both linear relations have a non-zero constant, indicating that maximum flow rates do not double when path size is doubled.
- Capacity of a 1m bicycle path is approximately 5,700 cyc/hr.
- After the onset of congestion, the maximum flow rate drops with approximately 0.45 cyc/s, which is around 1,600 cyc/hr.

CONCLUSION

Maximum flow rate before and after the onset of congestion is linearly and positively related to path width for widths 0.50 — 1.50m.

- Capacity increases by 4,000 cyc/hr for 1m additional path width.
- Queue discharge rate increases by 4,250 cyc/hr for 1m additional path width.

After the onset of congestion, the maximum flow rate drops by approximately 1,600 cyc/hr.

- The capacity drop phenomenon exists in bicycle traffic flow.

The gradual change in cyclist configuration when passing the bottleneck can explain the linear relation to path width.

- Configurations for decreasing widths resemble a merging process.