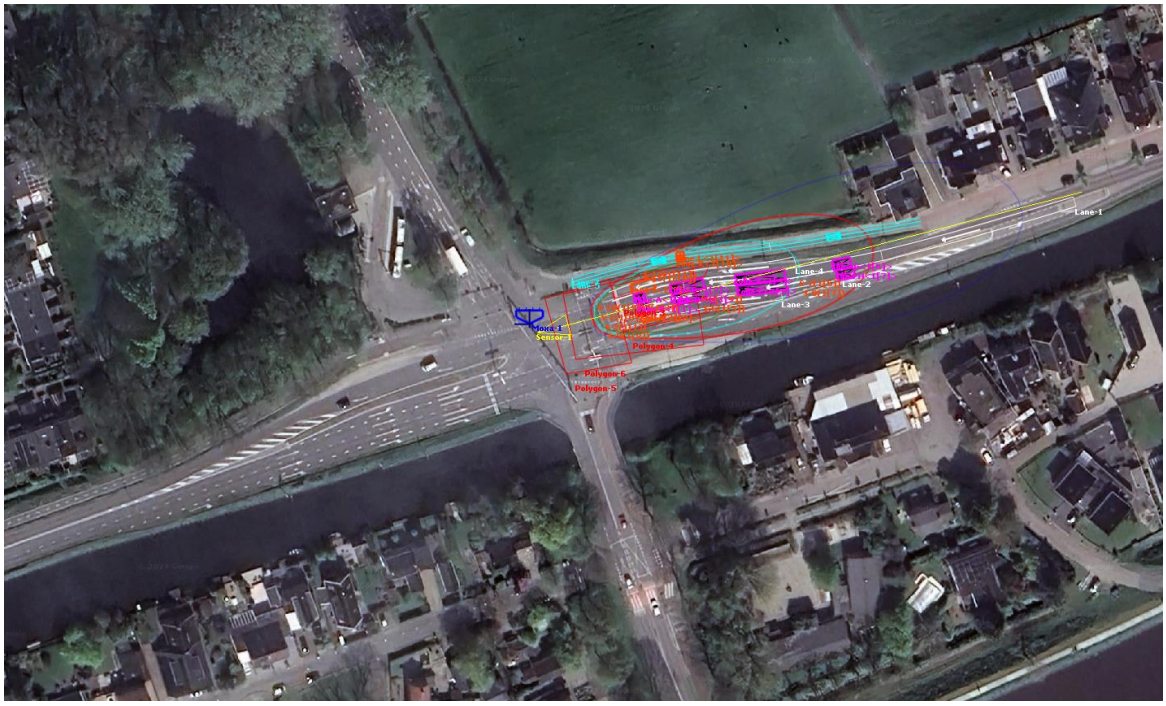
Introduction

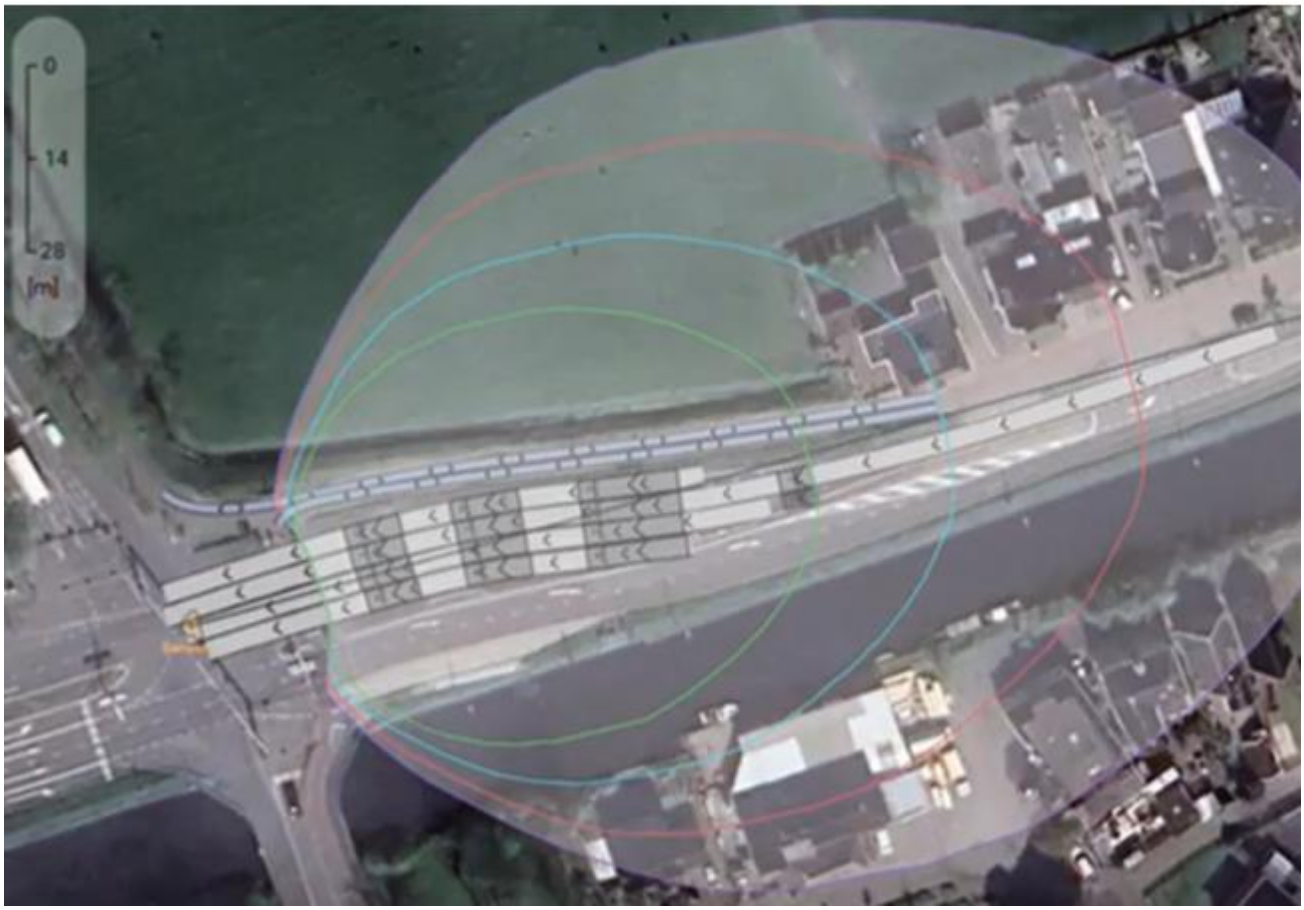
On 22-03-2024, at the VRI Ruischerbrug, in cooperation with the Province of Groningen, smartmicro and Verkeersinfo, a trial started with traffic detection using a radar (UMRR-11 Type 132) from smartmicro.
The objective was to see if this radar (and its successor TOPGRD) is suitable to be applied for traffic control systems with the detection configurations used in the Netherlands.
The immediate cause is replacing older visual cameras.



Configuration of UMRR-11 Type 132 radar

It concerns the eastern branch of traffic control installation Rijksweg/Noordijkerweg (object ID VR02 Ruischerbrug) in Groningen, the Netherlands. This is an important approach coming from the east and going to the ring roads and into the city.

On June 28, 2024, the evaluation of the UMRR-11 Type 132 radar was successfully completed. We waited for its successor, the TOPGRD, which was still under development at that time.
We therefore kept the UMRR-11 Type 132 radar in operation until March 20, 2025, after which it was replaced by the TOPGRD radar.



Configuration of TOPGRD Stop+Advance radar

On April 24, 2025, the evaluation of the TOPGRD radar was also completed.

The collaborating parties

On this trial, three parties worked together constructively and proactively. This perception has been mutual.

It concerns:

1) **The Province of Groningen**
   The Province of Groningen facilitated with the test setup within this traffic control installation. With its own people (and thus without the help of an external installation company), the radar was wired and attached to the portal and connected. It also provided an additional VPN connection between the radar and the supplying company, smartmicro.
   Finally, it facilitated Verkeersinfo to collect the VLOG information as well as access to the MobiMaestro management center to monitor its proper operation.

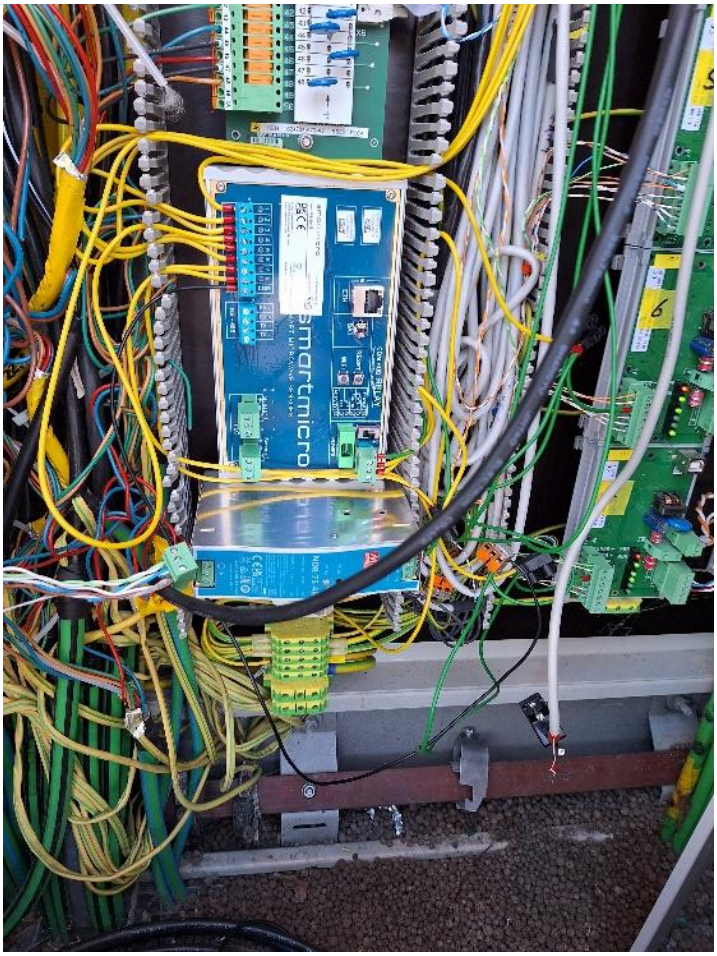
2) **smartmicro**
The German company smartmicro is a Braunschweig-based supplier of innovative technology, specialized in radar applications for traffic detection.
It provided the delivery of the radar with interface, the connection in the traffic light controller, installation support and optimization of this radar for the chosen application. The latter was done both from Braunschweig and on site.

3) **Verkeersinfo**
Verkeersinfo provided support for the implementation in the traffic light controller (the goal was implementing the hardware without modifying process control and application software, and connecting the interface in-house). Furthermore, Verkeersinfo performed the traffic control application, optimized the operation, and executed the overall evaluation.

Description of the TOPGRD radar

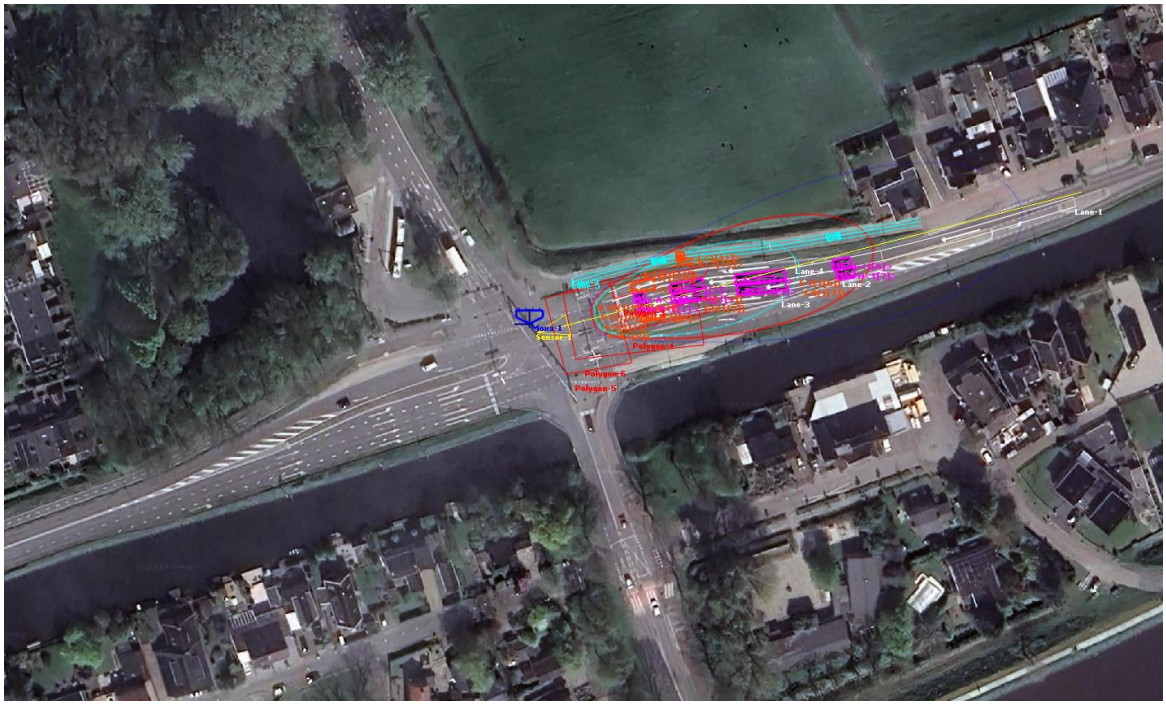

The TOPGRD radar is the size of a hand

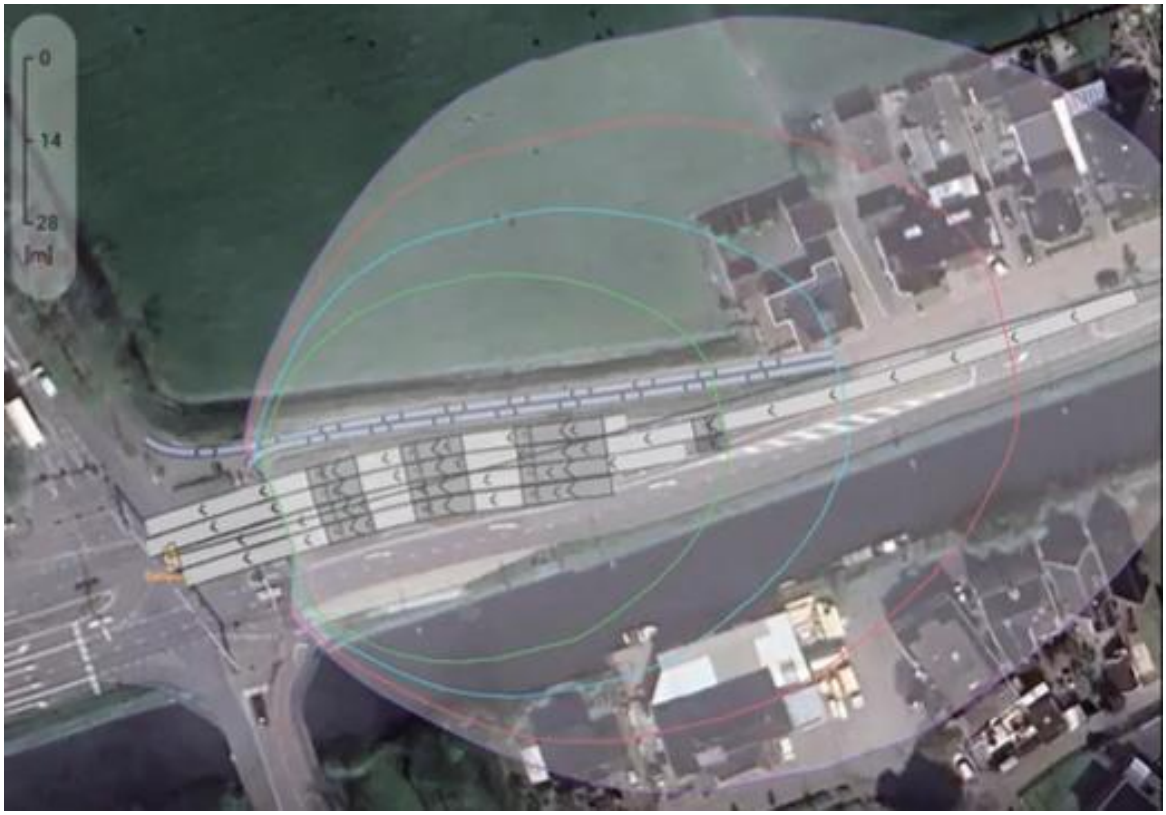
Indications for the tilt angle are shown on the mounting bracket. The tilt angle is already determined behind the desk using the link between the corresponding configuration tool Traffic WEB UI and Google Earth satellite images (several links are possible). At the intersection, the tilt angle and roll angle can be checked via the Traffic WEB UI, using an accelerometer in the TOPGRD radar.
The mounting bracket is attached with tension straps (steel bands).



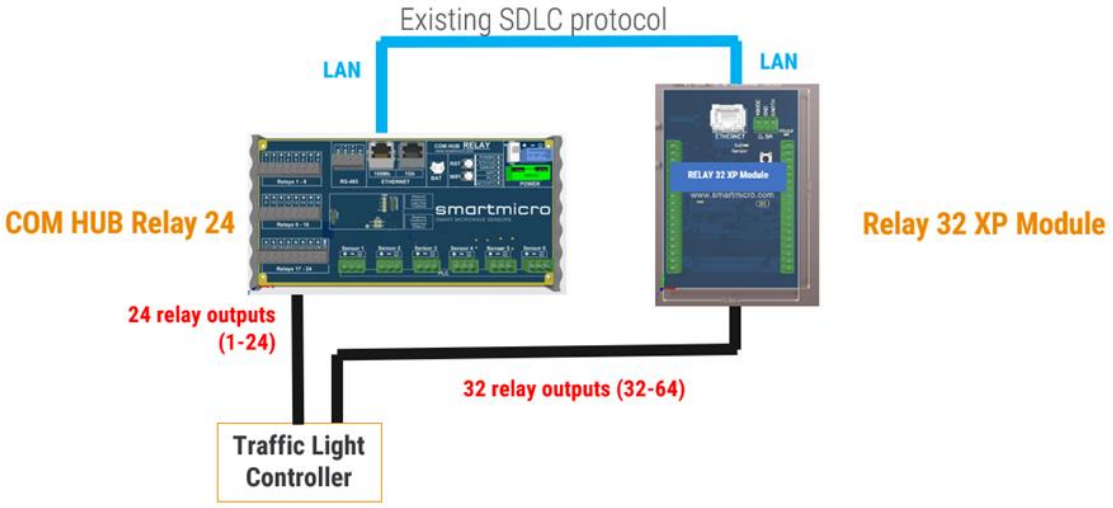
The applied power supply & interface card (COM HUB Relay 8, with 8 relay outputs onboard)

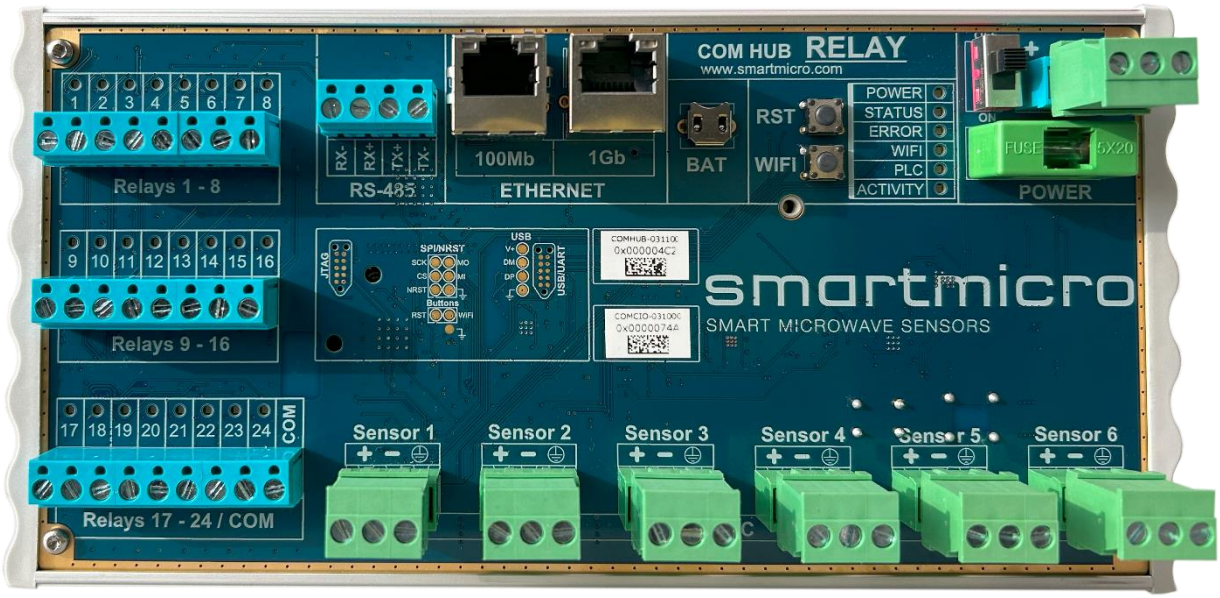
The radar can communicate the output status via Ethernet (LAN), RS-485 (serial), and/or via parallel contacts.
Parallel contacts were chosen for this trial because it enabled a solution without further hardware or software modification of the old traffic light controller, which will be replaced at the end of 2025.





Compared to UMRR-11 Type 132 (top), the effective radar detection range of TOPGRD (bottom) is wider and longer. Also, the dead zone is smaller.





In the new application, the COM HUB Relay 24 (with 24 outputs) will be used as an interface in combination with the Relay 32 XP Module (with an additional 32 outputs).
This makes 56 outputs for 4 radars. COM HUB Relay 24 allows 4 radar connections.
Several of these types can be applied next to each other.

Via the tracking mechanism, all types of traffic participants are tracked individually on the lanes and virtual radar loops inside the radar beam. In fact, all road users have a unique identification number in the tracking software.

The minimum distance to the first detection field (i.e. dead zone) of this type of radar is 15m, which is considerably shorter than the 27 meters of the previous radar (UMRR-11 Type 132).
The maximum detection distance was initially 240 meters, but during the trial this was reduced to 180 meters, allowing more accurate vehicle separation and distance measurements.
In addition, the radar field is much wider so that in many situations, often 1 radar per intersection branch is already sufficient.
Tests have been scheduled to reduce the dead zone to 12m, but that will impact the maximum detection distance. It is not yet certain that this is feasible, but this will be carefully tested.

The application

The current detection configuration still involves the traditional configuration within built-up areas, usually a stop bar loop and a long loop.

However, without modification of the software, the detection configuration 'IVER2018' was applied. This means 4 zones per lane with different distances and lengths from the original configuration. It involves 2 lanes, i.e. the straight through direction, for connection in the traffic light controller, and both turning movements and the parallel bike lane for visual inspection.
Because the controller has 2 detection loops per lane, the gap times of this direction have been adjusted.

There are count loops at this intersection that are not part of the control. For four of these loops, the wiring in the controller was disconnected and used to include the remaining four zones in the detection and thus also in VLOG. This is for evaluation purposes.
Furthermore, for the benefit of both turning directions and the parallel two-way bike path, zones have been drawn in that are not part of VLOG but are visually verifiable during on-site monitoring and through the remote VPN and camera connection.
This involved unscrewing the count loop wiring and connecting it to the interface card.
This way, a proper test setup became possible without software modification (only parameters adjusted) and without hardware modification requiring the manufacturer.
Additionally, the same control was possible directly from the MobiMaestro management center.

The additional detection zones did not affect the traffic flow management.

The installation work

The Province of Groningen performed the installation of the radar in-house. With the help of smartmicro's support team, the radar was attached and connected to the extension. The existing cameras were already partially disconnected in the traffic light controller cabinet last year.

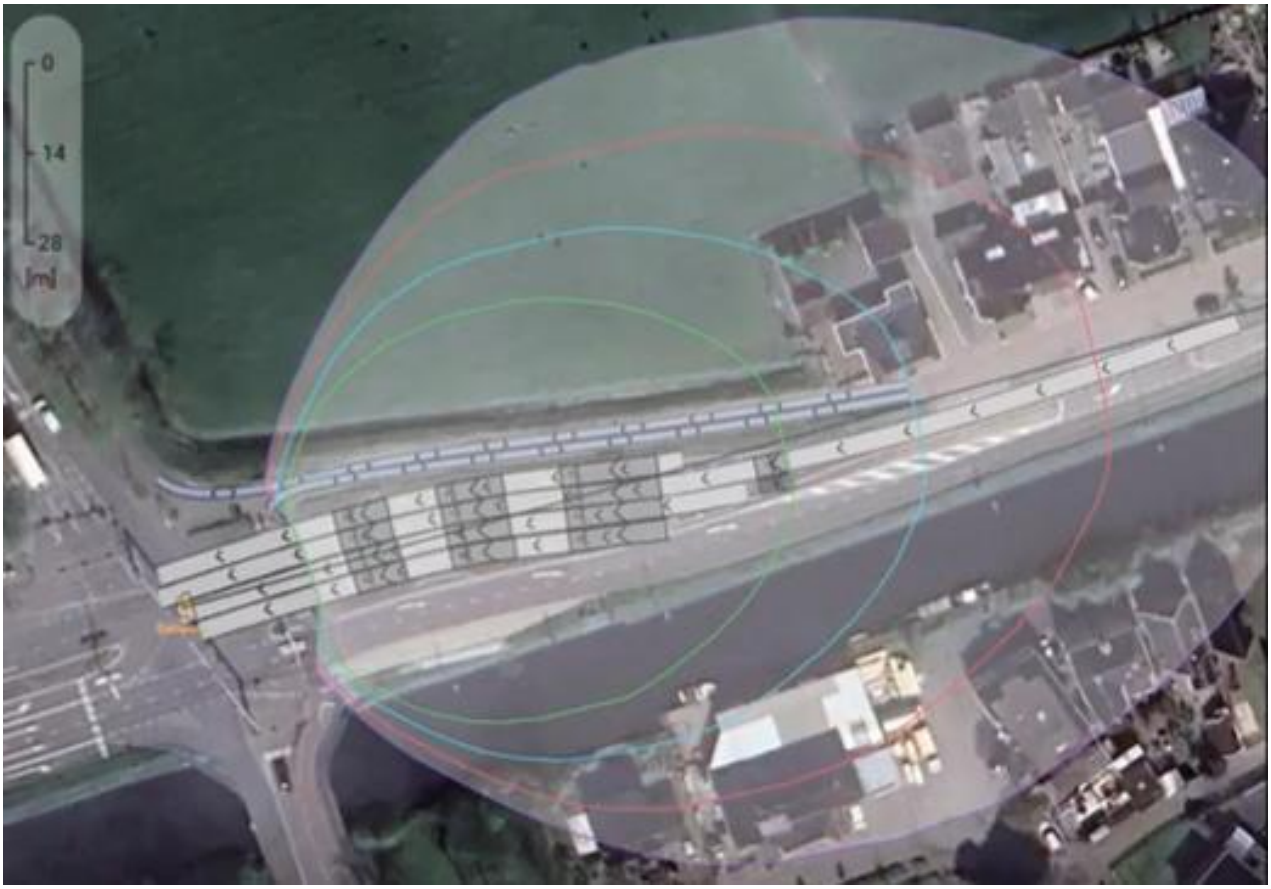
The white radar on the right is TOPGRD. Note that the commercially available version will be black. In the middle, next to the TOPGRD, is a TRUGRD Stream (with camera onboard) for validation purposes. The existing camera is on the left. Video images were accessible in real time from Braunschweig. The TOPGRD radar and TRUGRD Stream camera were synchronized. The 24GHz radar of TRUGRD Stream was not used.
The existing visual cameras were no longer needed, except for 2 cameras that were used for validation purposes.

Maintenance and management

The radar does not require maintenance, but checking the radar orientation once per year is recommended. Management consists of possible replacement of a radar or interface. There is one type of hardware, which simplifies management. In the same hardware, however, a different firmware version may apply which particularly can affect the range.
During the trial, firmware updates from Braunschweig took place. This was to assess their results. Traffic hardly noticed this. During an update, zones stayed high for a bit longer, causing the detection field to stay up a bit longer.

The configuration

The configuration tool "Traffic WEB UI" was used to build the configuration offline using a link to Google Earth satellite images.



The different colored curved lines indicate the range:

- Green = pedestrians
- Light blue = cyclists
- Red = passenger cars
- Dark Blue = trucks and buses

The range depends on position, mounting height and viewing angle, which are adjustable as variables in Traffic WEB UI.

This enables the design process in detail from behind the desk.
During the trial, detection was adjusted several times through the VPN connection so that optimal results were achieved.

This type of radar can measure the entire branch of the intersection. This is only possible if the stop line is at least 15m from the radar. Installation can be on a horizontal mast arm (portal) or on a pole. The recommended mounting height is 6-8m. To limit occlusion, it is recommended to limit the angle of the radar to the detection field. That is, as much as possible, straight above the area of interest.

When is the trial successful?

The objectives were the following:

- The system must run stable
- Traffic control must continue to work properly
- In any case, we should be able to see both on location and with VLOG that things are working fine
- Stopped vehicles should also remain visible
- Also vehicles falling away due to occlusion and then returning
- Also vehicles driving side by side
- No/little hanging zones
- A good count on stop bar loop zones

Further, the following points of interest for evaluation were:

- Proper operation of the distance zones
- Being able to count correctly on the stop bar zones
- Occlusion **behind** a vehicle and **next to** a vehicle
- Vehicle Classification
- The cyclists
- The detection range for the different categories
- Whether downstream vehicles (= receding traffic) were also detected

The trial would last over a month (March 20, 2025, to April 24, 2025).
That is exactly what has been realized.

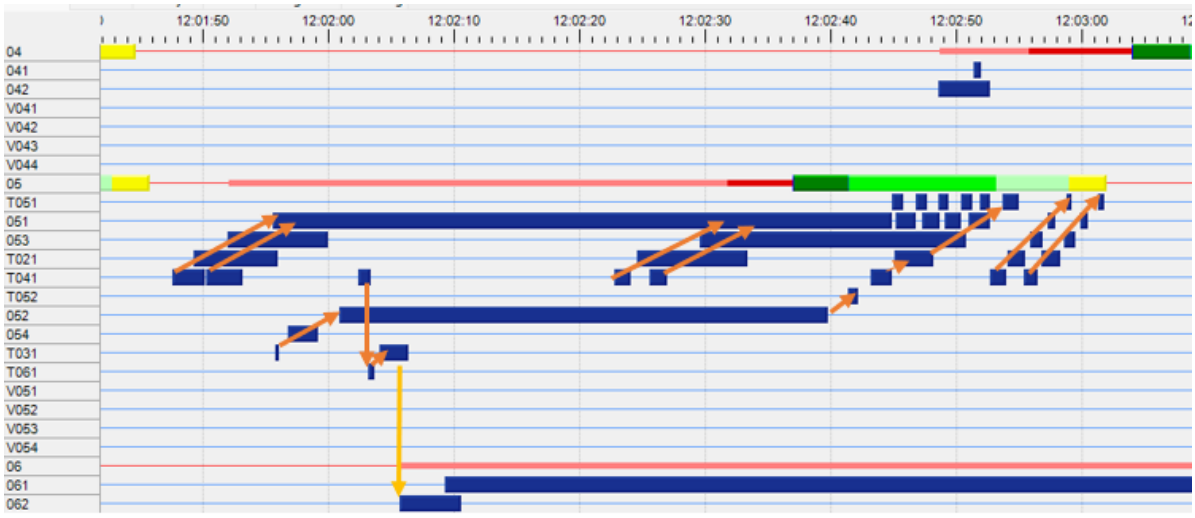
The tools for analysis have been the following:

- VLOG where all results were checked at detailed level
- Validation with synchronized visual material between camera image capture and radar
- MobiMaestro for the purpose of checking proper operation through the intersection view and checking malfunctions
- Traffic WEB UI, smartmicro's tool where online, both on-site and through the VPN to Braunschweig, the real-time monitoring of all traffic participants was possible (in which you see the vehicles driving in the lanes across the intersection satellite image)

With Traffic WEB UI software, it is also possible to build the offline configuration in advance and conduct vehicle simulations from behind the desk.

Evaluation results

- **The system must run stable (no, or as few failures as possible).**
  The TOPGRD had no detection failure during this period. That is no under behavior and no over behavior.
  However, any approaching over behavior is automatically cancelled within the radar by means of a monitoring time (maximum detection hold time) or by the arrival of a following vehicle.
  The detection sequence also proved to be correct in VLOG.

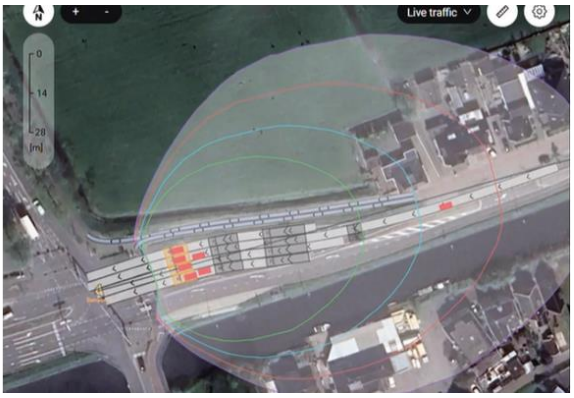


The order of approach to the stop line is above where T04.1 is the most distant distance loop for the right lane. Four radar zones are involved. One check zone was T051. But that is a camera zone. This one counted double (coincidentally) with the fourth vehicle.
There were 7 vehicles traveling on the right lane and 1 vehicle on the left (T031-054-052-T052). And 1 vehicle turned left (T041-T061-T031-062-061)

- **Traffic control must continue to work properly.**
  Through MobiMaestro, visual on-site checks and VLOG, this was frequently assessed.
  The traffic control always continued to work properly, and road users did not notice that the control worked differently.

- **The traffic control application must be able to work with the radar in common detection mode (detection inputs, occupancy times and gap times).**
  This indeed proved to be the case and, as a result, the previously changed parameter settings immediately worked correctly.
  Probably gap times can be even sharper because radar triggers very accurately. This has not been further explored.
  The gap times did adjust to the more extended detection configuration as configured.

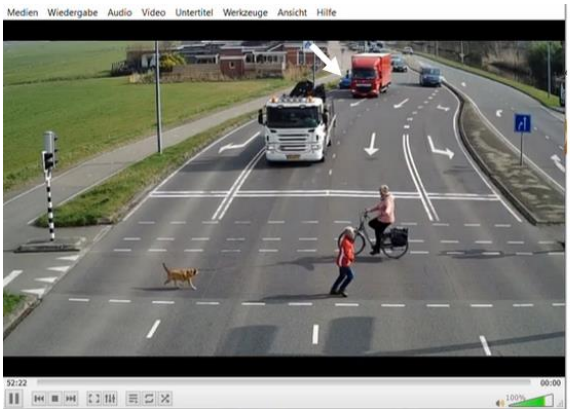
- **Since radar only detects moving traffic and this radar is also equipped with detection for stationary traffic, its proper operation must be demonstrable.**
  This was a success!
  The TOPGRD scored well in this regard. It was almost always correct, even during busy periods.

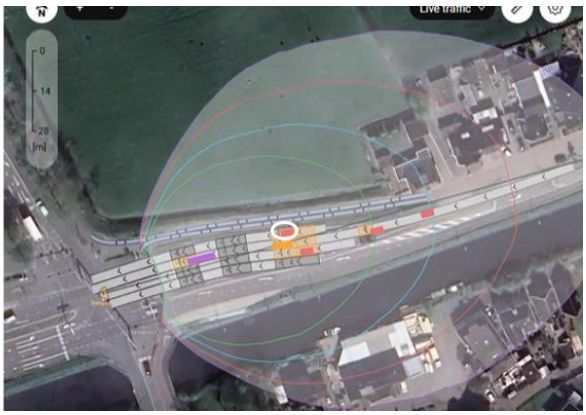


The number of vehicles waiting is correct. The next vehicle is on its way.
This was an area of improvement with the Type 132 and was resolved with the TOPGRD.

- **If a vehicle falls away due to occlusion (a vehicle located next to or behind a tall vehicle and therefore may not be visible), detection should remain active.**
  This indeed proved to be the case. Both **next to** a tall vehicle and **behind** a tall vehicle.
  The reason is that the tracking mechanism tracks each individual vehicle, and a vehicle must drive out of the zone before it disappears.

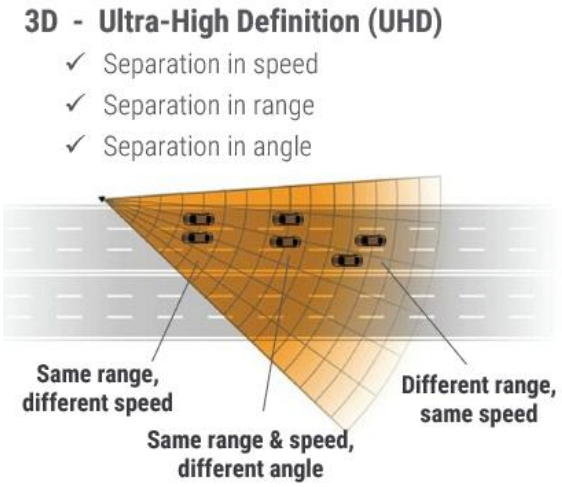
The blue vehicle **behind** the green truck is also seen by the radar.
Note: if a vehicle is completely occluded from a great distance until **after** the stop line, the radar will not pick it up. It is also possible for a vehicle to merge into another vehicle, e.g. a car with a trailer may first be seen as 2 vehicles and then as 1 vehicle.





A vehicle **next to** a truck is also seen, see the arrow next to the red truck.

- **With radar, it is difficult to individually detect vehicles driving side-by-side. This solution should demonstrate that it does work correctly.**
  This works correctly and was a positive surprise. The use of a 3D mechanism makes this possible. The radar system looks at the speed (velocity), distance (range) and angle/lane (azimuth) of each vehicle.
  It worked fine during the onsite visual checks, in Traffic WEB UI and in VLOG.



- **No/little hanging zones**

  This was an identified point of improvement for UMRR-11 Type 132.

  For this purpose, validation was done with both radar/camera and VLOG.
  This included looking at "stuck-calls" (unjustified hanging zones that are otherwise monitored to a maximum) and "dropped-calls" (vehicles that disappear).

  The camera-radar image validation yielded a 96.5% reliability.

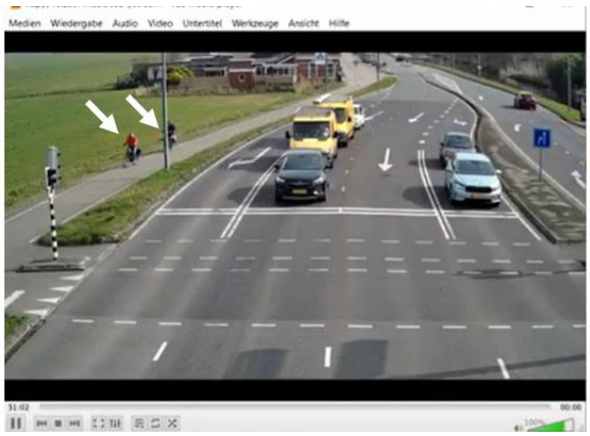
  The VLOG result was the following:
  Percentage of hanging zones of the number of cycles:
  - Morning rush hour : 2,1%
  - Evening rush hour : 1,2%
  - Daily : 0,9%

  The goal was 95% reliability. With that in mind, the result was good.

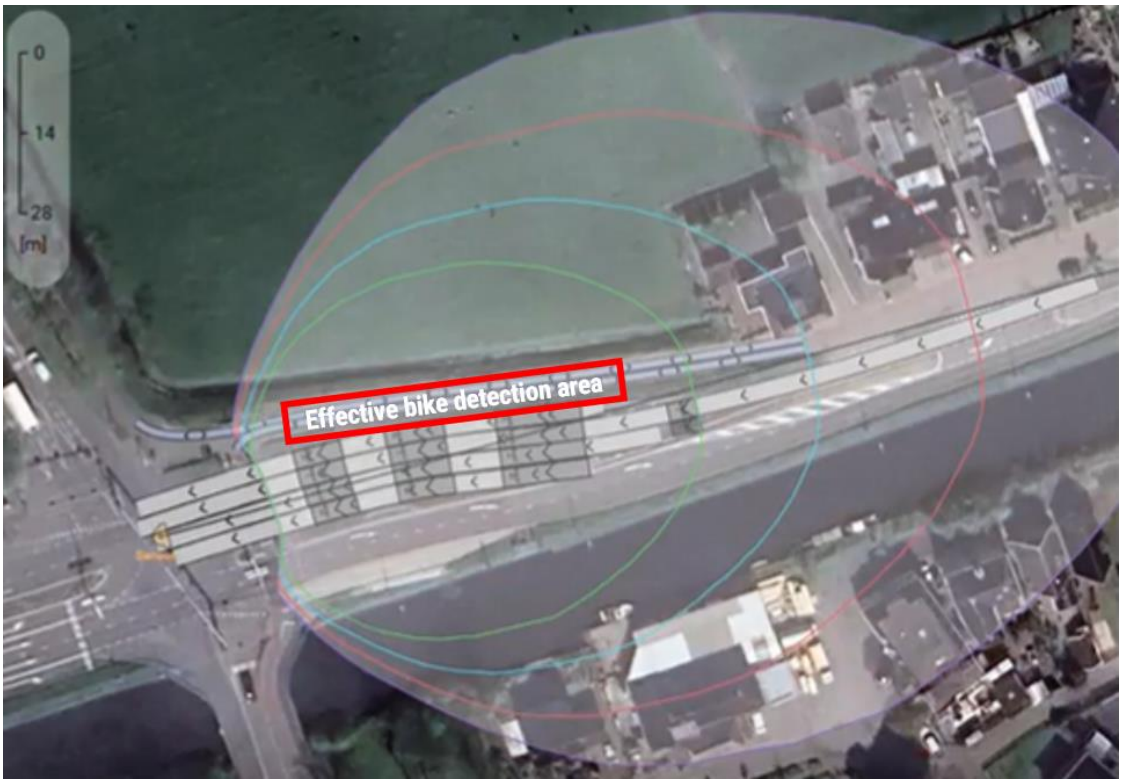
- **Detection must work correctly, including counts.**
  Again, this was an identified point of improvement for UMRR-11 Type 132.

  In particular, the accuracy of remote measurement has increased considerably with the TOPGRD. For this, however, the range of 240 meters has been reduced to 180 meters.
  The results of the measurements at the stop line are good.
  It could just be that physical detection loops do not work as good due to influence from an adjacent vehicle, for example. A radar has the advantage that a vehicle can only give detection in 1 lane at a time, while 2 inductive loops side by side can both give detection on the same vehicle.
  We however did see that a truck and a car with a trailer are sometimes measured by the radar as 2 passenger cars.

- **What is possible with cyclists?**
  It was not a primary goal for this site but was included in the study.
  Interesting to know is:
  - What is the detection range?
  - Is detection possible for both outbound and inbound cyclists?
  - Is the arrival time of cyclists configurable?
  - Is counting multiple cyclists possible?
  - To what extent is the blue arc radius in Traffic WEB UI correct for the detection range of cyclists?



Cyclists are seen inside the green area (so not at the edge of the blue area), even though there is occlusion by the public illumination light pole, see the two white arrows and circles.



The actual bike detection range was slightly shorter than the green zone, but still from about 20m to about 80m. The range of receding cyclists (so cycles driving away from the radar) went a little further.

Cyclists were detected in both directions.
Some firmware enhancements are planned in the near term to improve detection distance and discriminatory capability.

If cyclists drive side by side or close behind each other, separate bicycle detections usually do not take place. Therefore, accurate bicycle counting is currently not possible (yet).
Through further improvements, smartmicro expects to detect cyclists better and at higher distances in the future.

Cyclists crossing the approach were also detected. But that does not mean that detecting stationary cyclists is possible from this viewing angle.
Smartmicro has activated its visualization for demonstration purposes only. Detection of cross traffic (pedestrians, cyclists, vehicles) is not a supported functionality.

The pedestrian on the left was also seen, see the orange dot at the top in the satellite image.

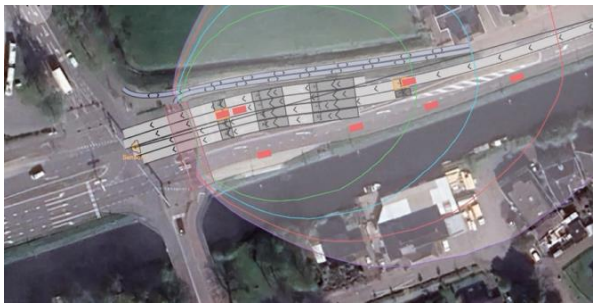
- **To what extent does vehicle classification work correctly?**
  Again, this was not a main goal, but it was included in the evaluation.

Usually, a truck was recognized, but sometimes a truck was also measured as 2 passenger cars. It requires improvement for the future.

Smartmicro has indicated that the classification is not yet good, as another 6-12 months are needed to nurture and train the AI model.

This bus was detected as early as 180 meters from the radar, well outside the red zone. Radar cannot distinguish buses from trucks.

- **Counting vehicles downstream**



It can be useful to also measure downstream traffic (the 4 cars on the right in the picture) and to provide that info to the next intersection, or for traffic research purposes, for example to determine turn rates.
The beam from the radar is very wide, as shown here. However, the advice is not to measure more than 4 lanes. In this case, this measurement was OK.

- **Weather conditions (snow and fog)**
  No snowstorms occurred during the short testing period with the TOPGRD, but experience was gained with the previous radar, UMRR-11 Type 132.
  There were 2 days in that year with Code Red on the road involving fierce snow showers combined with high winds. The radar faces east.

During the first snowy day, the wind was fierce west. In this situation, the radar experienced no problems and operated flawlessly.

During the second snowy day, there were fierce east winds. In that situation, the radar gave permanent output triggering for a period of a few hours.
Snow can stick on the radar front due to strong winds from the east. With a layer of ice underneath, which later melts due to the warm housing and subsequent rising temperature. At that moment the radar was blind and went into fail-safe mode (= permanent activation of the outputs).
As a result, no vehicles were missed, but traffic had the maximum green time each time.

There was fog in the early morning on April 22-23, 2025, and on April 29, 2025, between 5:45am and 6:45am.
On the right lane (the busiest lane), there was no difference with good weather conditions.
On the left lane, something is not right with the stop bar loop, but that was also the case when there was no fog.

Conclusion of the trial

The trial passed!

The radar worked stably and has a long range that allows a lot.
The arrangement continued to work well, and traffic did not notice anything outside of the installation work.
The improvements given to the previous UMRR-11 Type 132 radar as advice have been fully followed in the TOPGRD.
All the criteria that had to lead to the success of the trial were met.

There is a slight sensitivity to the situation with snow where a strong wind blows right on the radar. But this situation lasted a short time and resulted in a longer zone occupancy time.
Fog gave no problem on the most congested lane.

The range of the radar is wide in both length and width, which means that one type of hardware will suffice if the minimum detection distance (= dead zone) of 15 meters is considered.

The possibilities were surprising. Especially being able to pre-configure the radar offline. This saves a lot of time and possible problems during commissioning.

The fact that there is only 1 type of radar mainly benefits maintenance.

The radar solution is price competitive. Not only with the lower purchase price, but also with the required number of radars for an intersection.
The lifetime expectancy of the radar is at least ten operating years.
The radar requires no maintenance, no cleaning either.
An annual check of detection zones in relation to moving traffic may be desirable. This is possible with the Traffic WEB UI, either connecting in the traffic light controller cabinet, or remotely using a VPN connection.

Finally, the cooperation between the three parties was also enjoyable. Quite unique was that a solution was realized in an existing environment without the help of a manufacturer or an installation company.

The next step

The entire intersection will be equipped with smartmicro radars for detecting motor vehicles and cyclists.
All visual and thermal cameras will be replaced by radar and no physical detection loops will be present.
This will take place in the second half of this year with the traffic light controller also being replaced.
The new control application already foresees several extra things we want to validate such as considering the speed of cyclists, vehicle classification, congestion detection and more.
This will make the traffic regulation even more innovative, without needing specific apps to get priority in time.

Radar Sensor	TOPGRD
Number of Channels	48 (6 transmitters, 8 receivers)
Viewing Angle	100° horizontal, 20° vertical
Detection Distance	Min 15m Max 180m (trial)
J-BOX	Power PLC (power line communications)
Cable	3-wire
Interface	COM HUB Relay 8 (max. 2 radars per interface) COM HUB Relay 24 (max. 4 radars per interface), eventually in combination with the Relay 32 XP Module
Outputs	8 per COM HUB Relay 8 interface 24 per COM HUB Relay 24 interface 56 when adding Relay 32 XP Module to COM HUB Relay 24
Protocol	REST API via LAN connection MQTT via LAN connection Protocol (yet to be chosen) via RS-485
System Configuration	Via laptop or tablet and wireless/LAN connection
User Interface	Traffic WEB UI (software on interface)

This may also mean the start of other forms of detection, where we no longer talk about ***detection loops or zones,*** but ***detection areas***.

And there lies yet another innovative challenge!