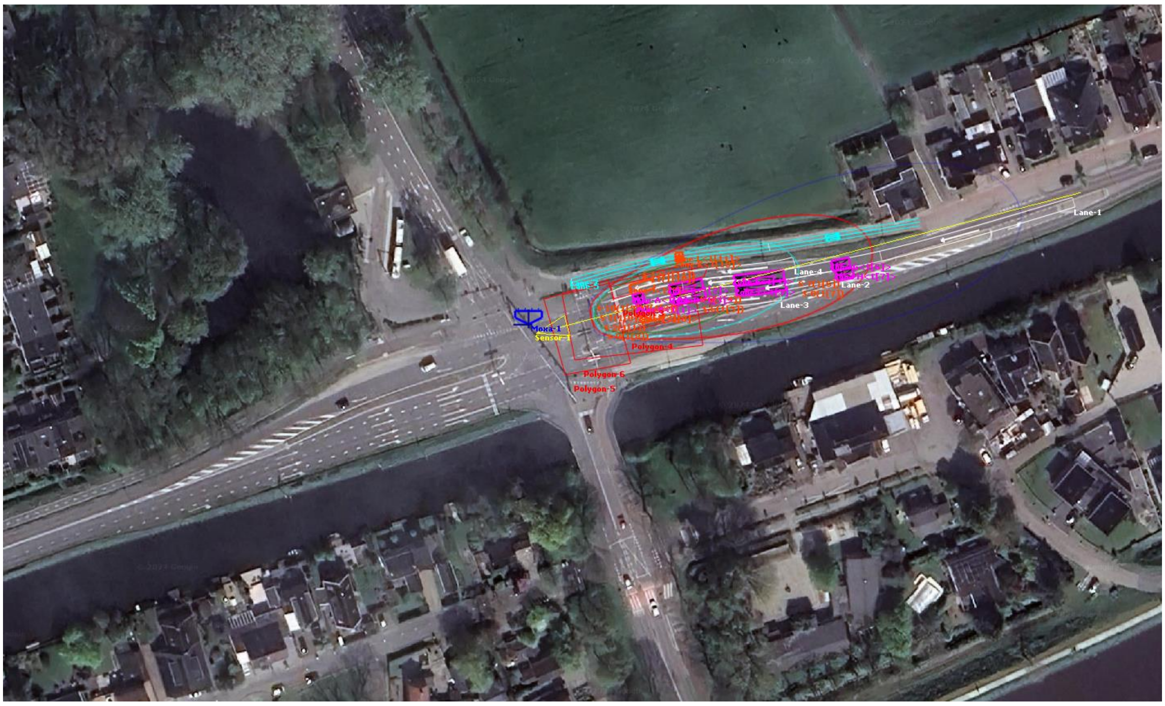
V3.1	09-07-2024	Actueel	Eindrapportage van de radar proef
V3.1-EN	22-08-2024	Current	Final report radar trial (translated version)

Introduction

On 22-03-2024, a trial started at the VRI Ruischerbrug in collaboration with the Province of Groningen, smartmicro and Verkeersinfo, using a smartmicro radar (UMRR-11 Type 132) for traffic detection and a smartmicro interface (CRO) for providing outputs to the traffic light controller.
The aim is to see to what extent this radar (and its successor TOPGRD) fits in traffic control systems with the detection configurations used in the Netherlands.
The immediate reason is the replacement of older visual cameras.



It concerns the approach from the east of the Rijksweg/Noordijkerweg traffic control system (object ID VR02 Ruischerbrug) in Groningen. This is an important road towards the east to the city and to the ring roads.

The cooperating parties

Three parties worked together on this trial in a constructive and proactive manner. That's how the experience has been.

The parties are:

1) **The Province of Groningen**
   The Province of Groningen has facilitated the test set-up within this traffic control system. With its own people (and therefore without the help of an external installation company), the radar was wired, attached to the portal and connected. In addition, an extra VPN connection has been established between this radar and the supplier of the radar, smartmicro.
   Finally, the province collected the VLOG information several times and forwarded the files to the consultancy firm Verkeersinfo for further analysis.

2) **smartmicro**
The German company smartmicro, with headquarters in Braunschweig, is a provider of innovative technology, specialized in radars for traffic detection applications.
smartmicro took care of the delivery of the radar and interface, the connection to the traffic light controller, the support during the installation and the optimization of this radar for the chosen application. The latter is done both in Braunschweig and onsite.

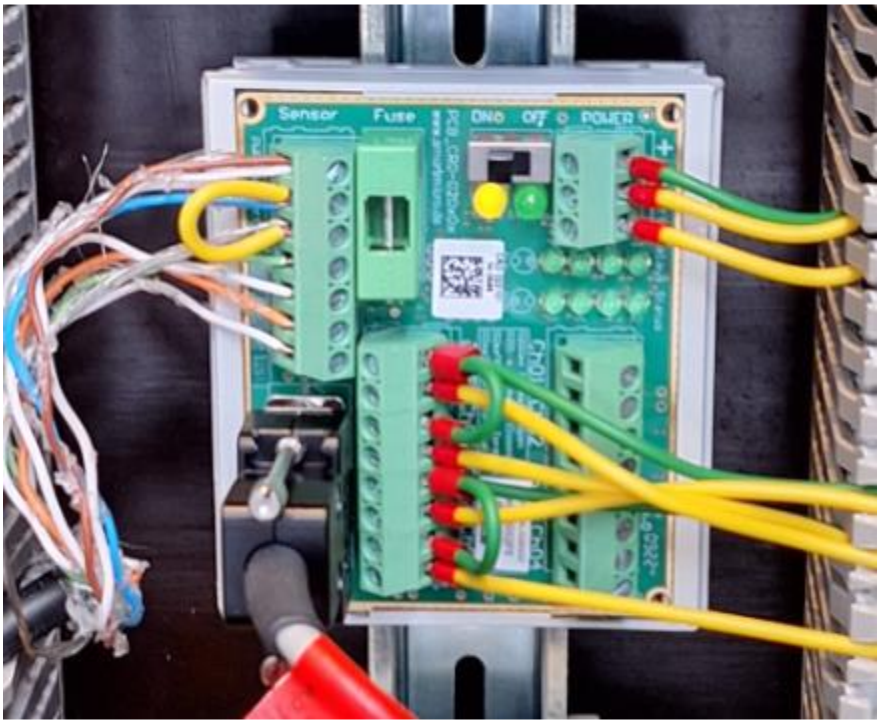
3) **Verkeersinfo**
Verkeersinfo provided the support for the implementation in the traffic light controller (the goal was implementation of the hardware without software, adjustment of process control and application and connection of the interface in-house). Furthermore, Verkeersinfo carried out the traffic control application, optimized the operation and carried out the overall evaluation.

Description of the radar

The UMRR-11 Type 132 radar in combination with the CRO interface card are existing products in Europe and came onto the market in 2020. This is the first roll-out for this application in the Netherlands.

The radar is the size of a hand. The mounting bracket, which is attached to a pole or beam with steel bands, is also shown in the picture.

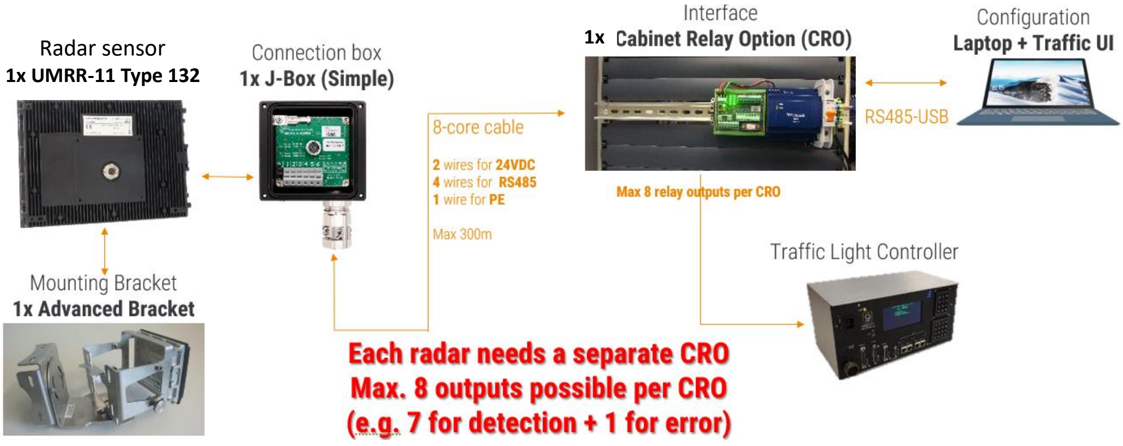
The tilt angle indications are displayed on the mounting bracket. The tilt angle is already determined behind the desk by the configuration tool Traffic UI and Google Earth (several links are possible). At the intersection, the tilt angle and roll angle can be checked via the Traffic UI, by means of live input from an accelerometer in the radar.



The interface card (cabinet relay option, CRO)

This type of radar was deliberately chosen to gain a first experience with it. This is because a successor will be on the market later this year with even more possibilities in the application of traffic control systems.

The radar can communicate over a serial line, as well as via output relays/contacts.
In this trial, parallel conditional contacts were chosen because this made a solution possible without further hardware or software modifications to the older traffic control system. The traffic light controller will be replaced next year.

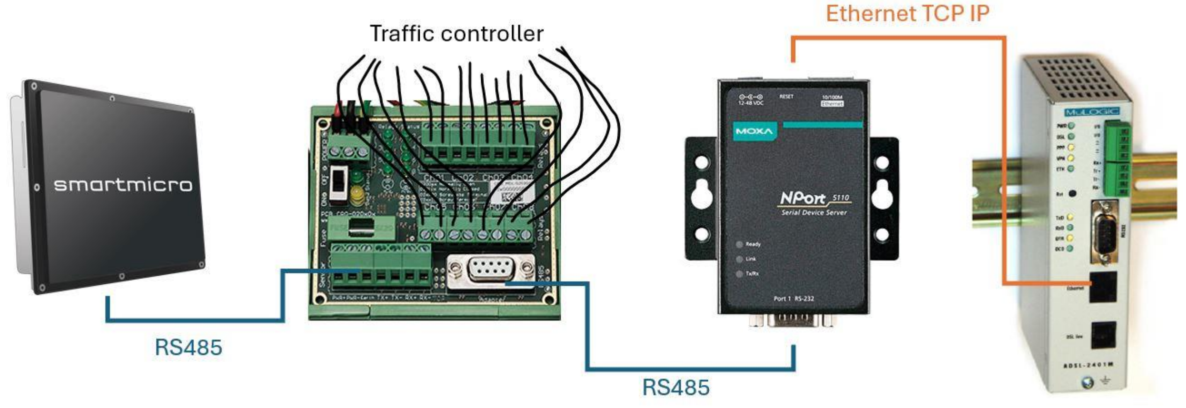


This type of radar can control up to eight outputs via the CRO and allows the configuration of many zones. The limit of the number of outputs is caused by the CRO. With the yet to be released interface "COM HUB Relay Version 24", connectivity with up to 4 radars and up to 24 outputs can be provided.

Through the tracking mechanism, all types of road users are tracked individually across the marked zones. These road users are all given their own unique identification number in the radar software.

The minimum distance to the first detection field of this type of radar is quite large, namely 27 meters. This means that the current radar is not suitable for all traffic signals.
For that reason, the successor, which will be on the market at the end of this year, is in the picture. That new radar will be able to detect from 15 meters onwards.

RS-485 is converted to Ethernet via a MOXA Nport module. The remote connection is established via a MuLogic ADSL router.



The application

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

However, without modifying the software, the detection configuration 'IVER2018' has been applied. In this case, that means 4 zones per lane with different distances and lengths compared to the original configuration.
It concerns 2 lanes, i.e. the through lanes, physically connected to the traffic light controller. The two turning movements and the parallel cycle path are configured for additional visual evaluation. Because the traffic light controller has 2 detection loops per lane, the gap times of this direction have been adjusted.

There are counting loops at this intersection that are not part of the scheme. The wiring in the circuit breaker was disconnected from four of these loops and used to include the other four zones in the detection and thus also in VLOG. This is for the purpose of the evaluation.
Furthermore, for the benefit of the two turning directions, and for the parallel two-way cycle path, zones have been drawn that are not part of VLOG but can be visually checked during on-site validation and via the remote VPN connection.
The wiring of the counting loops is unscrewed and connected to the interface card.
In this way, a good test set-up was possible without software modification (only parameters adjusted) and without hardware modification for which the manufacturer was required.
The same verification was also possible directly from the MobiMaestro management center.

The additional detection zones did not affect the handling of traffic.

The installation work

The Province of Groningen carried out the installation of the radar in-house. With the help of the smartmicro support team, the radar was attached to the portal (horizontal beam) and connected. The existing visual cameras were partially disconnected from the traffic light controller.

The UMRR-11 Type 132 radar in addition to existing cameras.
However, given the long range of the radar, the various cameras would no longer be necessary.

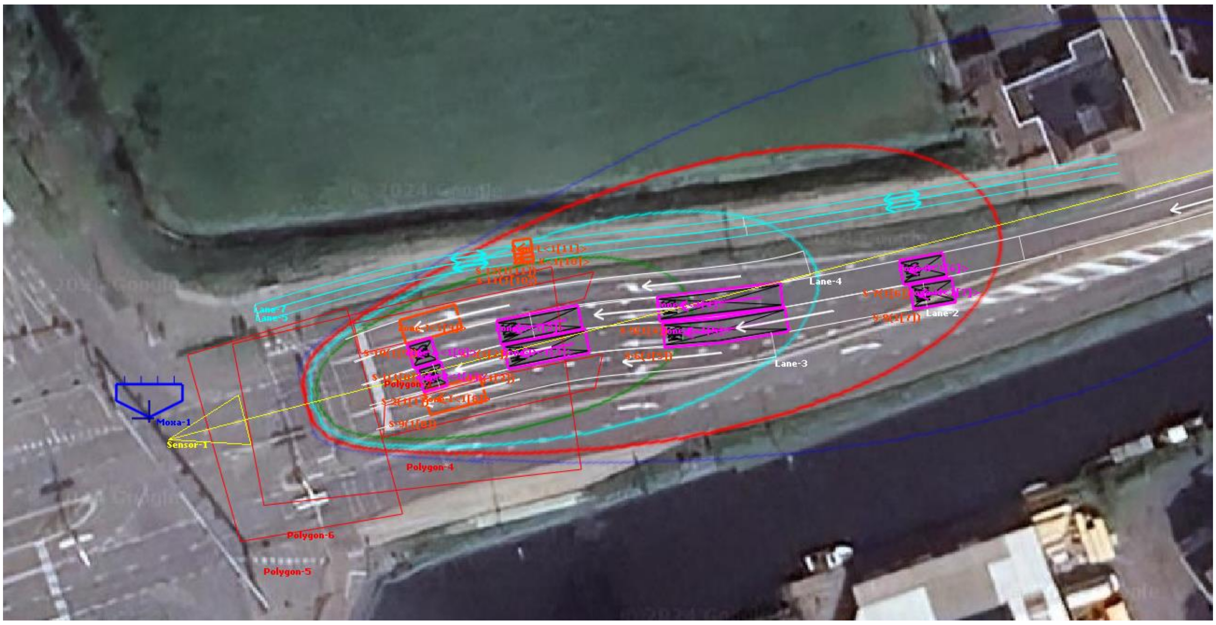
Maintenance and management

The radar does not require any maintenance.

The management consists of possible replacement of a radar or an interface. There is one type of hardware, which simplifies management. Multiple firmware versions may apply in the same hardware.

The Configuration

Using a link with Google Earth and through the "Traffic UI" configuration tool, which was installed on a laptop, the configuration was built offline.



The different colored lines indicate the effective radar detection range, which depends on position, mounting height and viewing angle. These can be set as variables in Traffic UI and makes a detailed design process possible from behind the desk.

During the trial, the configuration was adjusted a few times by means of the VPN connection so that an optimal detection result was achieved.

Green = pedestrians
Light blue = cyclists
Red = cars
Dark blue = trucks and busses

With this type of radar, the entire branch of the intersection can be measured. This is only possible if the stop line is at least 27m from the radar. Installation can be done on a horizontal beam or on a pole. The recommended 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 directly above the detection area.

When is the test a success?

The constraints for this have been the following:

- The system must run stable (no or as few failures as possible),
- The traffic control must continue to work properly,
- The traffic control application must be able to work with the radar in the usual way (e.g. detection entrances, occupancy times and gap times),
- Because radar only detects moving traffic and this radar is also equipped with stationary traffic detection, its proper functioning must be demonstrable,
- If a vehicle is lost due to occlusion (a vehicle that is next to or behind a tall vehicle and therefore may not be visible), the detection must remain active,
- With radar, it is still difficult to detect vehicles driving side by side individually. With this solution, it must be demonstrable that this works correctly,
- Detection must work correctly, including for counts.

Furthermore, the desire was to find out the following:

- What is possible with cyclists?
- To what extent does the vehicle classification work correctly?

The trial would last two months (April-May 2024). Due to a holiday period, this has been extended to three months (April-May-June 2024).

The tools have been the following:

- VLOG in which all results have been checked at a detailed level.
- MobiMaestro for the purpose of checking the proper functioning by means of the intersection view and the check of malfunctions.
- Traffic UI, the smartmicro tool that allowed real-time visualization of all detected road users online, both on site and via the VPN to Braunschweig (you can see the vehicles driving across the screen).
  With this software it is also possible to build the offline configuration in advance, and vehicle simulation is possible from behind the desk in advance.
- On-site inspection where the traffic handling was verified and any differences with the real-time visualization in Traffic UI, where the laptop was connected to the interface.

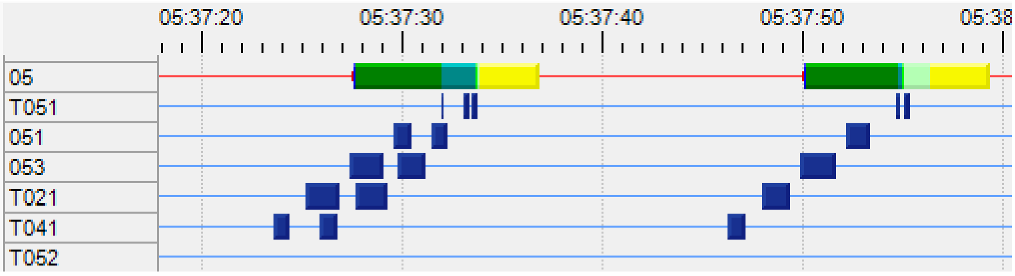
Evaluation results

- **The system must run stable (no or as few failures as possible).**

  There has not been a single detection failure during this period. That is, no under-behavior and no over-behavior.

  It is true that any over-behavior is automatically cancelled out within the radar by means of a monitoring time or by the arrival of the next vehicle.

  Also, the detection sequence turned out to be correct in VLOG.

  The order of approach to the stop line is above with T04.1 being the most distant distance loop. It concerns four zones of the radar. One control zone was T051. But that's a camera zone. This (coincidentally) counted double at that time.

- **Traffic control must continue to work properly.**

  This has been frequently assessed by means of MobiMaestro, on-site visual verification, and VLOG.

  The traffic control system always continued to work well, and road users will not have experienced that the control system worked differently.

- **The traffic control application must be able to work with the radar in the usual way (e.g. detection inputs, occupancy times and gap times).**

  This turned out to be the case and therefore the previously changed parameter settings immediately worked correctly.

  Gap times can probably be even sharper because the radar triggers very accurately. This has not been tried further.

  The gap times have been adjusted to the more extensive detection configuration as configured.

- **Because radar only detects moving traffic and this radar is also equipped with stationary traffic detection, its proper functioning must be demonstrable.**

  This was indeed evident immediately during commissioning. The stationary traffic corresponded to the intersection view in the traffic light controller and to the real-time Traffic UI tool.

  As a normal consequence, the VLOG data was also correct.

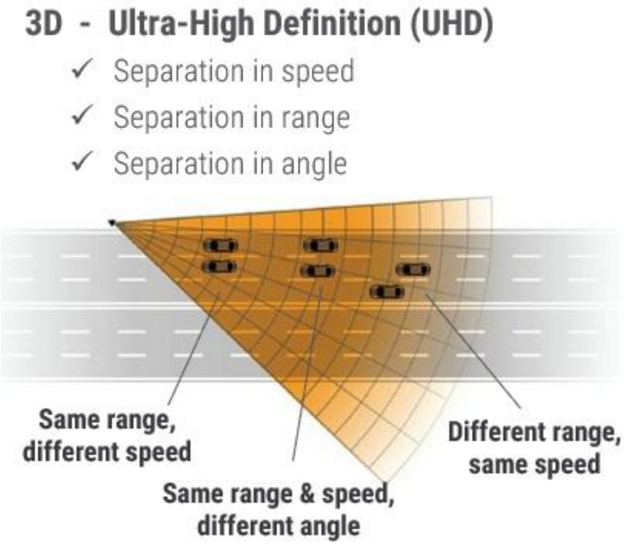
  There is room for improvement in this area, and perhaps it is desirable. In a few cases, only when traffic was stopped, a zone was briefly suspended without any traffic still present. However, this was automatically solved by the monitoring time or by the next vehicle.

  In the VLOG, it has been checked how this can be solved. It is possible through conditional outputs; this option has been discussed with smartmicro. This is definitely solvable this way.

  Incidentally, as far as we know, the correctness of detection has never been looked at so deeply. It may just be that physical detection loops or camera detection score worse.

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

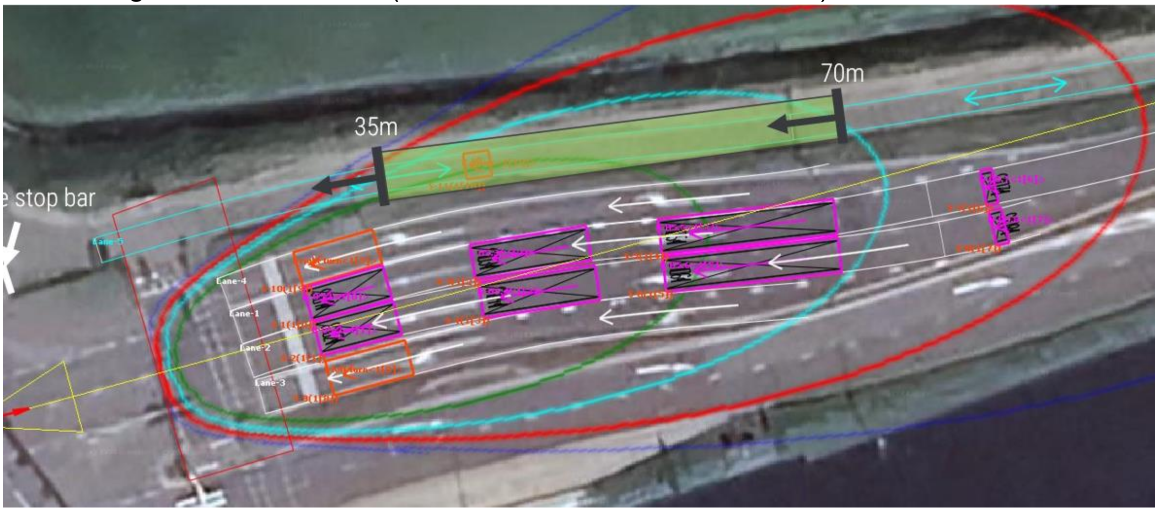
- **With radar, it is difficult to detect vehicles driving side by side individually. With this solution, it must be demonstrable that this works correctly.**
  This works correctly and was a positive surprise. The application of a 3D-mechanism makes this possible. This involves looking at the speed, the distance (range) and the angle/track section (azimuth) of each vehicle.
  It was shown during the on-site inspection, in the Traffic UI and in the VLOG.



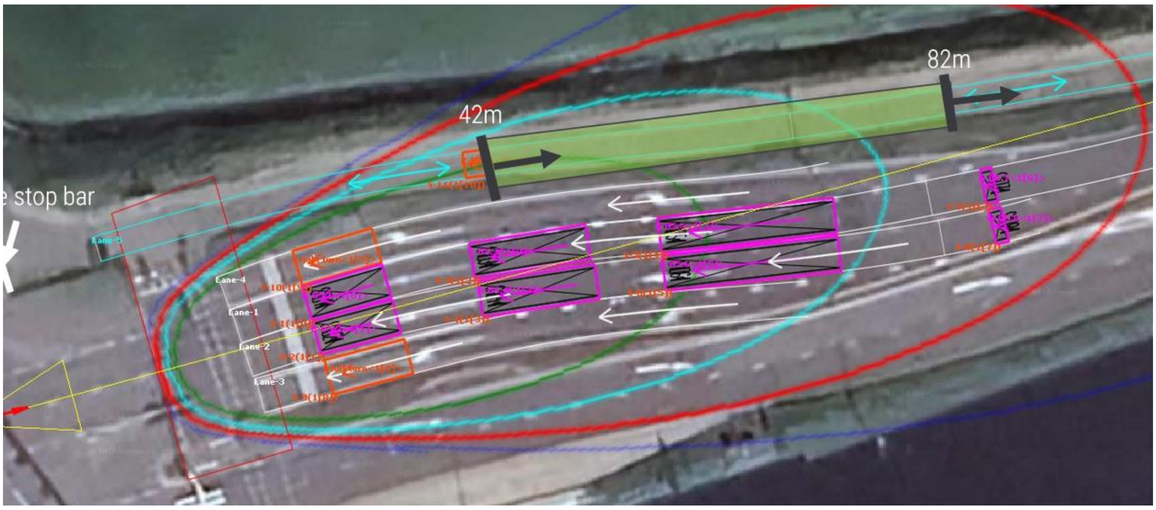
- **Detection must work correctly, including for counts.**
  This is especially important when it comes to being able to count correctly on check-out loops at the stop bar and on check-in loops at distance. The application is able to count on stop bar loops, network instruments and adaptive control.
  The result is not always correct, however, there are no comparison figures with physical detection and camera detection. The deviation is not known exactly because no visual count has been carried out. Sampling in VLOG indicated a deviation of less than 10%.
  With conditional outputs (i.e. a minimum interval before the next output is sent) this can be solved almost completely. As such, the findings have been passed on to smartmicro.

- **What is possible with cyclists?**
  It was not a main goal for this location, but it was included in the study.
  Interesting to know is:
  - What is the detection range?
  - Is detection possible for both approaching and receding cyclists?
  - Can the time-to-arrival of cyclists be configured?
  - Is it possible to count multiple cyclists?
  - To what extent is the blue radius of curvature correct for the detection range of cyclists in Traffic UI?

The blue lobe of Traffic UI is completely correct for oncoming cyclists.
The bicycle detection range for this type of radar is 35m to 70m away from the radar, for traffic driving towards the radar (in accordance with the blue lobe).

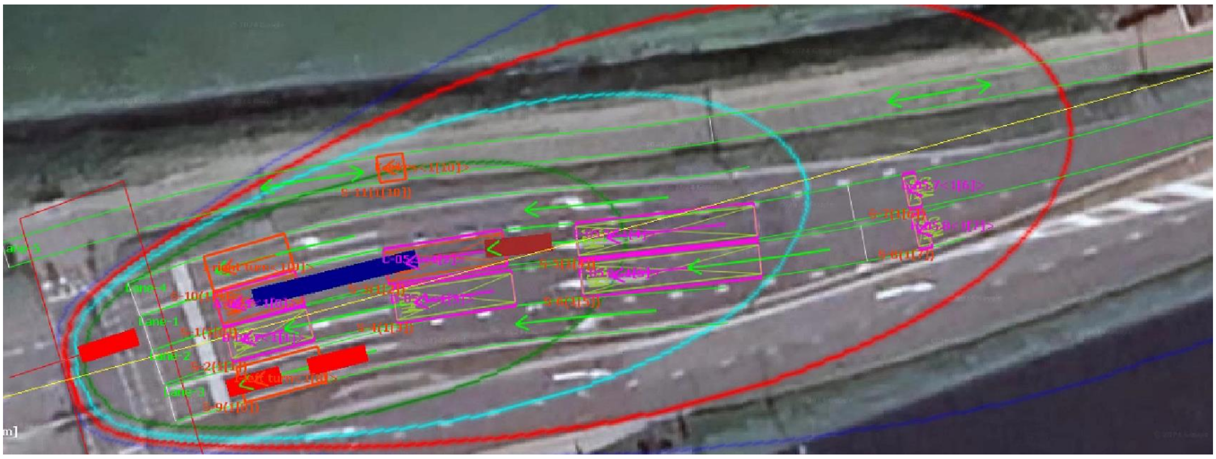


The bicycle detection range is 42m to 82m away from the radar, for traffic driving away from the radar (the latter is a bit outside the blue lobe). Several radar cycles are needed to confirm the bike track, while the track can also be maintained a bit further.



As with car traffic, the radar detects both oncoming and departing traffic. There is, however, a difference in the effective detection range. This is due to the nature of radar technology. Several cyclists next to each other were not tested on site because the traffic was not as such. The expectation is that this is not yet possible with the current type of radar, the cyclists will ride too close to each other for accurate separation.
With cyclists cycling behind each other, separate detection is probably possible.
The time of arrival for both cars and cyclists can be transmitted not only serially but also with outputs. This is based on the actual distance and the actual speed of the road user.

- **To what extent does vehicle classification work correctly?**
  That was not the main goal either, but it was included in the evaluation.
  The radar can handle seven vehicle classes.
  The assessment took place by means of visual inspection in combination with the real-time Traffic UI. And it worked almost correctly, both, large and small trucks/buses, vans, passenger cars, motor cyclists, cyclists. A car with a trailer was seen as a small truck. There were no pedestrians.



On the first through lane there is a passenger car (red), followed by a truck or bus (blue) and a delivery van (brown). There are 2 passenger cars (2 times red) in the left lane. You can see here that the radar loop was a bit too big. This was adjusted afterwards.
What has also been learned here is that the physical loop length in the radar zone should be slightly longer than a real inductive loop.

Conclusion of the result of the trial

The test was a success!

The radar is stable and has a long range, which creates a lot of possibilities.
The traffic control continued to work well and people passing by did not notice anything outside of the installation work.
By means of some advice, a small optimization has been given as a wish to smartmicro.
The range of the radar is large in both length and width, which means that one type of hardware can suffice, provided that the minimum detection distance of 27 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 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 years of operation.
The radar requires no maintenance, nor does it require cleaning.
An annual check of the detection zones in relation to moving traffic may be desirable. This is possible with the Traffic UI software, through a local connection to the traffic light controller, or remotely via a VPN connection.

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

The sequel

Because the radar "UMRR-11 Type 132" is running well, it has been agreed that it will be retained (with the outputs operational, linked to the traffic light controller) until the successor (TOPGRD radar) is available for a new trial around September/October 2024. At that time, the same evaluation will be possible. Not only a comparison with the current radar will take place, but there also will be an exploration of additional possibilities that this radar will bring.

	AVAILABLE NOW	AVAILABLE LATER (subject to change)
Radar Sensor	UMRR-11 Type 132	TOPGRD Stop+Advance
Number of channels	12 (3 transmitters, 4 receivers)	48 (6 transmitters, 8 receivers)
Viewing angle	32° horizontal, 15° vertical	110° horizontal, 20° vertical
Detection Distance	Min 27m, max 175m	Min 15m, max 240m
J-BOX	RS485 + Power	RS485 + Power, or PLC (power line communications)
Cable	8 wires	8 wires (using CRO), or 3 wires (using COM HUB Relay)
Interface	CRO (1 radar per interface)	CRO (1 radar per interface), or COM HUB Relay Version 8 (max. 2 radars/interface), or COM HUB Relay Version 24 (max. 4 radars/interface)
Outputs	8 per interface	8 per interface (using CRO or COM HUB Relay Version 8), or 24 per interface (using COM HUB Relay Version 24)
Protocol	Specific smartmicro protocol via RS-485	Using CRO: • Specific smartmicro protocol via RS-485 Using COM HUB Relay: • REST API via LAN connection • MQTT via LAN connection • Protocol (to be chosen) via RS-485
System Configuration	Via laptop & serial connection	Via laptop & serial connection, or Via laptop or tablet & wireless/LAN connection
User Interface	Traffic UI (software on laptop)	Traffic UI (software on laptop, using CRO), or Traffic Web UI (software on interface, using COM HUB Relay)

This may also mean the start of other forms of detection in which we no longer speak of ***detection loops or zones,*** but of ***detection areas or regions***.

And therein lies a new innovative challenge!