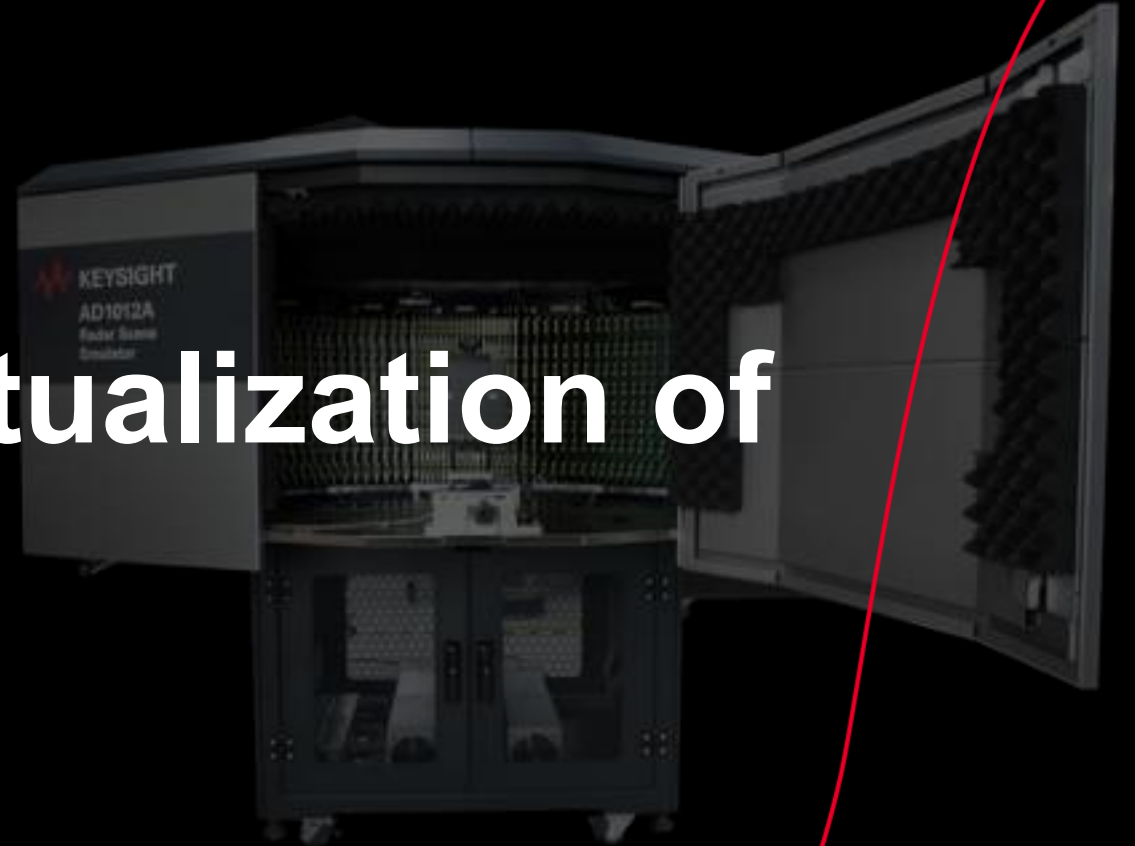


On the Road to Virtualization of NCAP Testing

Bernhard Holzinger, Tim Schöffler, et al.



NCAP Virtualization

Why would we want do to this?

- Definition: NCAP Testing in either a SIL or HIL environment in the lab or on a test stand
- Requirements to be fulfilled to justify NCAP Virtualization:
 - Speed up of verification.
 - More controlled testing environment leads to better reproducibility.
 - Allowing testing earlier in the design cycle (shift left¹)
 - Proving Ground Testing can be reduced.
 - Costs can be reduced.

1: I promise to refrain from using too many marketing buzz words for the remainder of this presentation!

NCAP Virtualization

Requirements to be fulfilled – from a Radar Perspective

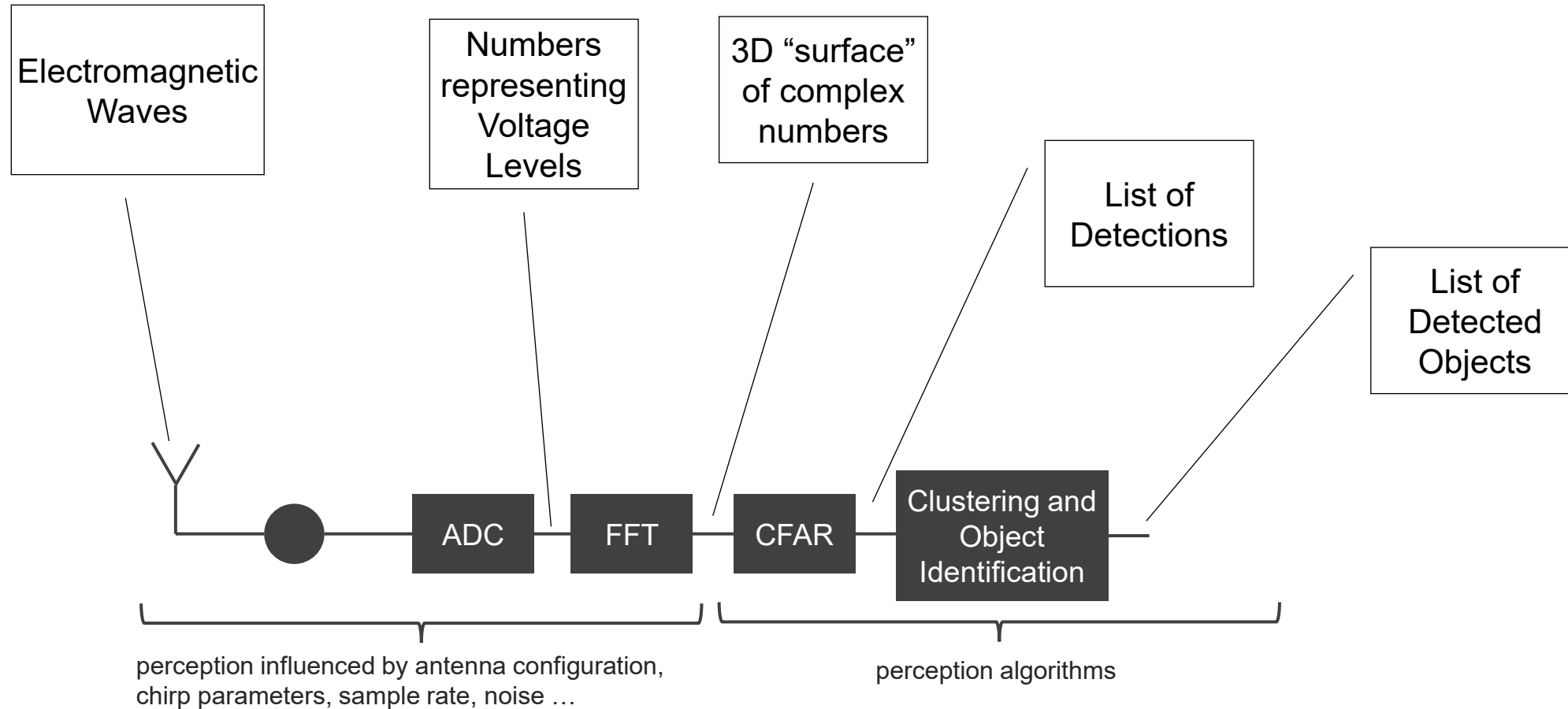
- Further Discussion is on Radar Perception, only!
- Requirements to be fulfilled (as we see it):
 - Test approach must actually test the radar perception algorithms.
 - Fidelity of virtualization must be measurable and sufficiently high.

Test approach must actually test the radar perception algorithms.

Chapter 1

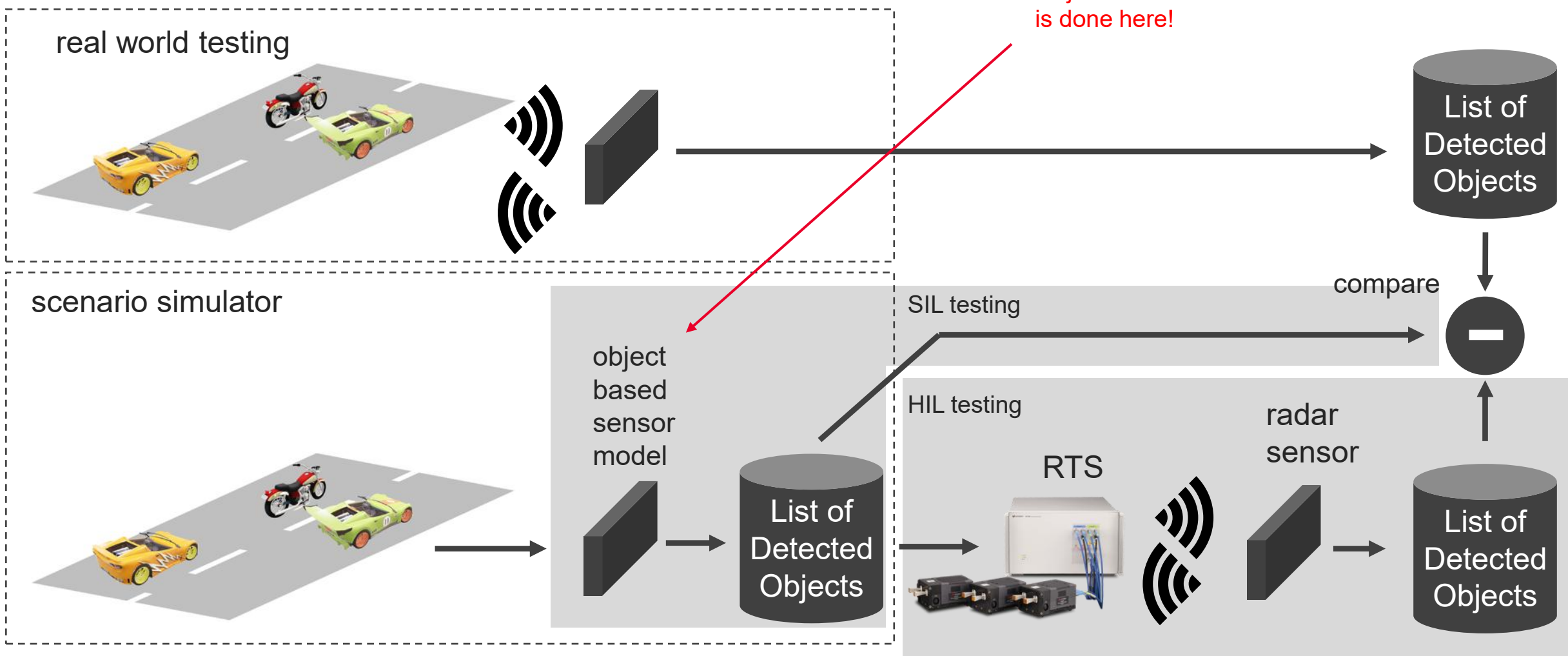
Radar Perception

Definition of Terms



Virtualization of NCAP Testing

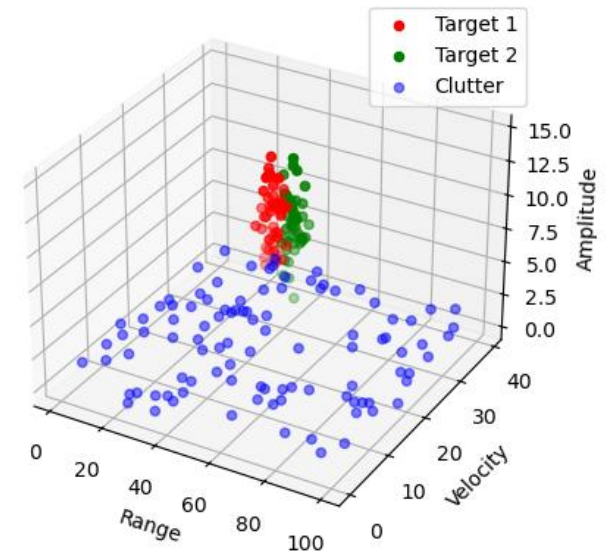
Object Based Radar Perception – Limited Meaningfulness



Introduction of the Concept of Scattering Centers

Proposing a Higher Fidelity Modeling Approach for the Radar Scenes

- Goal: We want the FFT to output the same 3D “surface” as in the real world
- Basic Concept: “Radar images of complex targets can be understood as a superposition of the reflected signals from a high number of scattering centers” [1]
- Ray Tracing can be used to extract such Scattering Centers
- A Point Cloud of Scattering Centers can include
 - multiple points to represent an object
 - multiple points to represent a reflection of an object (multi-path effects)
 - multiple points to represent the clutter
- Scattering Centers \neq Detections

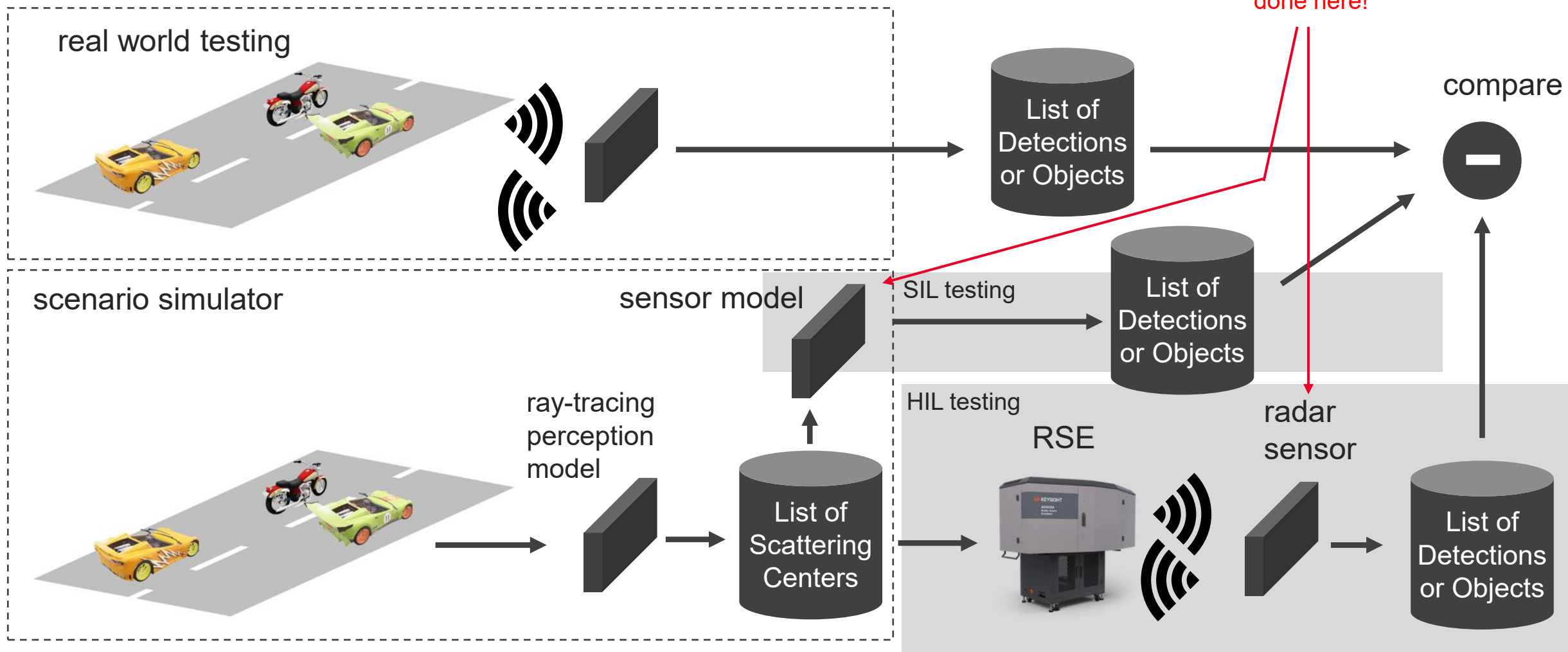


This is how Copilot thinks a cloud of Scattering Centers would look like.

[1] K. Schuler, D. Becker and W. Wiesbeck, "Extraction of Virtual Scattering Centers of Vehicles by Ray-Tracing Simulations," in IEEE Transactions on Antennas and Propagation, vol. 56, no. 11, pp. 3543-3551, Nov. 2008, doi: 10.1109/TAP.2008.2005436.

Virtualization of NCAP Testing

Detection Based Radar Perception – Potential for Improvement Meaningfulness



Fidelity of virtualization must be measurable and sufficiently high.

Chapter 2

Virtualization of NCAP Testing

Detection Based Radar Perception – Potential for improving Meaningfulness

General Questions:

- How to assess the fidelity of virtualization (simulation, emulation)?
- If fidelity is poor: how to find the root cause where this comes from (bad model, bad emulation, bad ray tracing algorithm)?

Emulation Specific Considerations to be assessed:

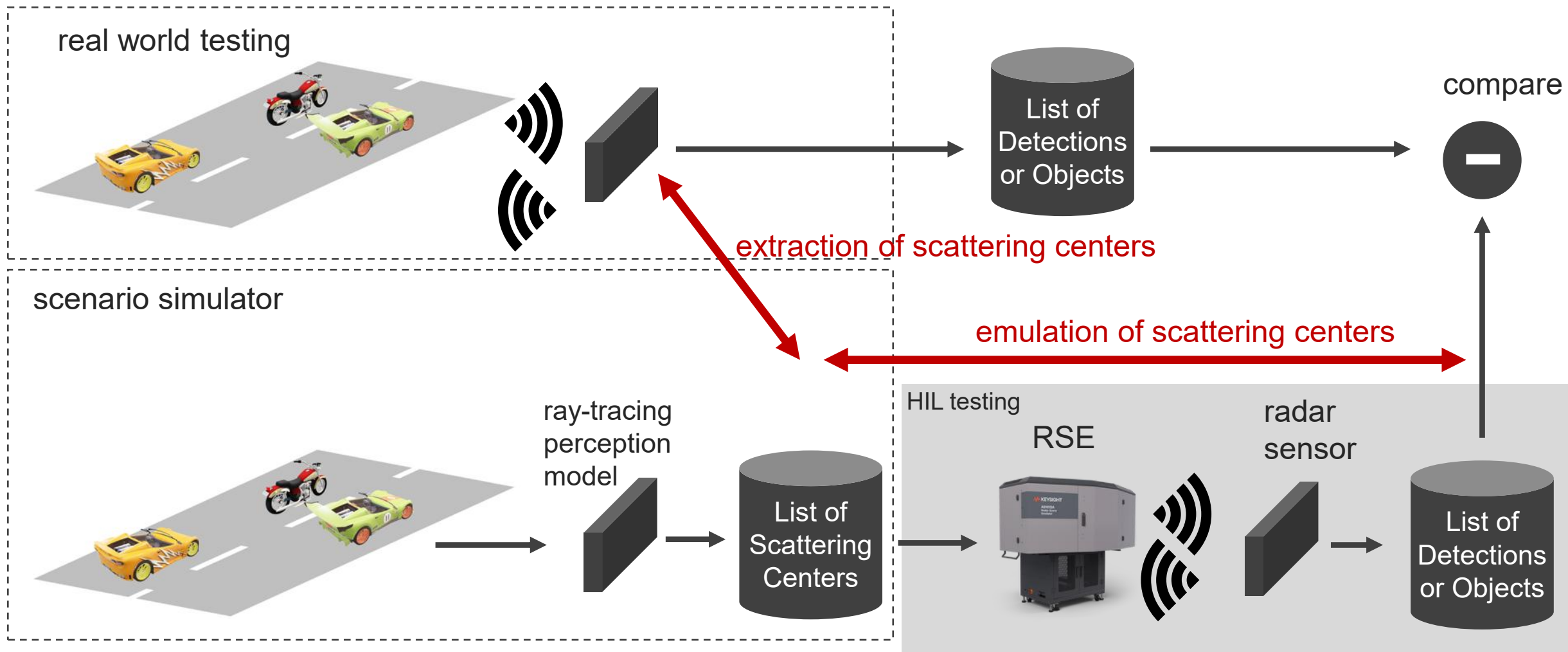
- Number of Scattering centers can easily exceed emulation capabilities:
 - How to select scattering centers to be emulated (some filtering is required but CFAR of radar should still be tested)?
 - How to cluster scattering centers?
- Selected Scattering Centers have to be emulated faithfully.
 - What's the fidelity of the emulation?

Simulation Specific Considerations to be assessed:

- How to extract scattering centers in general (not further addressed here)

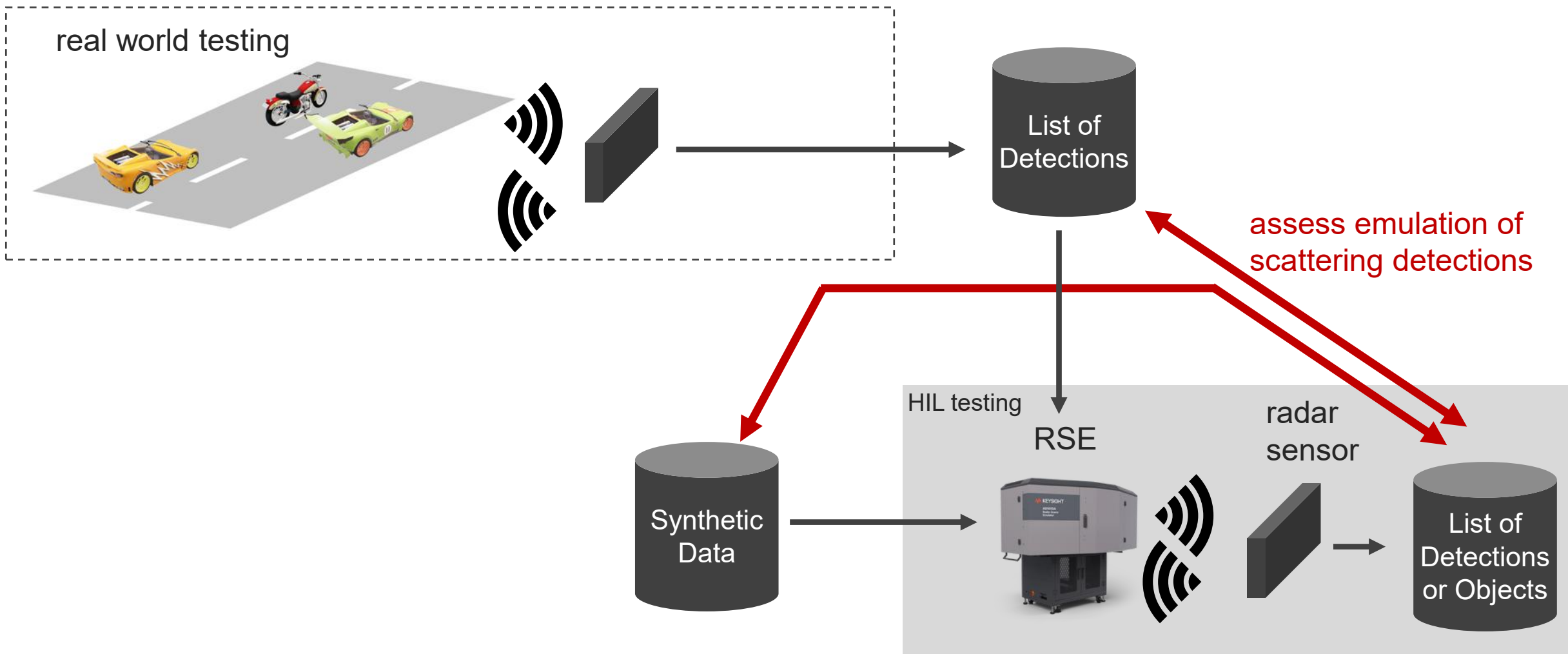
Virtualization of NCAP Testing

Splitting up the Assessment



Coming up with an Assessment Algorithm (First Draft)

Assessing the Emulation of Point Clouds



Coming up with an Assessment Algorithm (First Draft)

“Spatial” Assessment

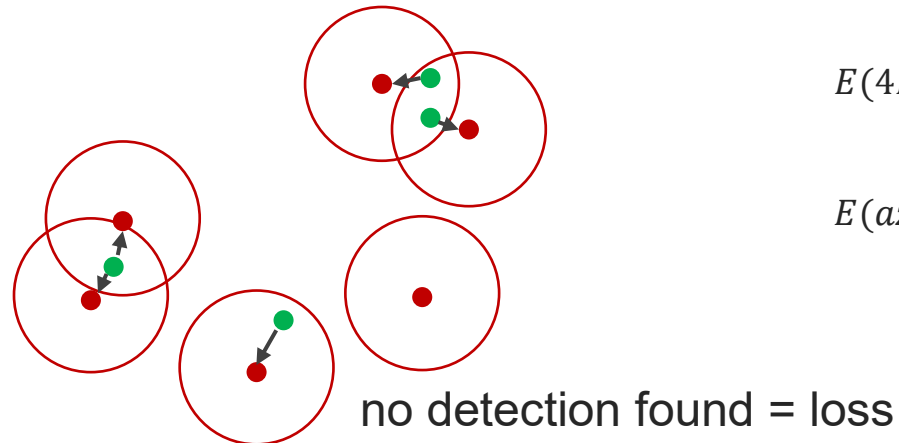
For demonstration purposes the concept is shown in 2D instead of 4D

● = Scattering Centers (Simulated Targets)

● = Detected Targets

○ = Search Radius

↓ = Distance of closest Detection (Error)



Possible Error Measures:

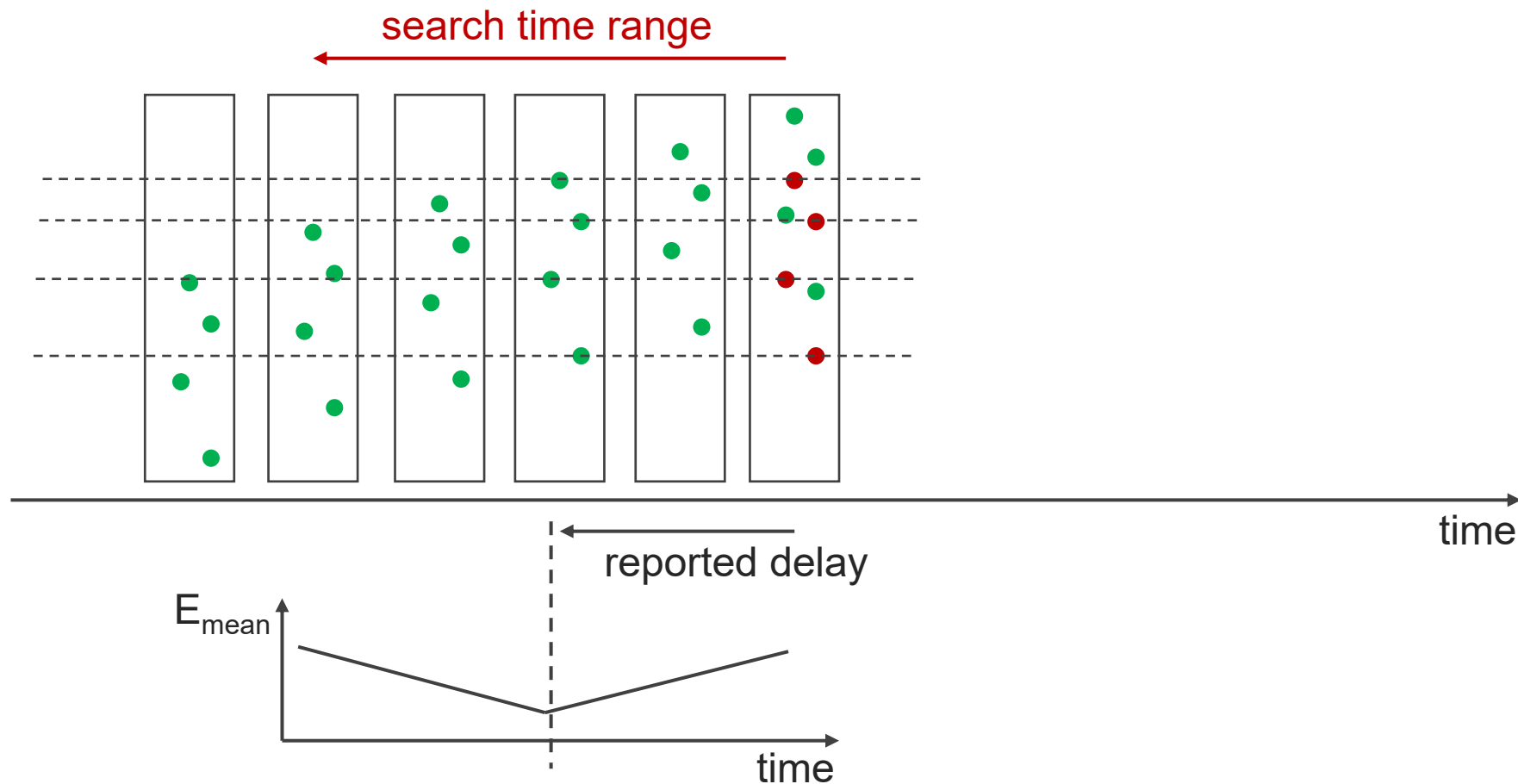
$$E(spatial)_{mean} = \frac{1}{n} \sum_n \overline{E(spatial)_{individual}}$$

$$E(4D)_{mean} = \frac{1}{n} \sum_n \overline{E(4D)_{individual}}$$

$$E(azimuth)_{mean} = \frac{1}{n} \sum_n E(azimuth)_{individual}$$

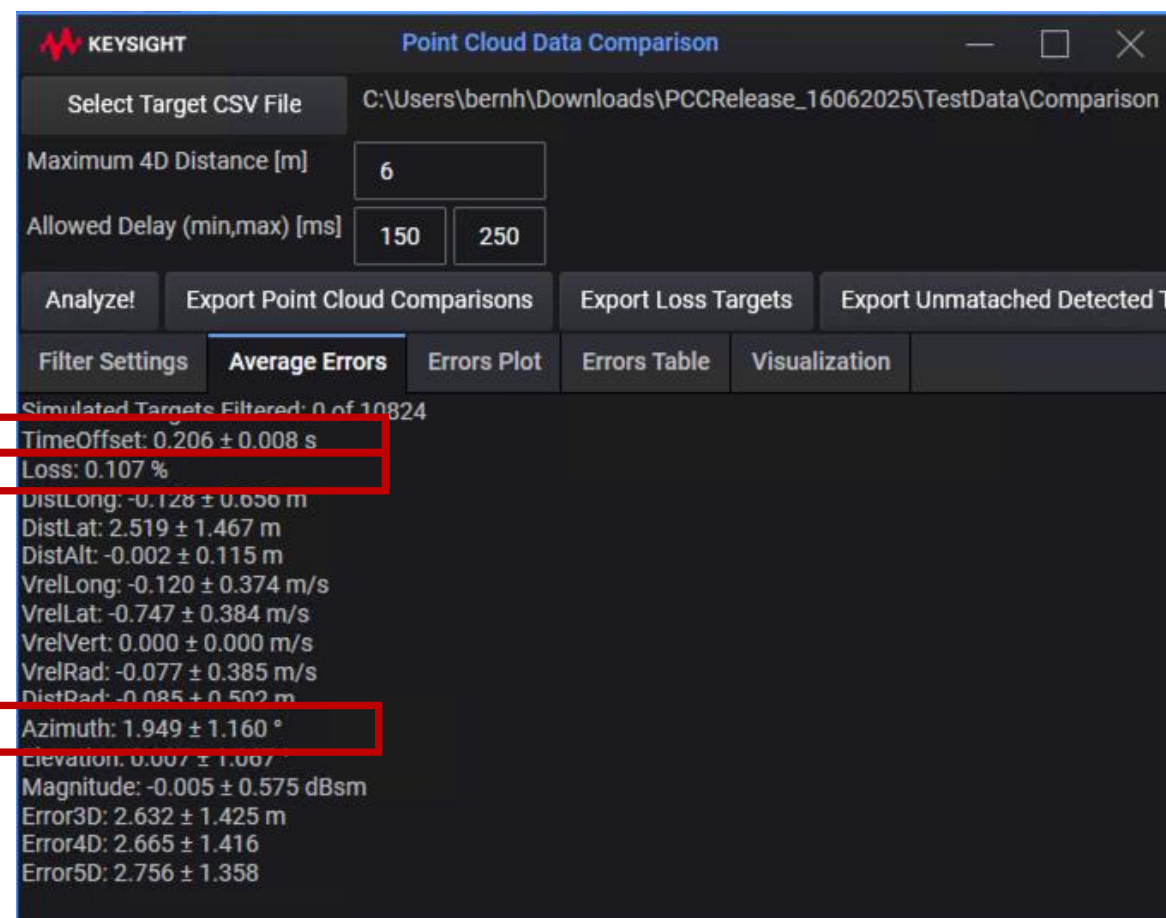
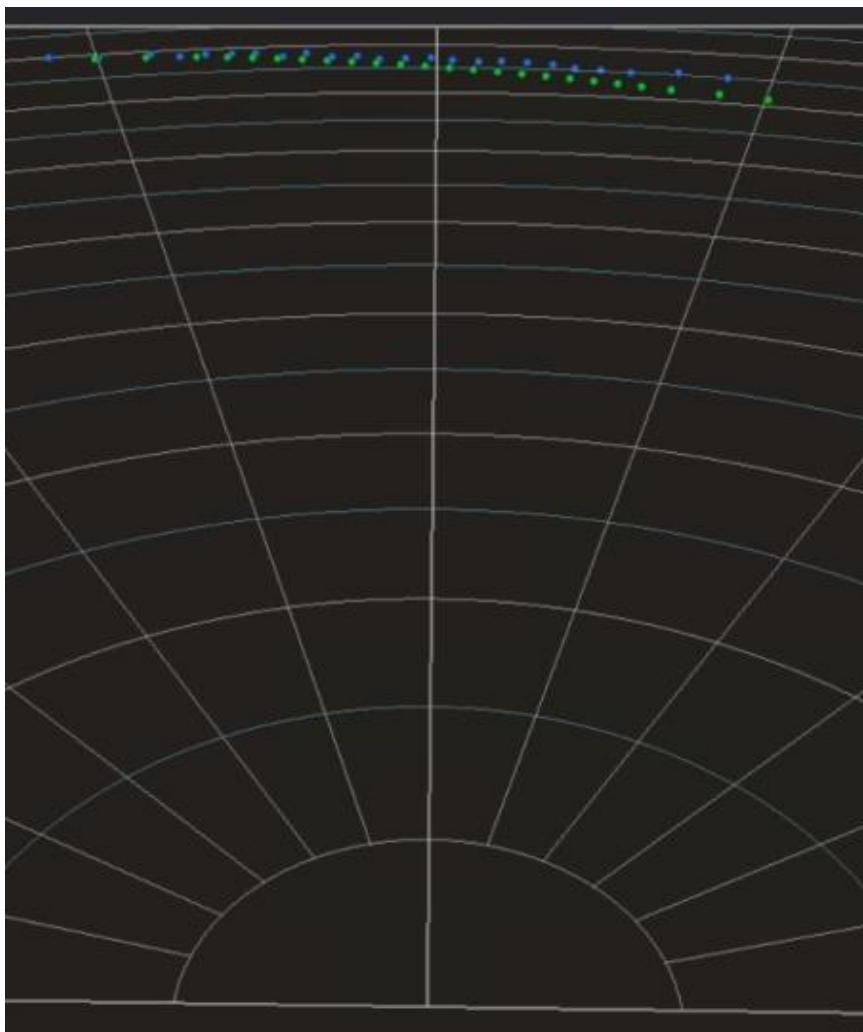
Coming up with an Assessment Algorithm (First Draft)

Temporal Assessment – based on E_{mean}



First Assessment based on Synthetic Data

Intentional Delay: 200ms; Intentional Azimuth Error: 2°



Assessment Algorithm

Next Steps

- Test with real world data playback
- Assess the emulation of clutter
- Add simulation and assess the extraction of scattering centers in simulation

Conclusions

And Outlook

- NCAP Virtualization must effectively reduce cost of testing (\$ and time) to become viable.
- We think: For radar this implies that testing of the perception algorithms must be included.
- Our Proposal: Introduce the concept of scattering centers for simulation and emulation.
- It's an ongoing work to improve the fidelity of this approach
- We started to develop means to assess the fidelity of emulation of objects
- There's more to come - stay tuned (or reach out to us if you want to join us on this journey)
- I'm sure: NCAP Virtualization is just a first step towards “real world” Virtualization

Thank you

