Trust Building for Data Sources of a Digital Twin

Webinar “The German LL in the PoDIUM Project: Preliminary Results from the Use Case ‘Cooperative Corridor Management in the City of Ulm involving Multi-connectivity’”

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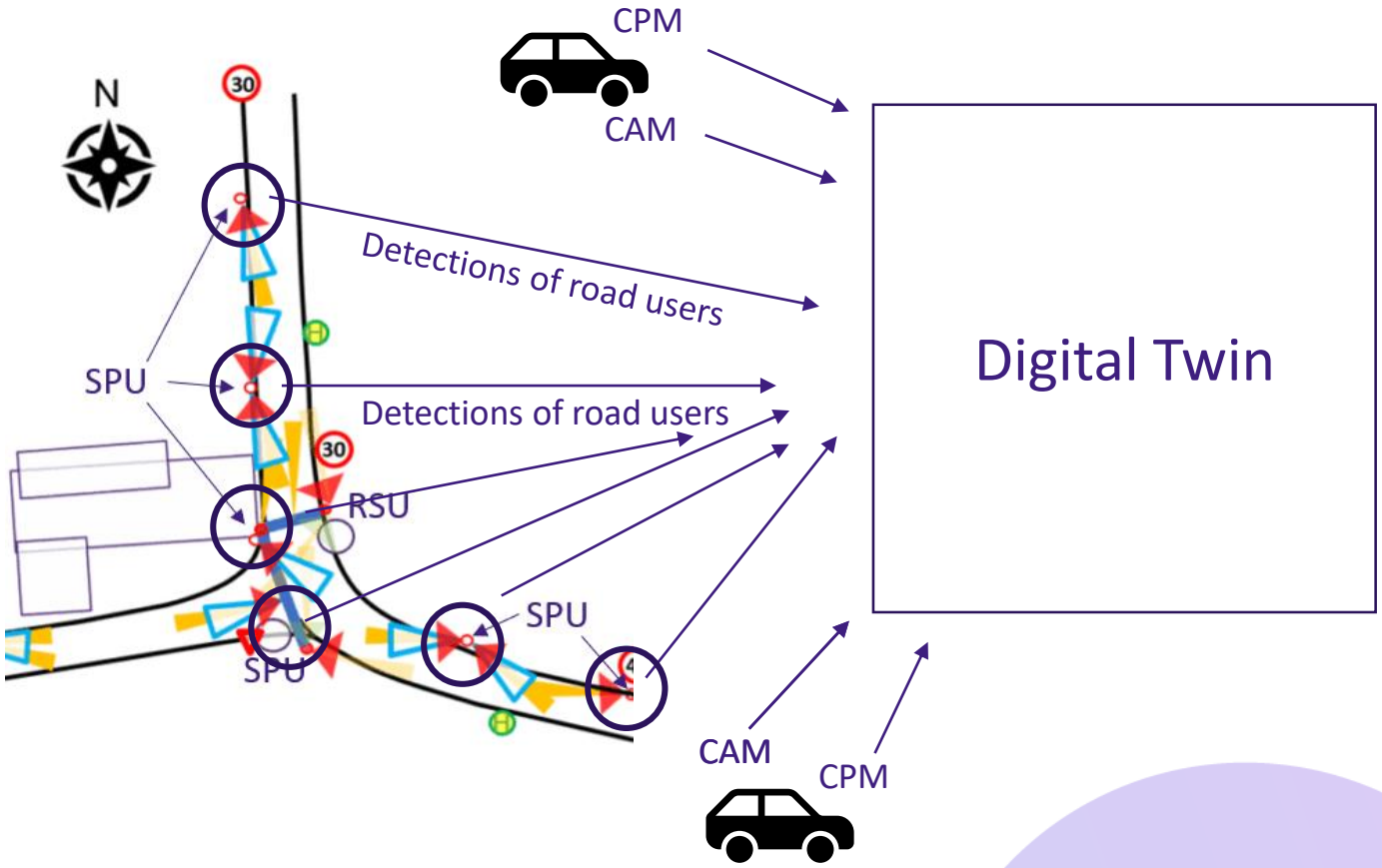
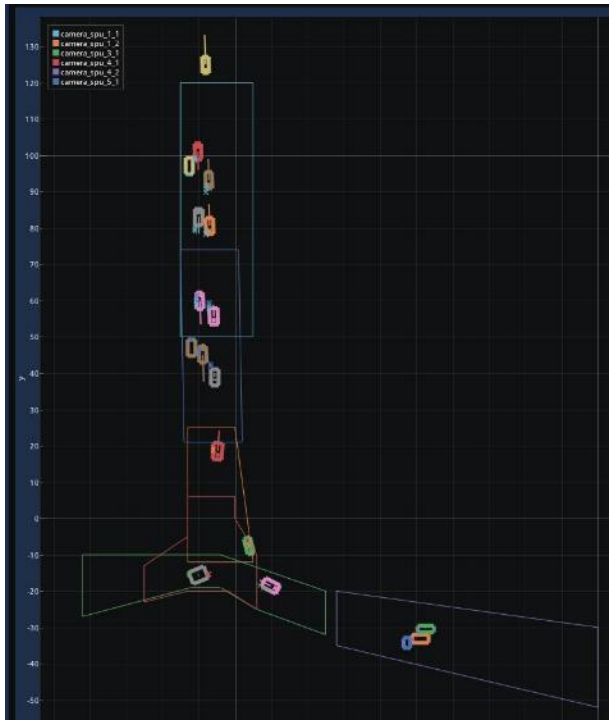
Co-funded by the European Union

The Task

Fusion of all relevant information

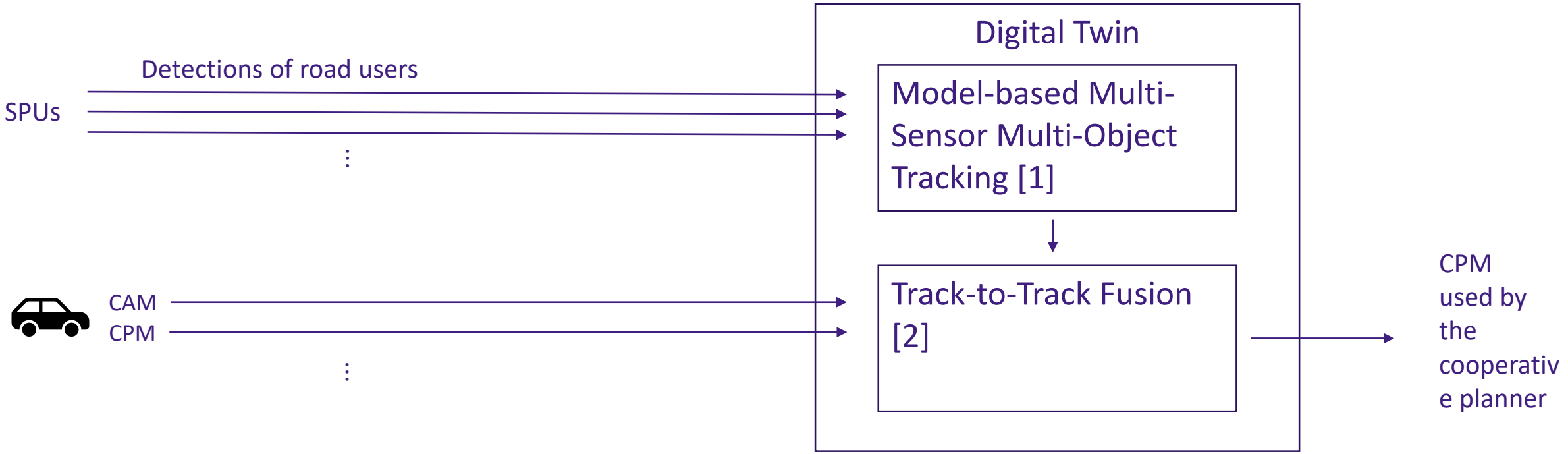


Digital Twin



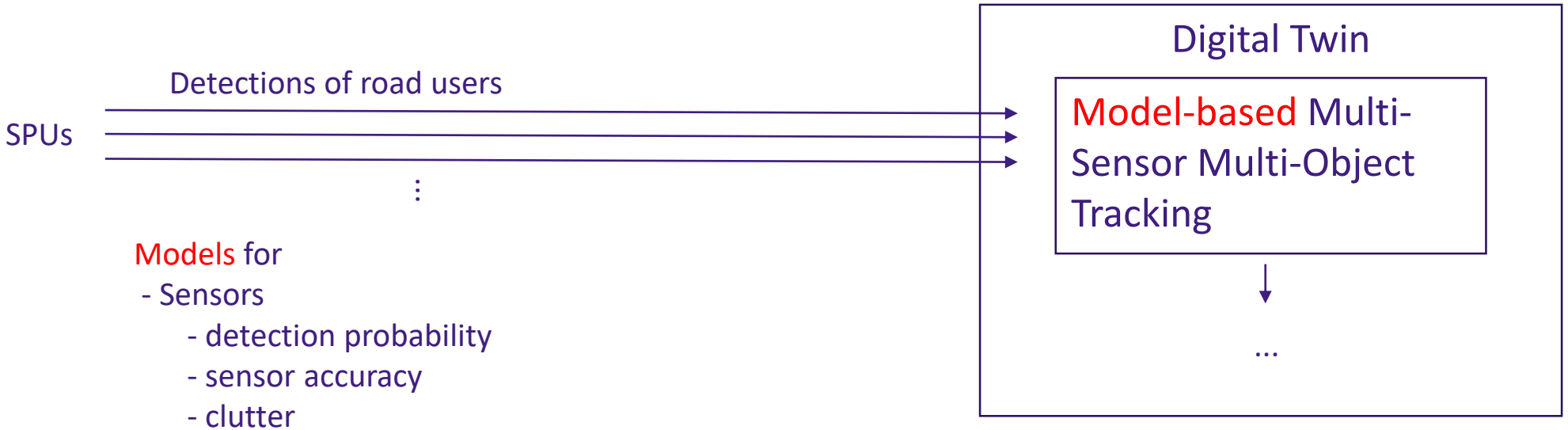
CPM
→ used by the cooperative planner

The approach



[1] T. Kropfreiter, F. Meyer and F. Hlawatsch, "A Fast Labeled Multi-Bernoulli Filter Using Belief Propagation," in *IEEE Transactions on Aerospace and Electronic Systems*, vol. 56, no. 3, pp. 2478-2488, June 2020, doi: 10.1109/TAES.2019.2941104.
[2] S. J. Julier and J. K. Uhlmann, "A non-divergent estimation algorithm in the presence of unknown correlations," *Proceedings of the 1997 American Control Conference (Cat. No.97CH36041)*, Albuquerque, NM, USA, 1997, pp. 2369-2373 vol.4, doi: 10.1109/ACC.1997.609105.

Building Trust in the Data Sources



Models for
- Sensors
  - detection probability
  - sensor accuracy
  - clutter
  - ….
- Road User behavior
- …

Tracking algorithm is based on these models + Bayes theorem → good models == good performace

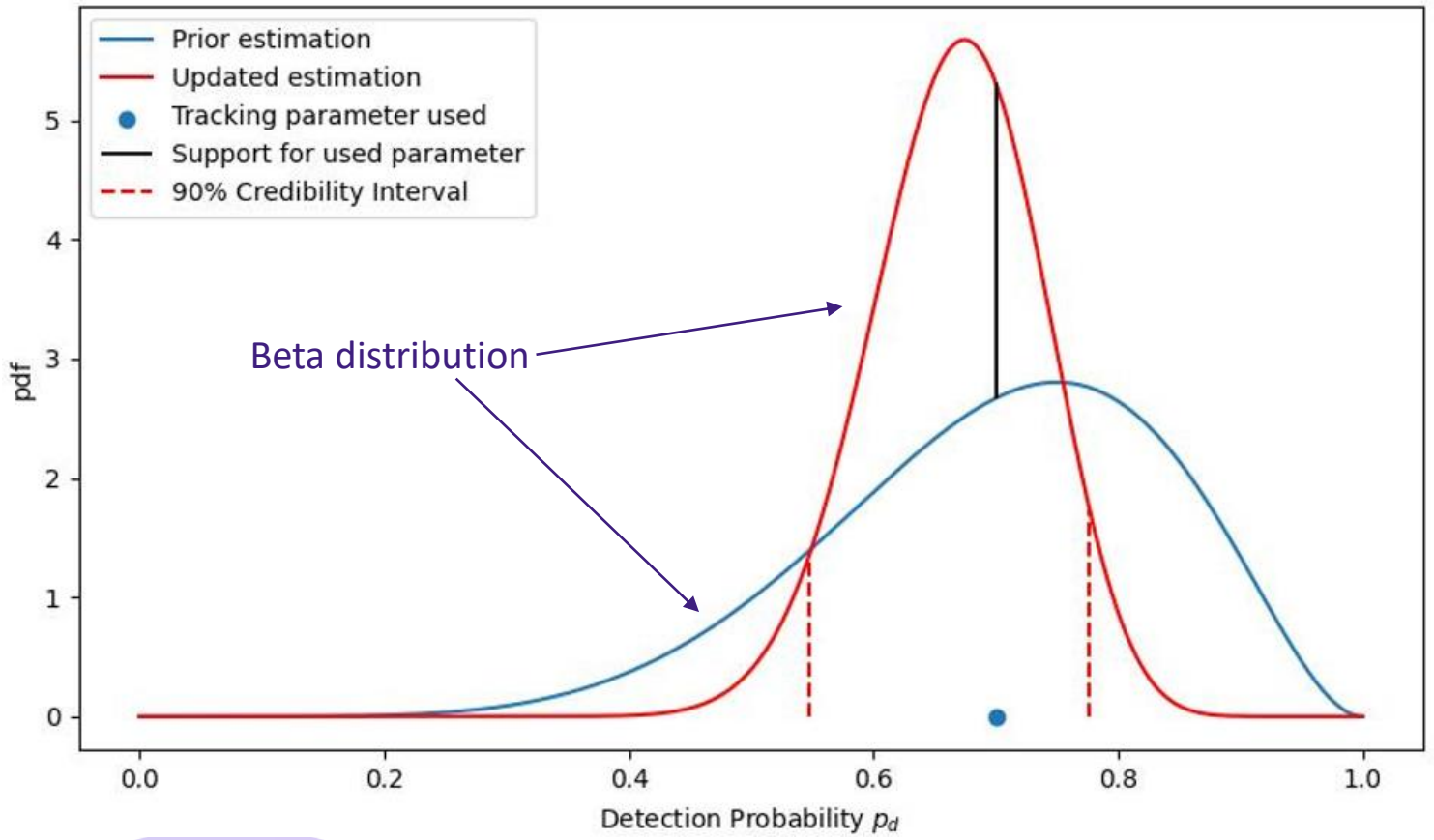
Trust in something: It behaves as expected

→ check models for the sensors

Building Trust in the Data Sources

Detection Probability [3]

- Probability that a road user will be detected (d) by a sensor: $d \sim Bernoulli(p_d)$
- Estimate and evalutate p_d based on live data
  - Prior estimation: $p_d \sim Beta(p, q)$
  - Update this estimation based on information computed by the tracker
- Check if the parameter used match the estimation
  - Credibility interval
  - Prior/posterior comparison



Clutter Model / Clutter Rate [4]

- Detections that do not belong to a real object
- Similar approach

[3] A.Scheible, T. Griebel and M. Buchholz, „Self-Monitored Detection Probability Estimation for the Labeled Multi-Bernoulli Filter“, *2024 27th IEEE Internation Conference on Intelligent Transporatation Systems (ITSC),* Edmonton, Canada, 2024, pp. 1-7 (accepted and presented)

[4] A. Scheible, T. Griebel and M. Buchholz, "Self-Monitored Clutter Rate Estimation for the Labeled Multi-Bernoulli Filter," *2024 27th International Conference on Information Fusion (FUSION)*, Venice, Italy, 2024, pp. 1-7, doi: 10.23919/FUSION59988.2024.10706463.

Building Trust in the Data Sources

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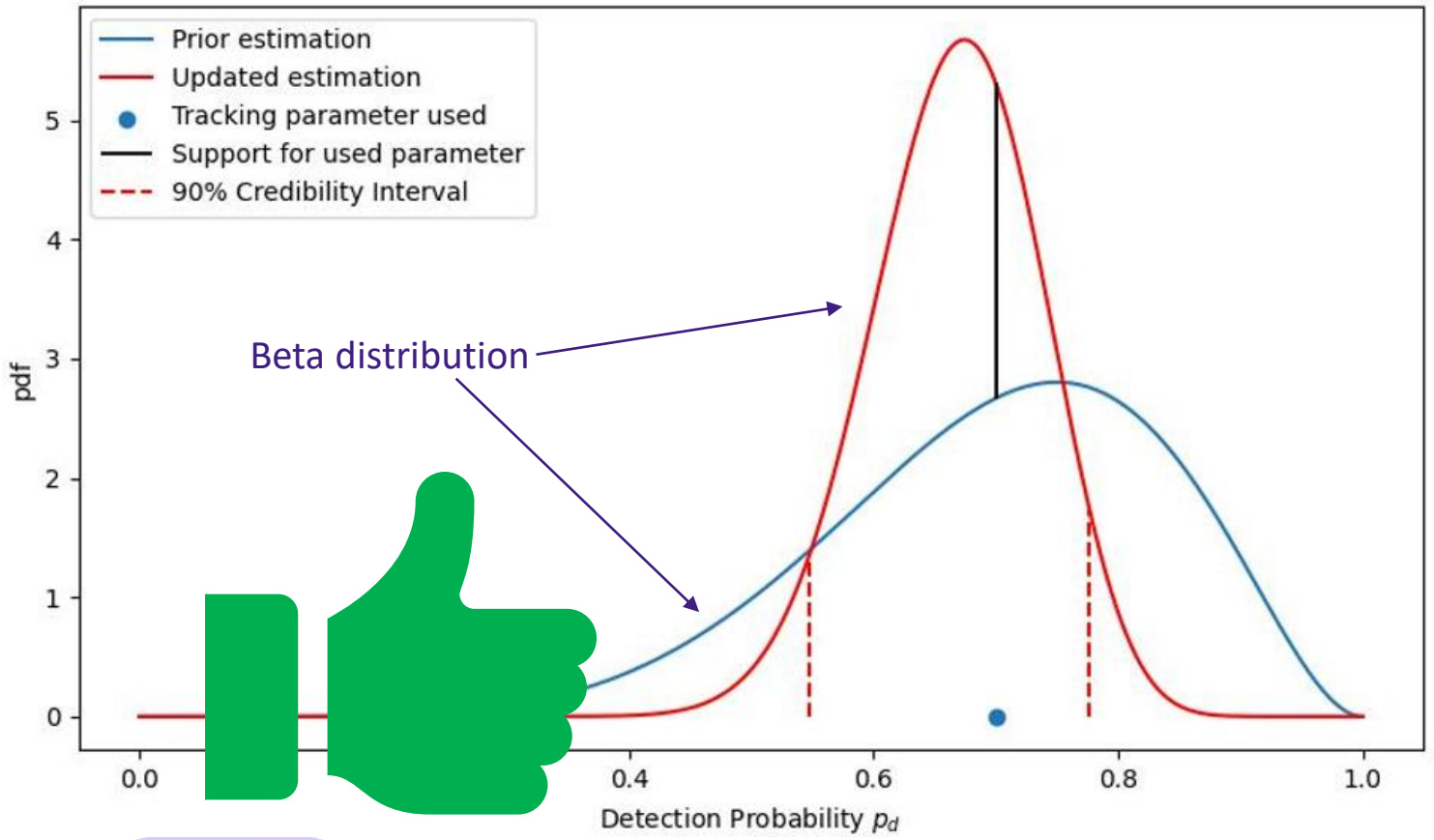

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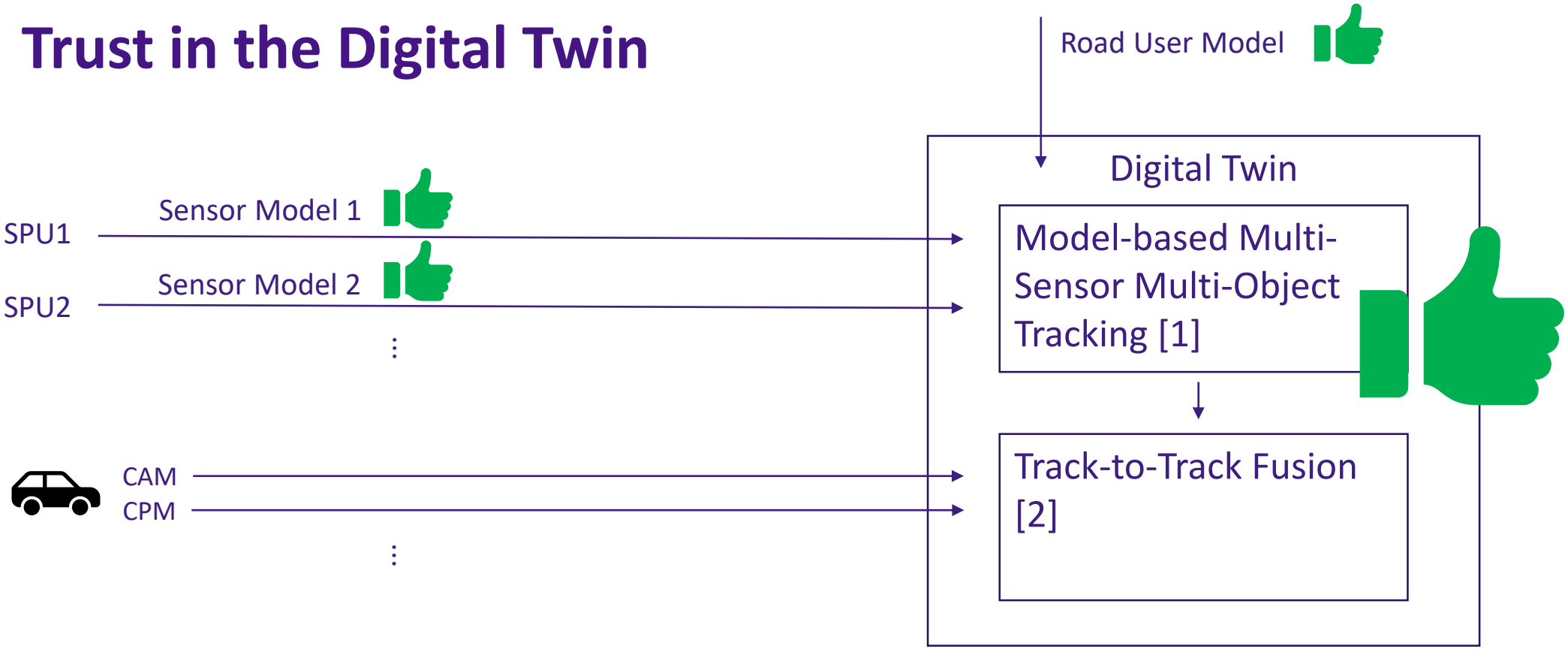
Trust in the Digital Twin



If all models fit
→ mathematical guarantees of performance
→ trust the Digital Twin

Important: This checks whether the models fit and NOT whether is sensor is good or bad

Thank you!

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