



FORSCHUNGSINITIATIVE  
**K O - F A S**

# Inter-Vehicle Information Fusion

Fahrzeugübergreifende Informationsfusion

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Supported by:



on the basis of a decision  
by the German Bundestag

# Motivation

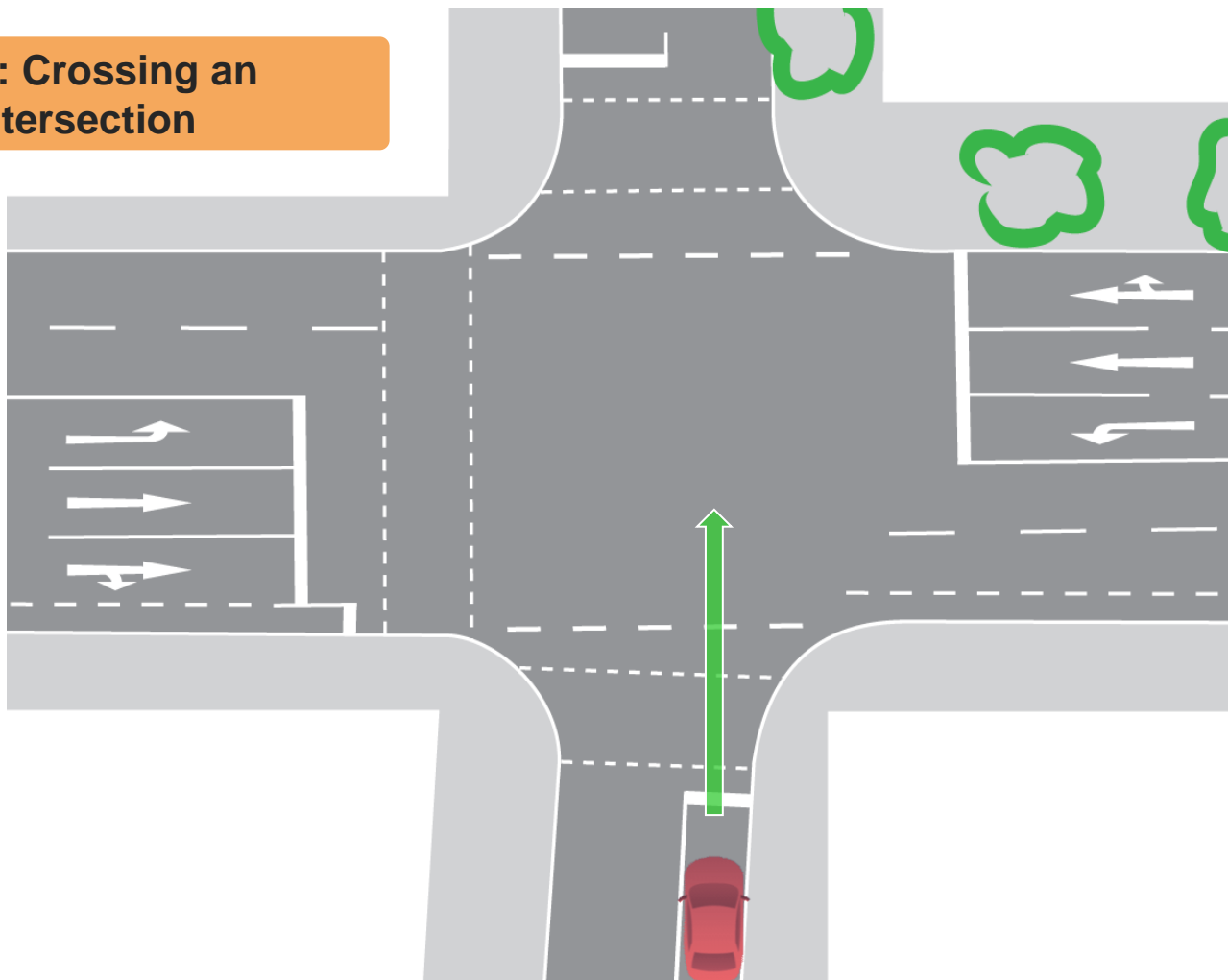


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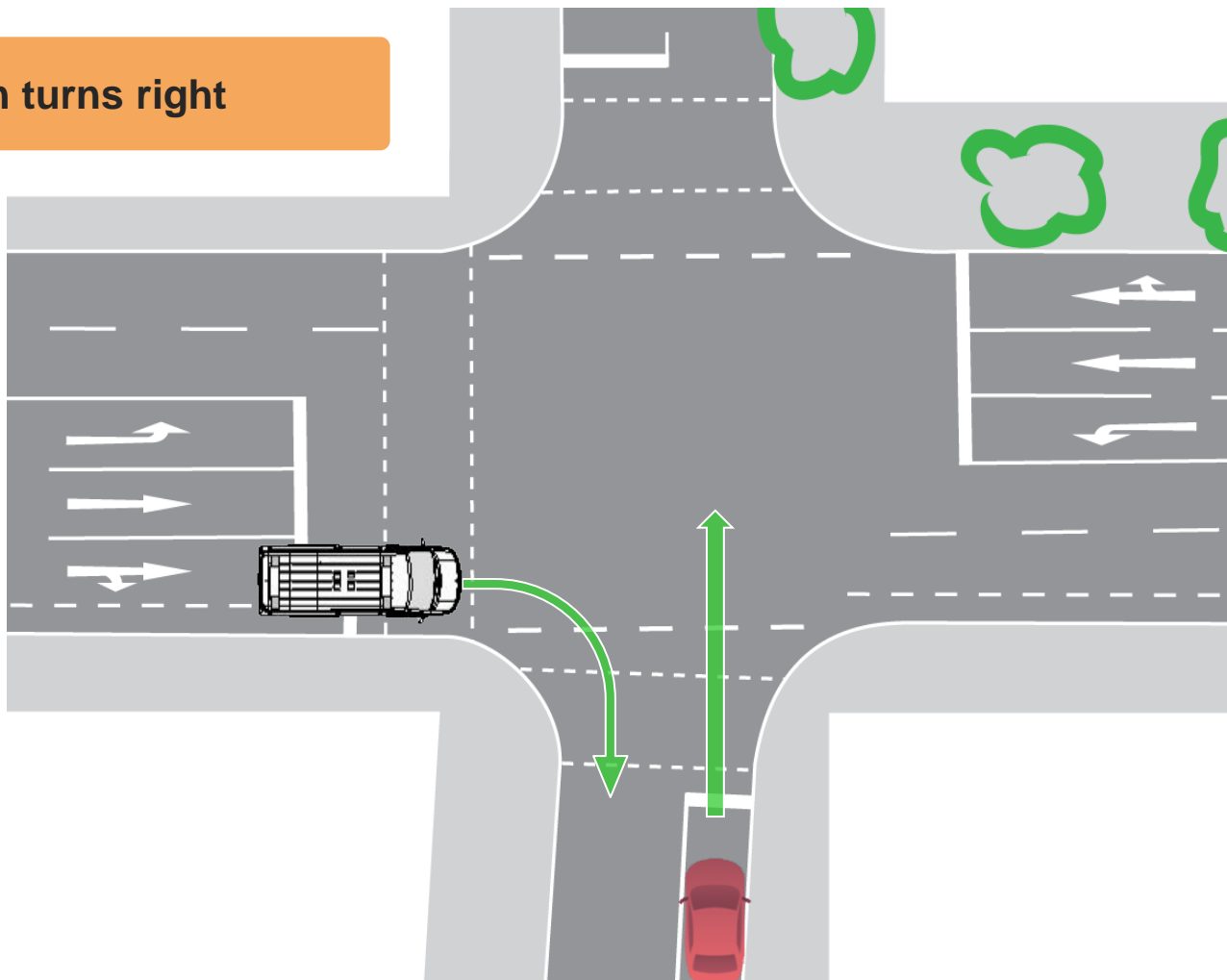
# Example: fourway intersection

**Task: Crossing an  
intersection**



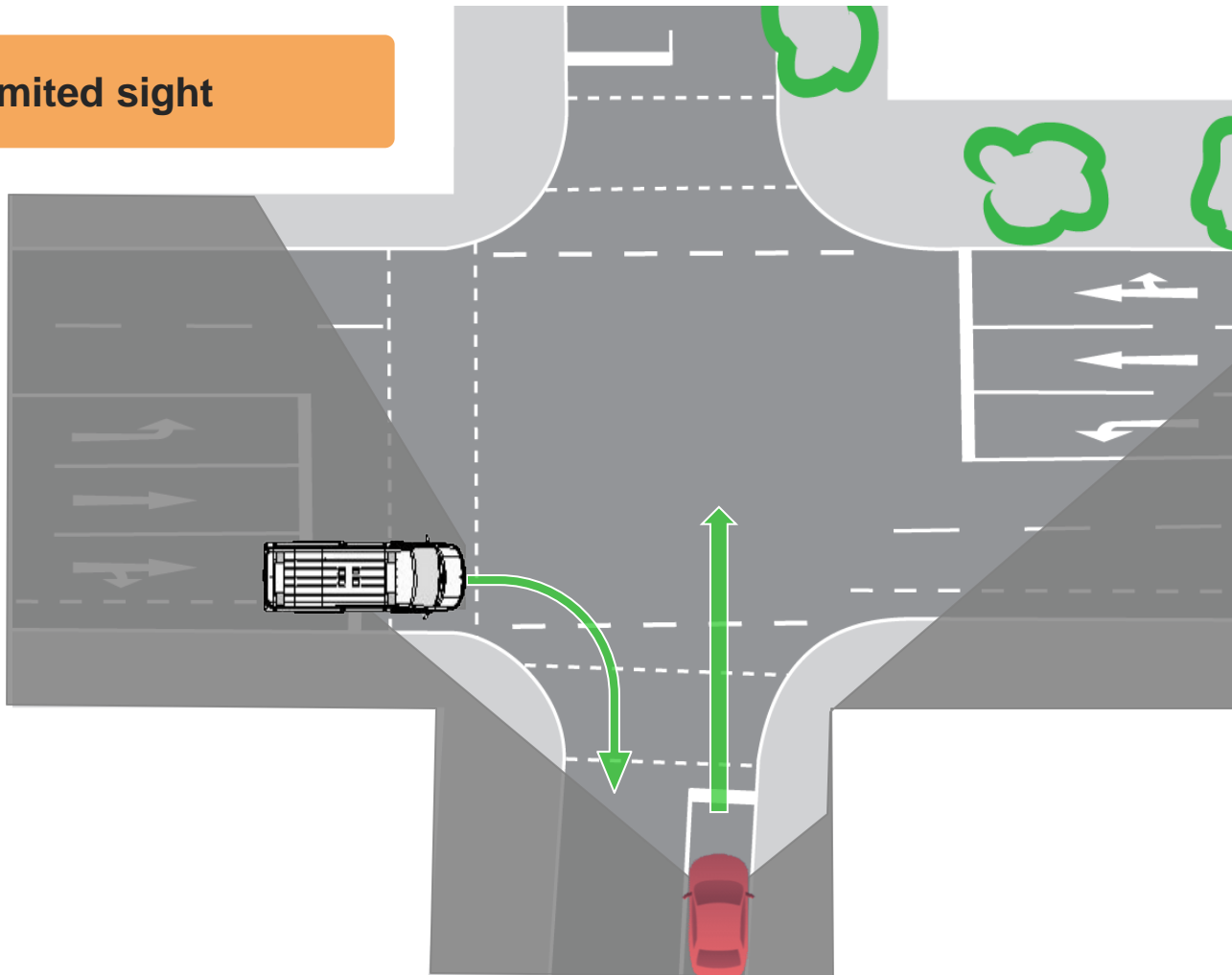
# Example: fourway intersection

Van turns right



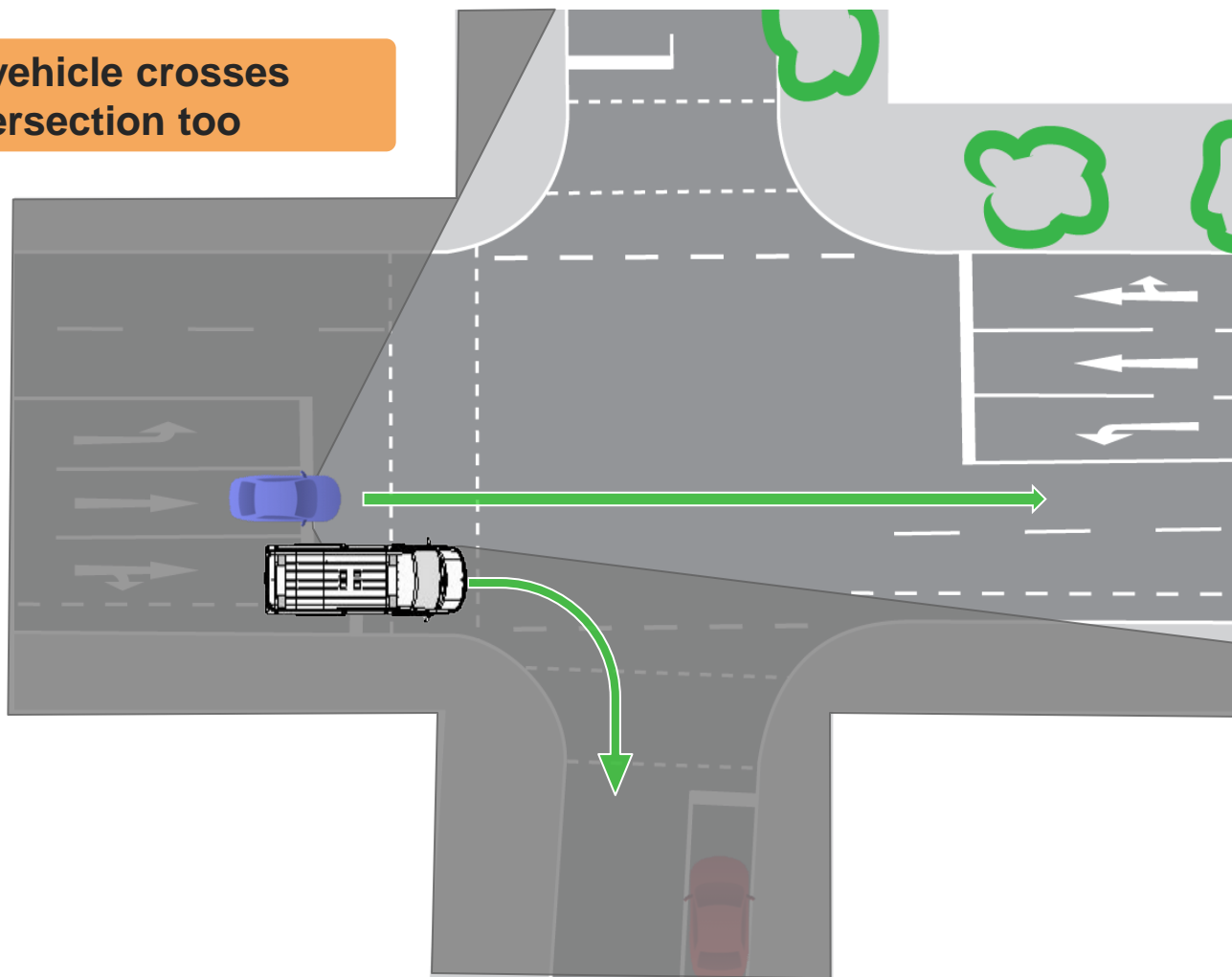
# Example: fourway intersection

Limited sight



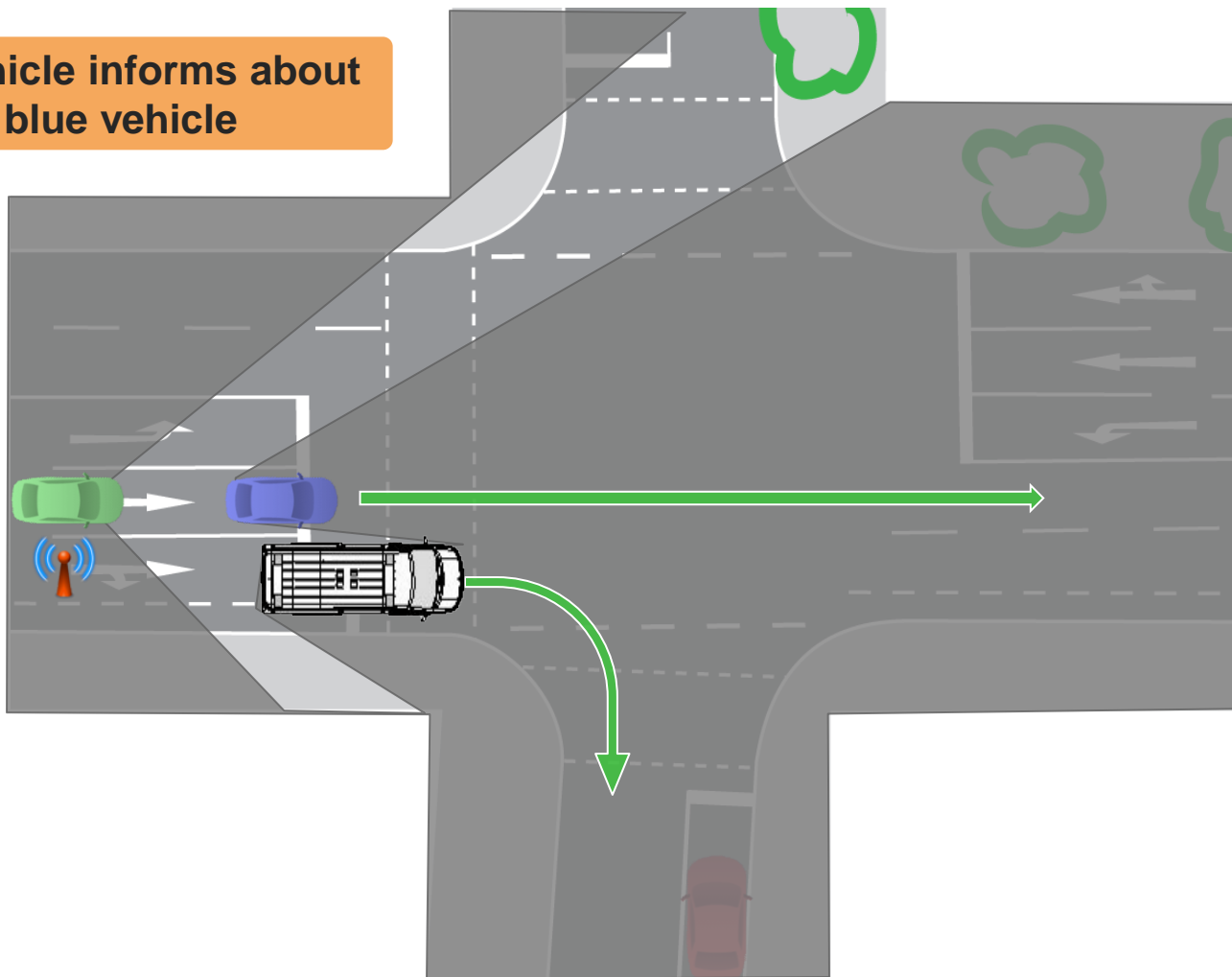
# Example: fourway intersection

Blue vehicle crosses  
intersection too



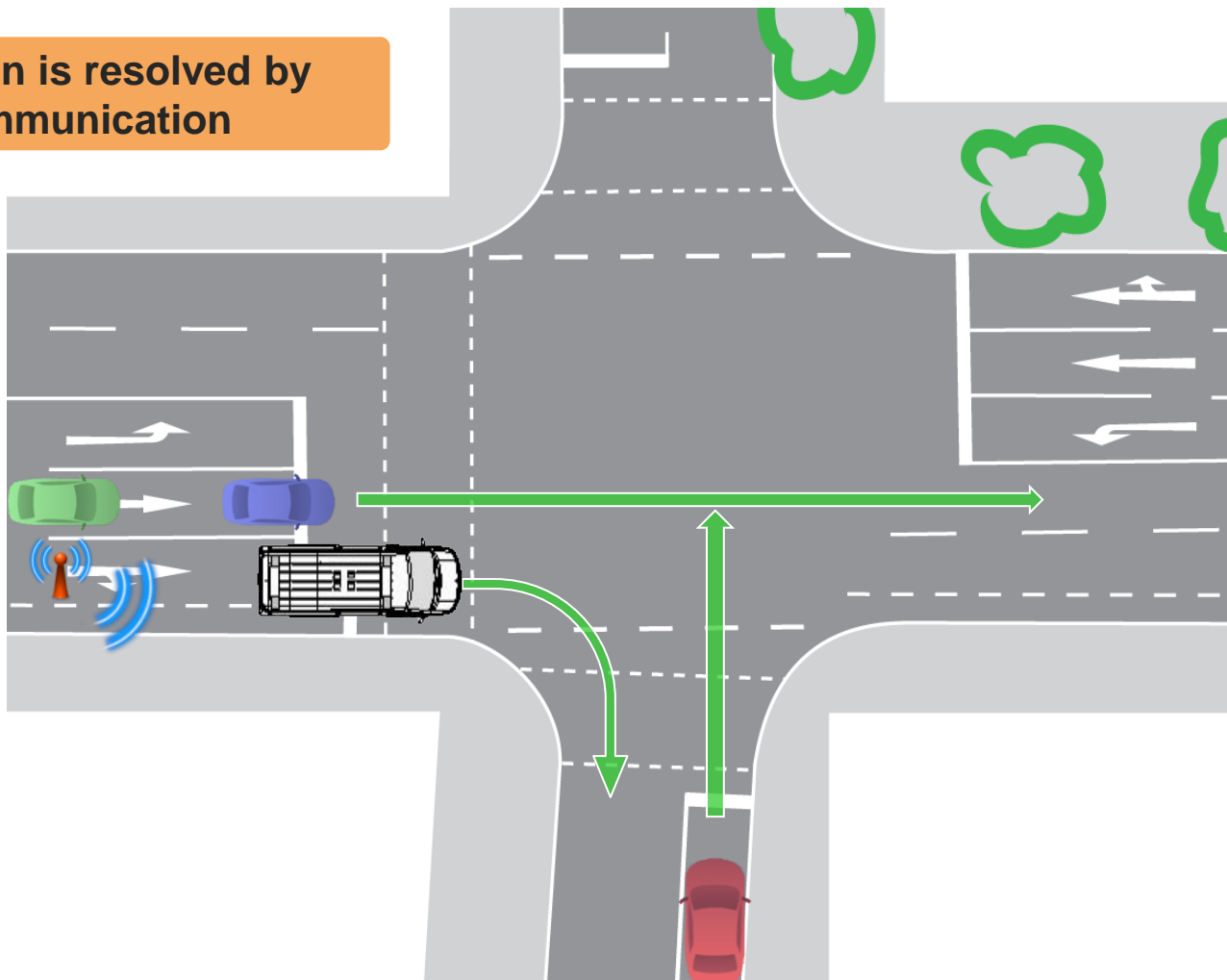
# Example: fourway intersection

Green vehicle informs about the blue vehicle

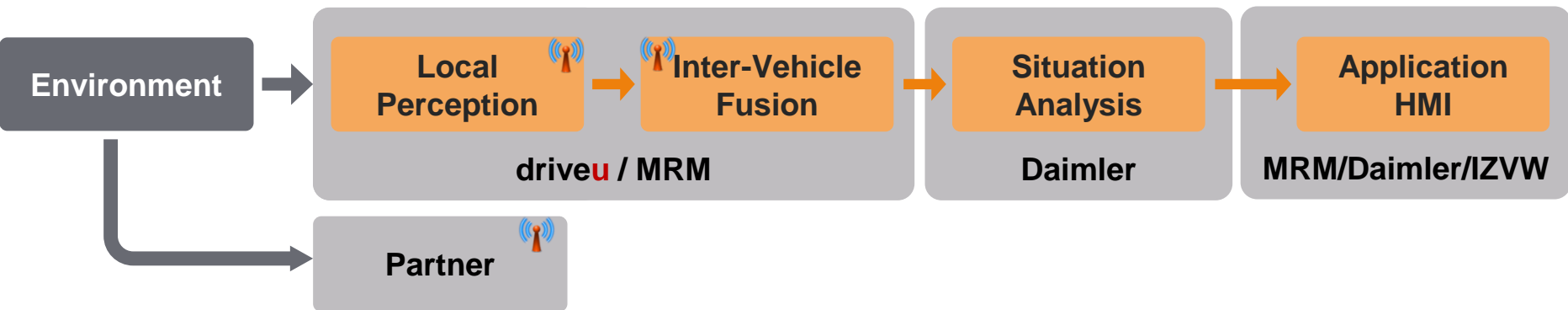


# Example: fourway intersection

Situation is resolved by  
communication







[5], [6], [7]

# Requirements on Information Sources

## Synchronization

UTC Time Stamping

Synchronized  
Local Perception and Localization



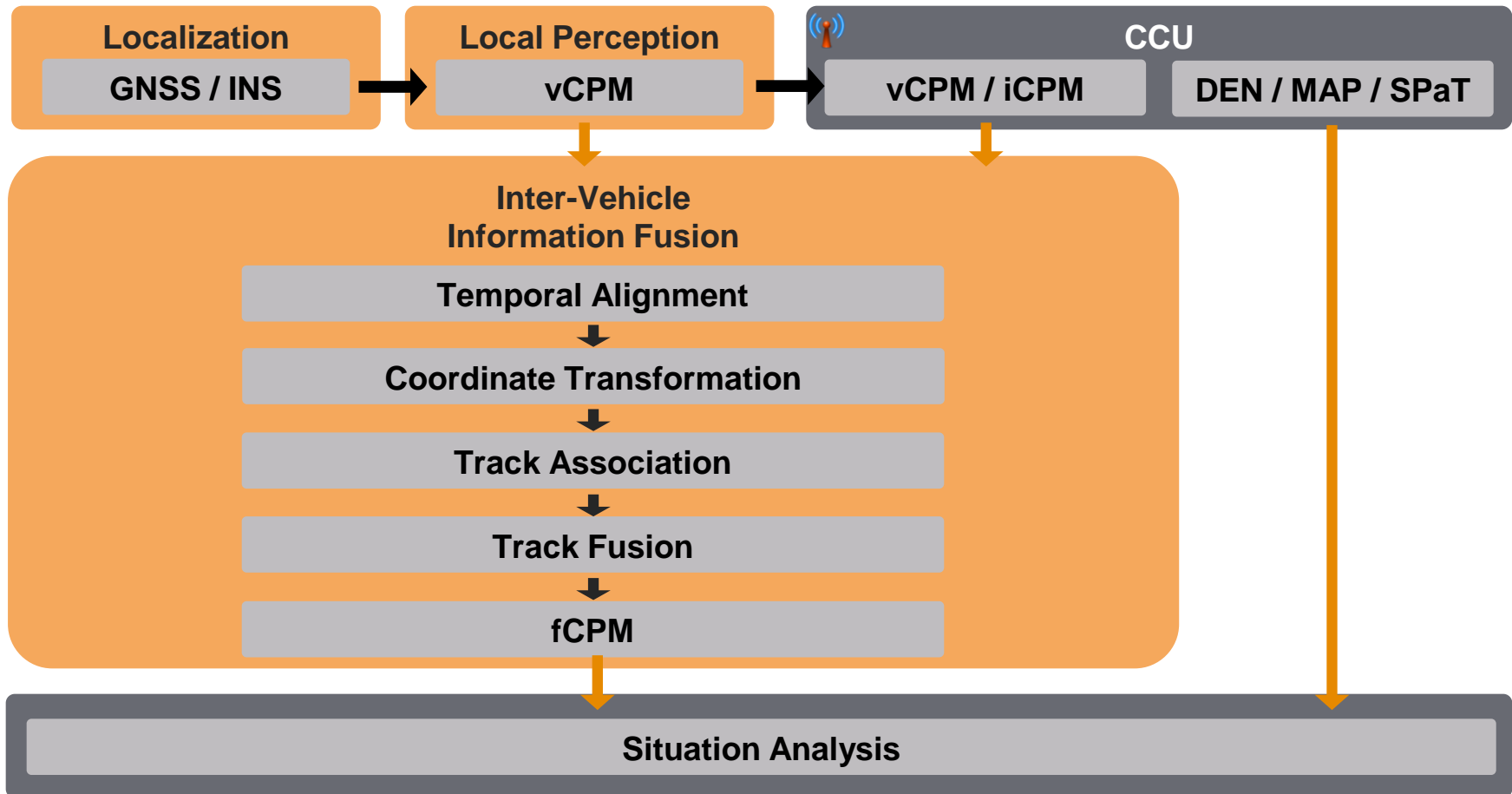
## Localization

Lane Accurate Localization

Precise Orientation Estimation



# System Structure for Inter-Vehicle Information Fusion



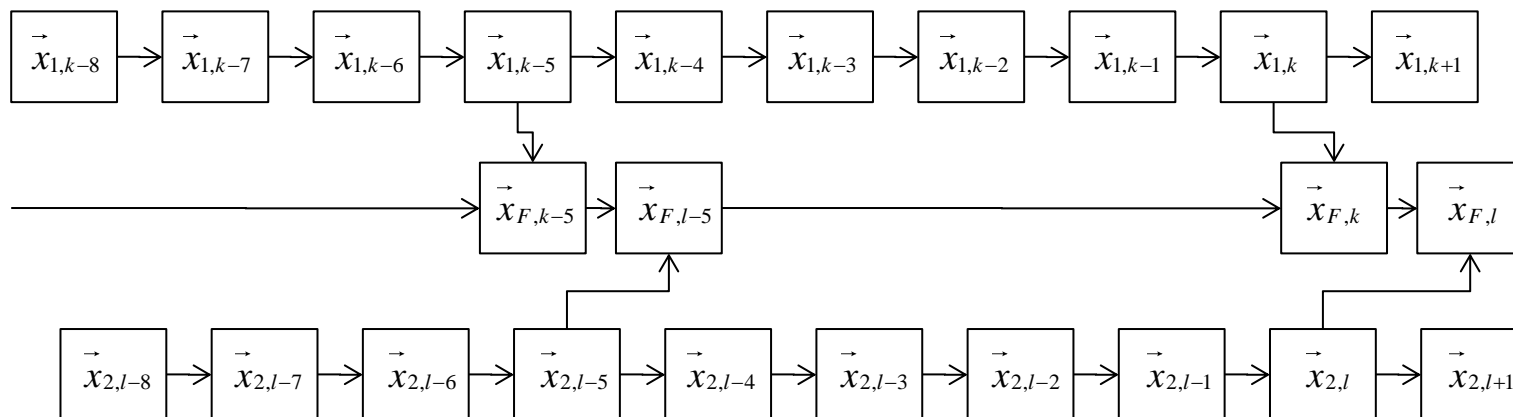
## Prediction

10Hz Communication and Update Rate

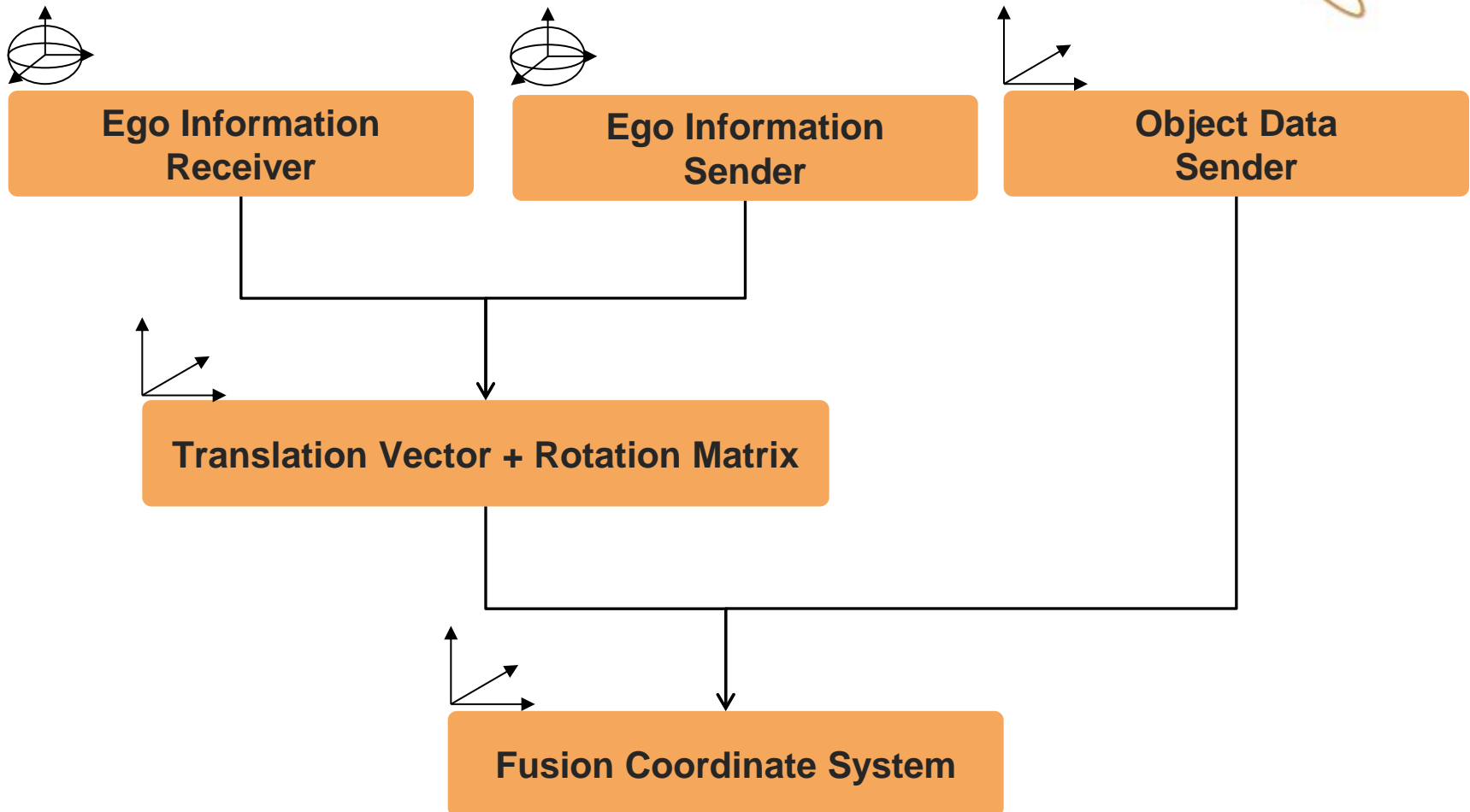
Standard Models: CV, CA, CTRV, CTRA



## Fusion with global Track

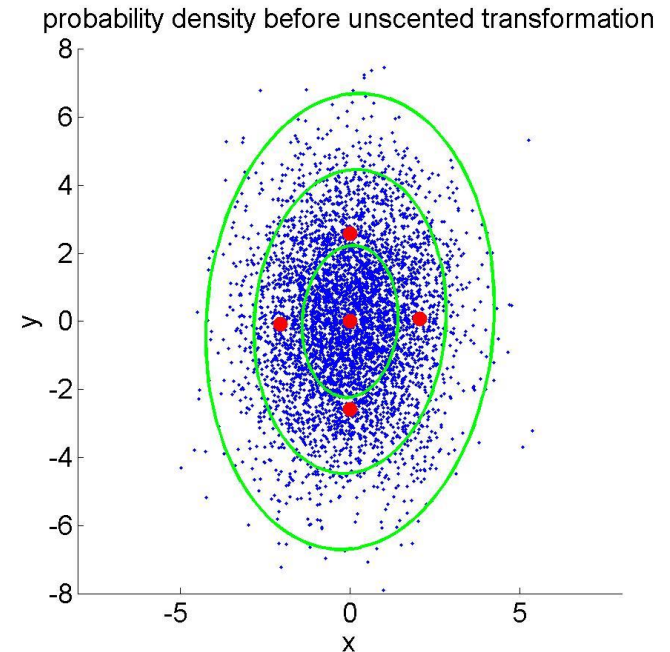
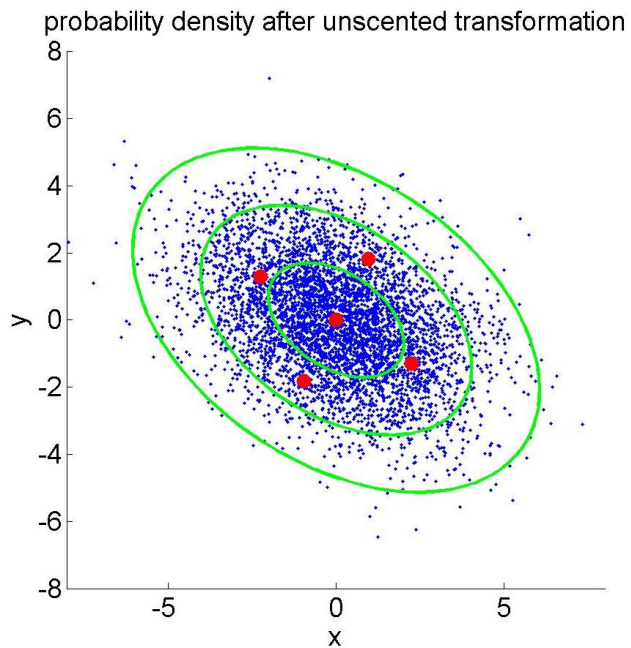


# Coordinate Transformation of Received Data

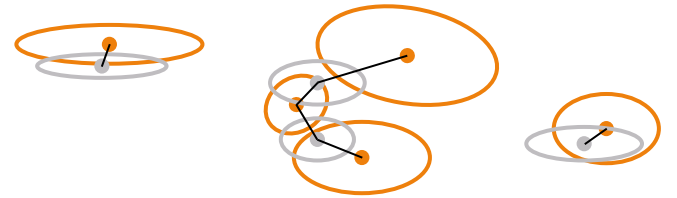
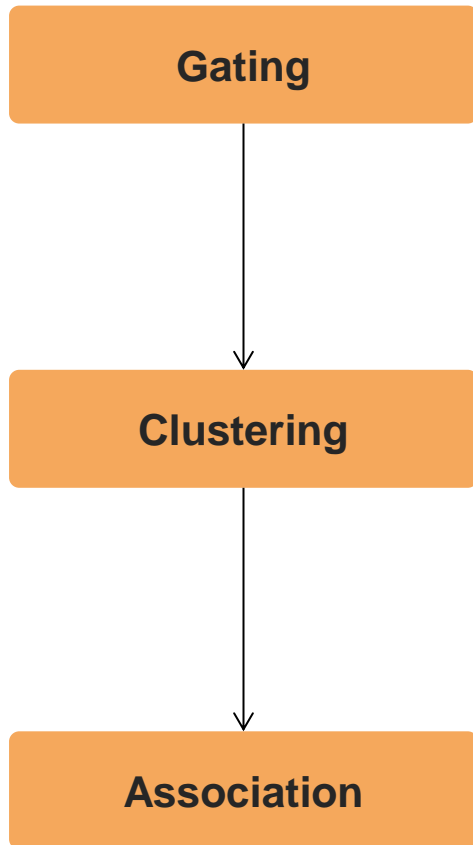


## Nonlinear transformation of a Gaussian distribution

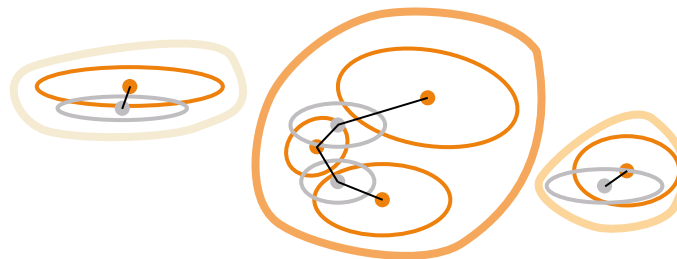
### Unscented Transformation



# Track Association Processing Scheme



	$X_{2,1}$	$X_{2,2}$	$X_{2,3}$	$X_{2,4}$	$X_{2,5}$
$X_{1,1}$					
$X_{1,2}$					
$X_{1,3}$					
$X_{1,4}$					



	$X_{2,1}$	$X_{2,2}$	$X_{2,3}$	$X_{2,4}$	$X_{2,5}$
$X_{1,1}$					
$X_{1,2}$					
$X_{1,3}$					
$X_{1,4}$					



	$X_{2,1}$	$X_{2,2}$	$X_{2,3}$	$X_{2,4}$	$X_{2,5}$
$X_{1,1}$					
$X_{1,2}$					
$X_{1,3}$					
$X_{1,4}$					

## Fusion Formula:

$$\underline{P}^{-1} = \omega \underline{P}_1^{-1} + (1 - \omega) \underline{P}_2^{-1}$$

$$\hat{\underline{x}} = \underline{P} (\omega \underline{P}_1^{-1} \hat{\underline{x}}_1 + (1 - \omega) \underline{P}_2^{-1} \hat{\underline{x}}_2)$$

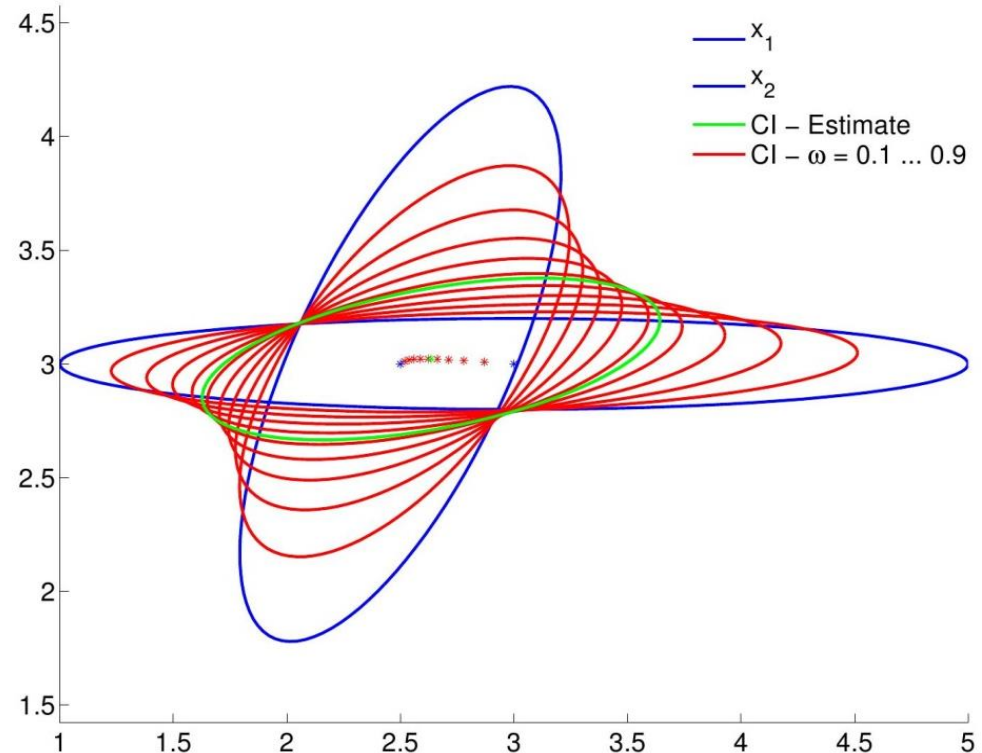
$$\omega = \arg \min(\det(\underline{P}))$$

## Alternatives for calculating $\omega$ :

$$\omega_{trace} = \frac{\text{trace}(\underline{P}_2)}{\text{trace}(\underline{P}_1) + \text{trace}(\underline{P}_2)}$$

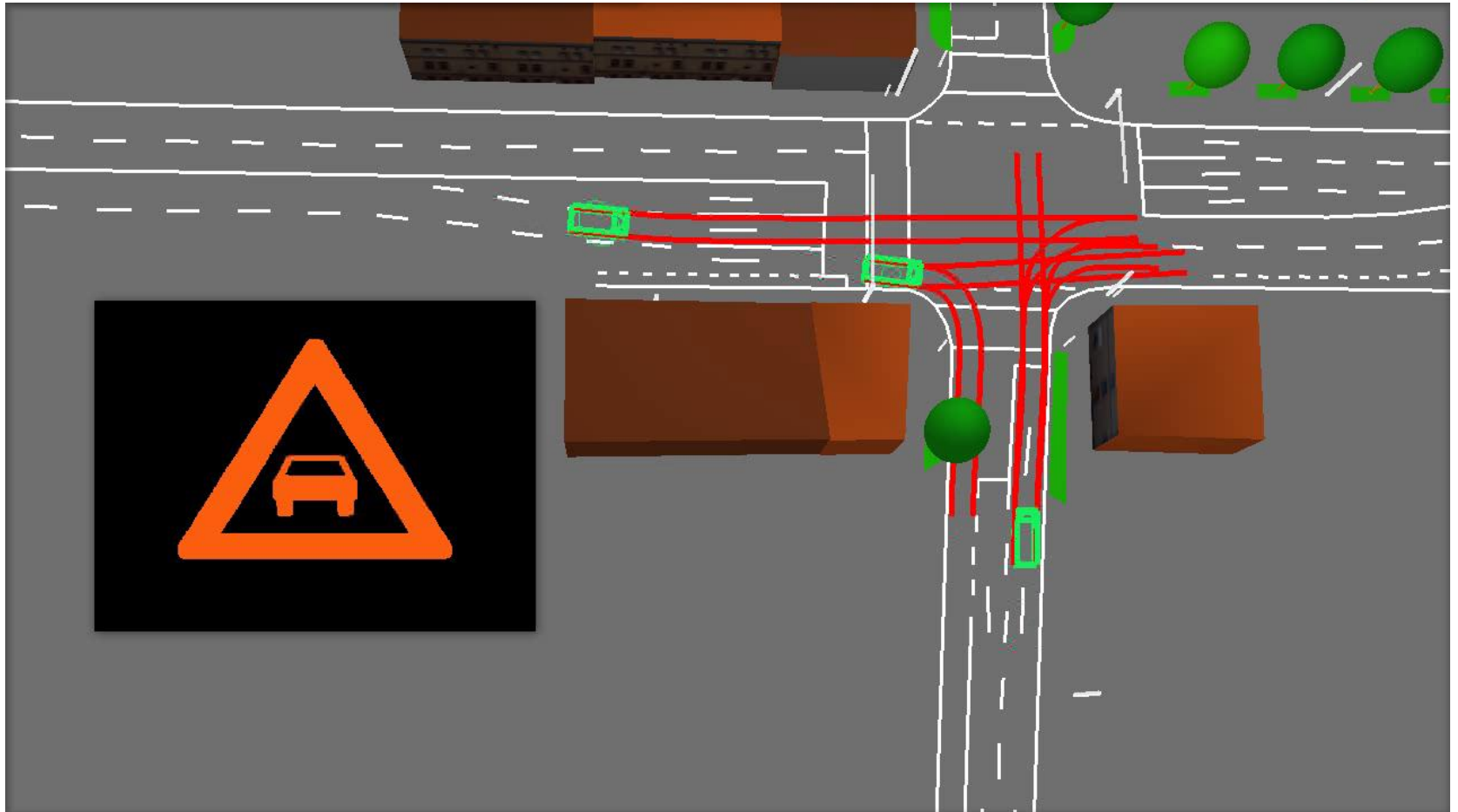
$$\omega_{det} = \frac{\det(\underline{P}_2)}{\det(\underline{P}_1) + \det(\underline{P}_2)}$$

$$\omega_{Improved} = \frac{\det(\underline{I}_1 + \underline{I}_2) - \det(\underline{I}_2) + \det(\underline{I}_1)}{2 \det(\underline{I}_1 + \underline{I}_2)}$$



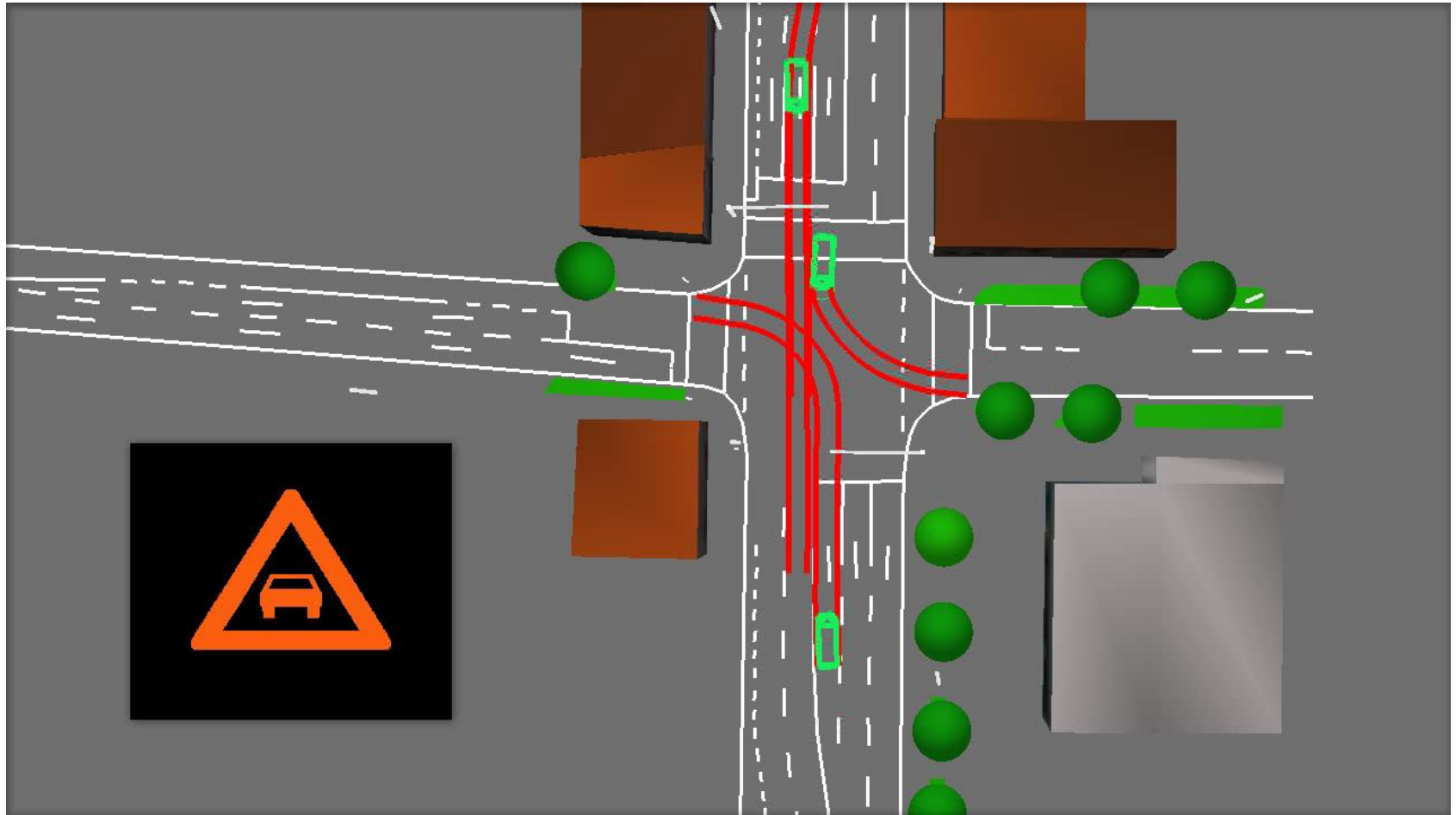


# Results: fourway intersection



[5], [6], [7]

# Results: left turn



[5], [6], [7]

- Ko-PER vehicles need UTC timestamped perception data and lane accurate localization
- An Inter-Vehicle environment model with lane precision can be realized in realtime
- Small latencies in processing and communication enable early warning



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