Université Gustave Eiffel

Observation of vehicular response time in CACC platooning experiments

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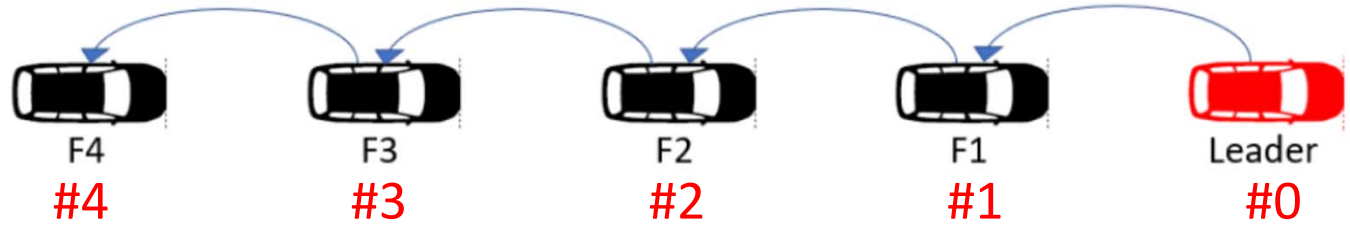
Where are we regarding ACC behavior?

- The speed of vehicles equipped with Automated Cruise Control (ACC) is imposed to ensure a minimal distance with their leader
- If the response time is equal or longer than the one of a human driver:
  - The potential gain in safety remains questionable and
  - There is no gain in infrastructure capacity
- For an example see Makridis et al. IEEE Intelligent Vehicles symposium, 2018. After an experimental study conducted with ACC platoons, they conclude "**Results show that the response time of the particular ACC controller was in the range 0.8s-1.2s, which is similar to what is commonly assumed for human drivers.**"

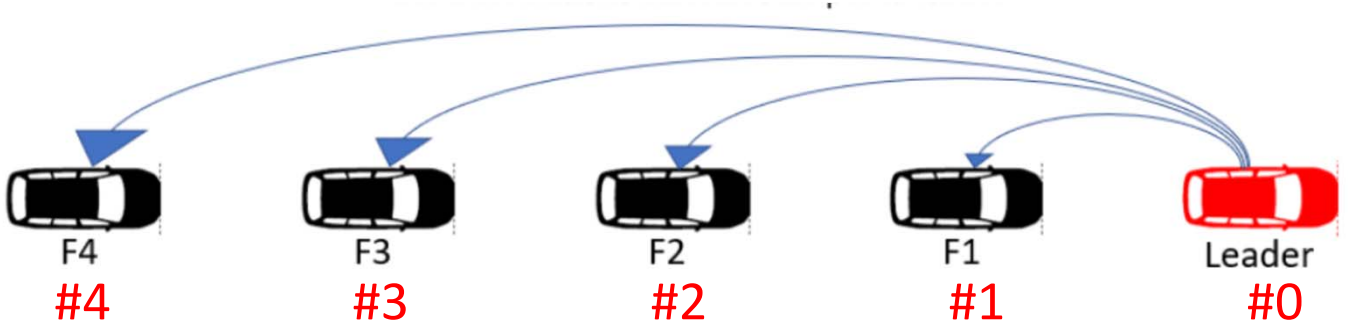
→ ***Can we expect better response times from Connected ACC (CACC)?***

Promises of CACC

- Instead of leader/follower interaction like in ACC



- CACC should permit a direct communication between the leader and all the followers inside a given platoon



Research question:

- Can we measure the response times of a set of CACC vehicles in a platoon?

- And observe if
  - The response time of the follower#4 to a speed change of the platoon leader
  - Is similar to the response time of follower#1 to a speed change of the platoon leader?

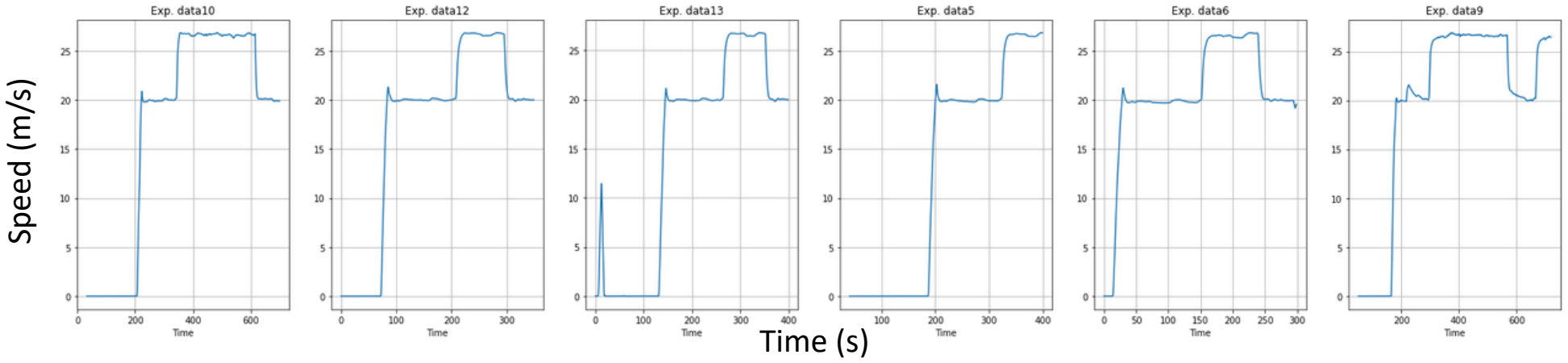
To answer this question we need

1. A set of CACC platoon experiments
2. A response time determination method suitable for this data set
3. An analysis of the response times depending on the # of the follower

1. A set of CACC platoon experiments

- We use the 6 platooning experiments of U.S. DoT CARMA database (Cooperative Automated Research Mobility Applications http://doi.org/10.21949/1504485)
- Each platoon is made of 5 vehicles: leader, follower 1, follower 2, follower 3, follower 4. We name them #0, #1, #2, #3 and #4.

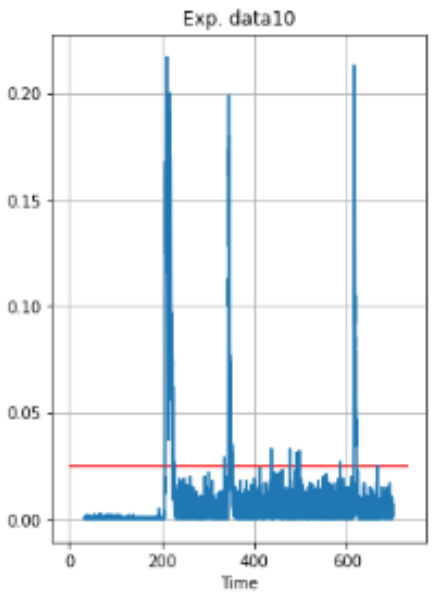
Leader (#0) speed evolution during the 6 experiments. We selected 11 coherent speed changes.



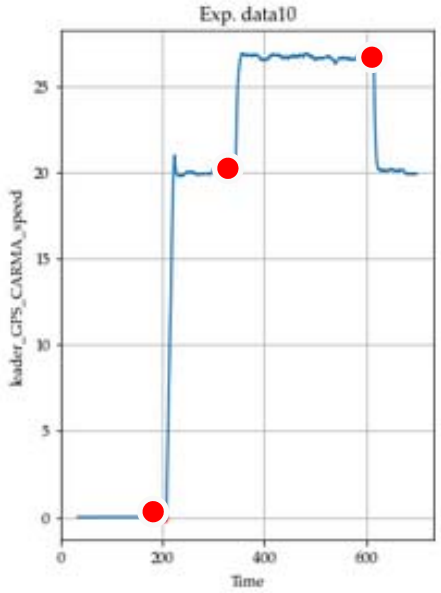
2. A response time determination method suitable for this data set

- We identify, in each trajectory, the instant of speed change:
- A speed change is detected when the variation is bigger than 3σ (σ is the rolling mean value of the standard deviation of the speed) and *this was not the case before*
- We repeat the principle for all vehicles of the platoon

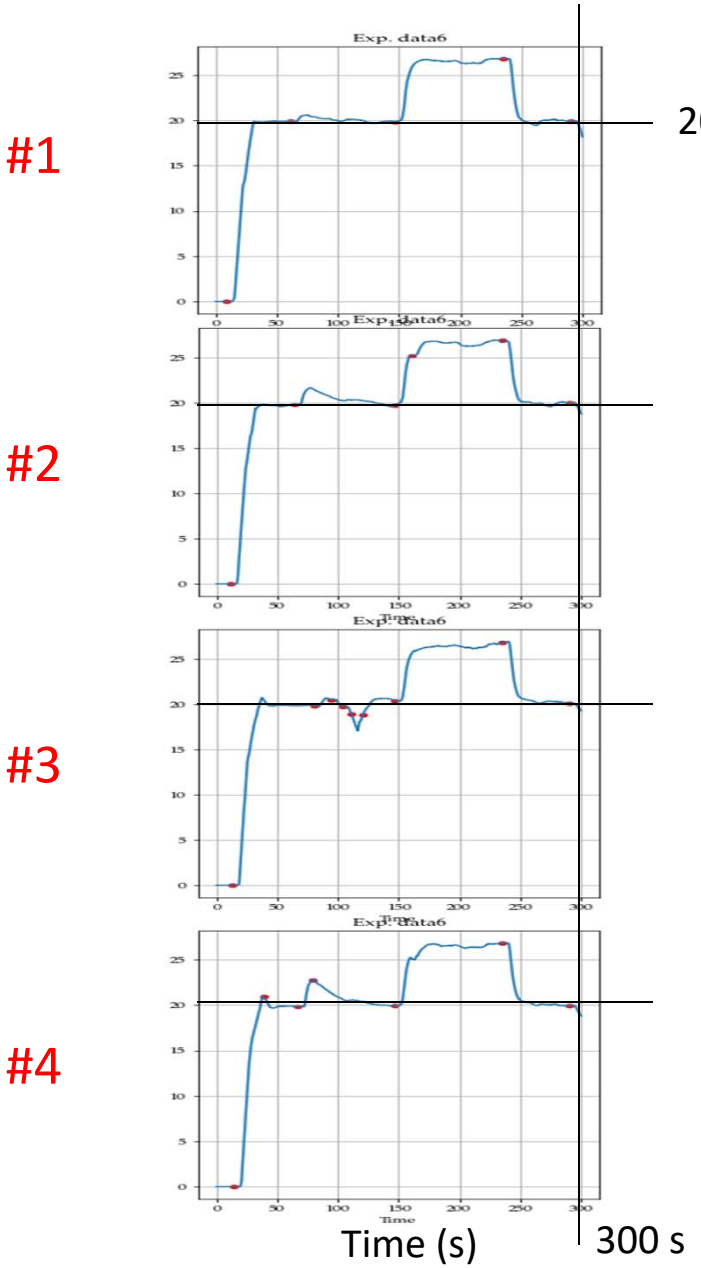
An example of the rolling mean value of the standard deviation of speed



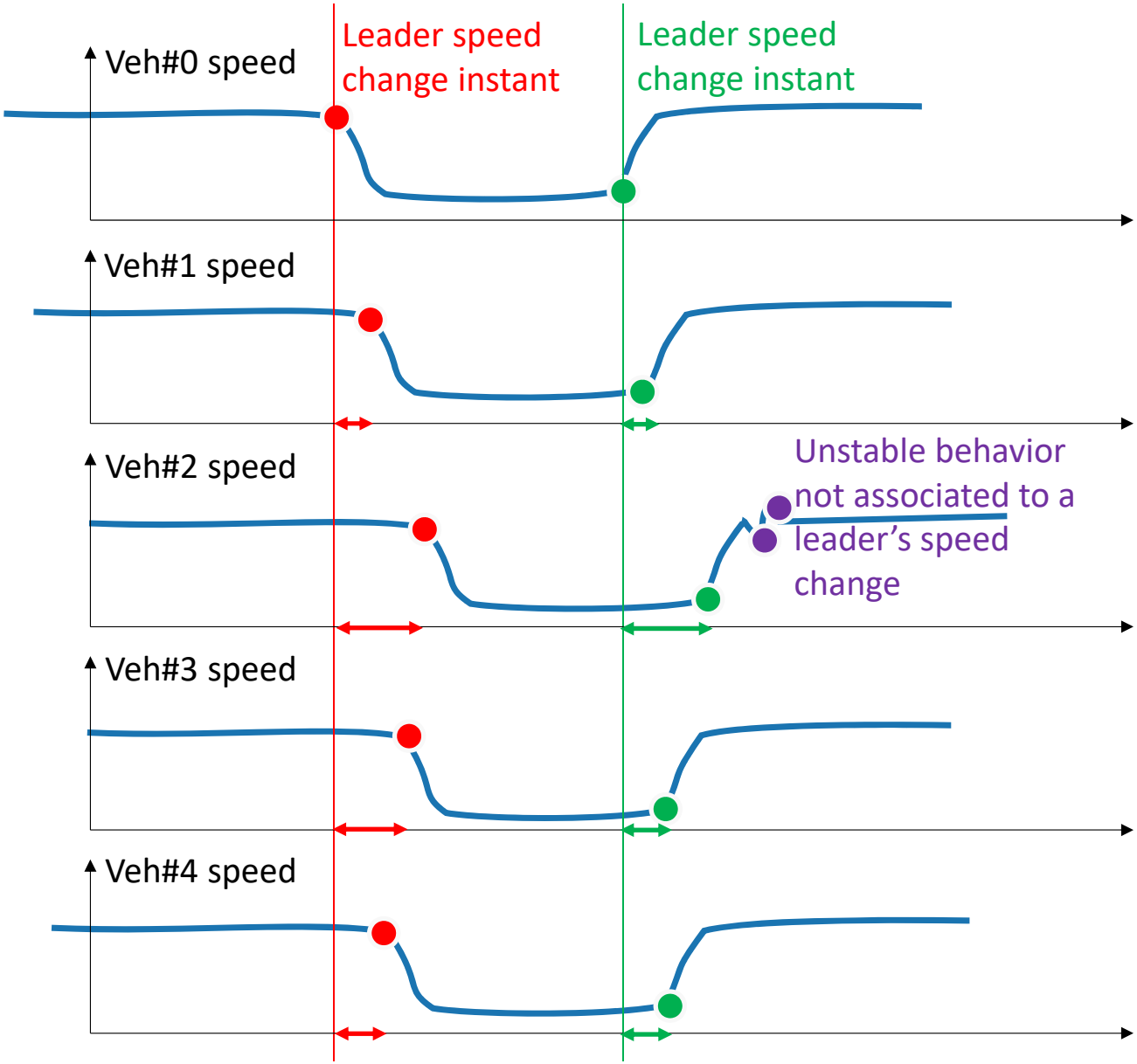
Identification of the corresponding speed changes for one vehicle



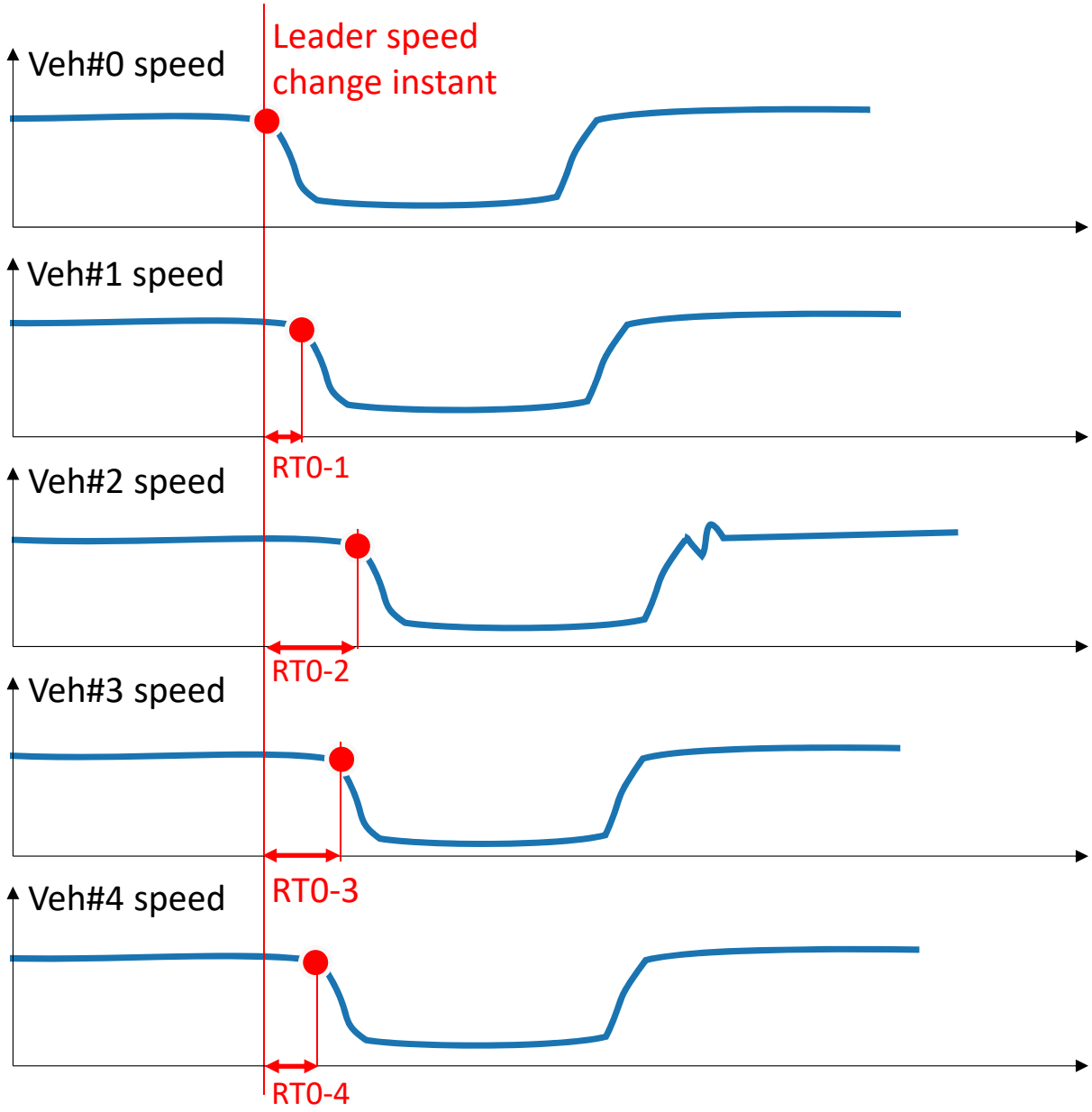
For the successive vehicles of the platoon, the same logic is applied to identify the instants of changing speed but…
we need to reject the artefacts due to unstable following behavior.
An example for the 4 followers of experiment 6.



Selecting the changing speed instants sets associated to a leader's speed change



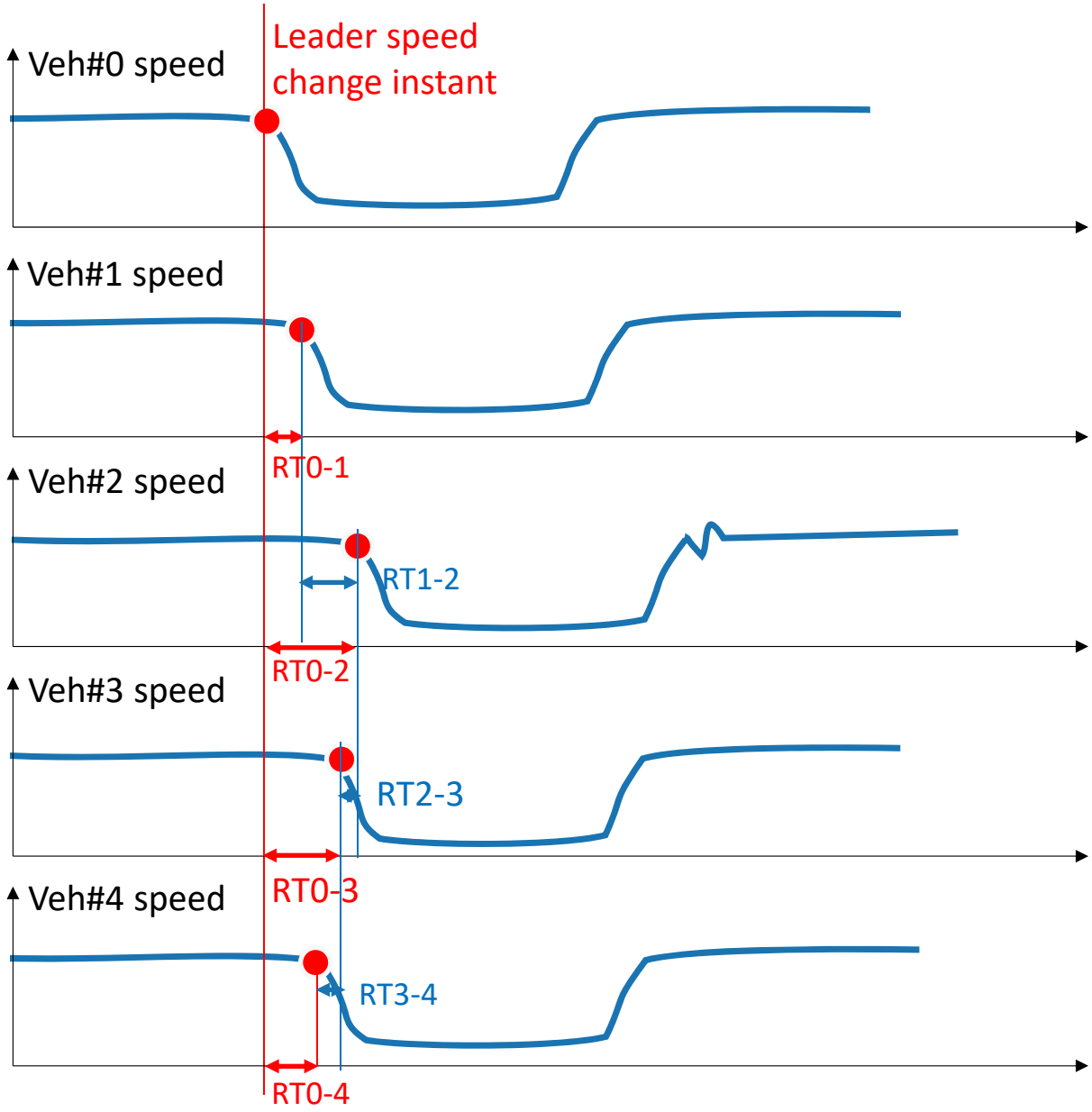
Leader-follower response time



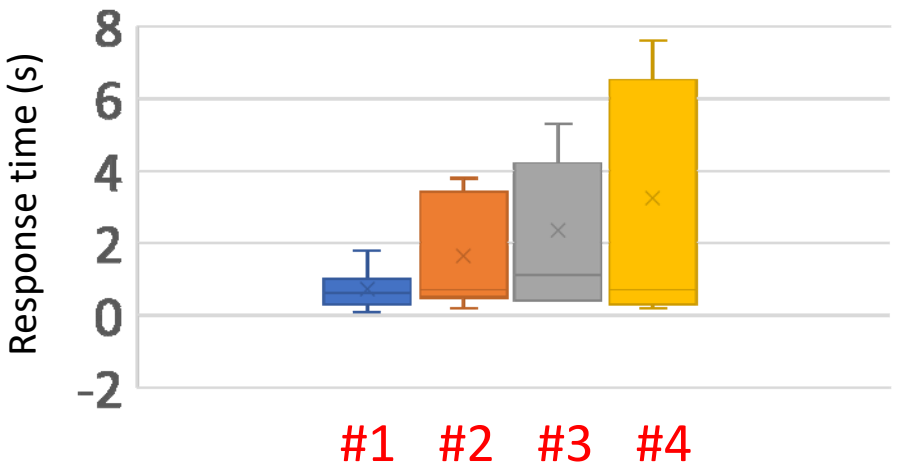
Leader-follower response time

and

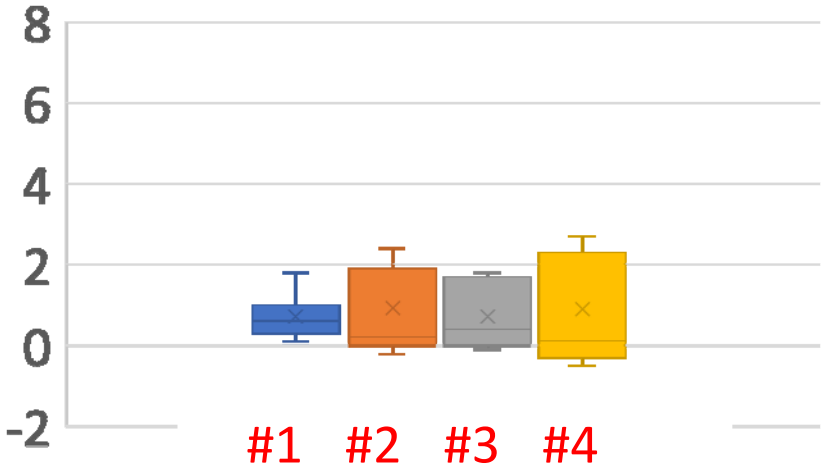
Follower-follower response time



Leader-follower response time



Follower-follower response time



- ***Tentative conclusion:***
  the farther you are from the leader,
  the bigger the chance
  that your response time is bigger
- ***Future research direction:***
  a better analysis of the effectiveness of connectivity for all vehicles of CACC platoons

We need more data!

Good news: we have a second data set!

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Thank you for your attention

Un example of unstable behavior of the vehicles of the platoon