FULL DOCUMENTATION

TRAFFIC MANAGEMENT SENSOR

TRUGRD (UMRR-12 TYPE 48)
TRUGRD Stream

CONTENTS

1   ABOUT THE RADAR SENSOR

In the following chapter, a general overview of the radar sensor is provided.

1.1   FIELDS OF APPLICATION

The smartmicro radar sensor can be used for many applications, such as:

- Intersection management
    - Stop bar detection
    - Advance detection
    - Combined stop bar and advance detection
    - Queue length estimation
- Arterial management
    - Traffic counting and classification
    - Wrong way driving detection
    - Incident detection
    - Ramp metering
    - Statistical analysis
- Enforcement
    - Red-light enforcement
    - Stationary speed enforcement
    - Portable speed enforcement
    - Mobile speed enforcement

Please note that the radar system – although being well optimized to be used for these applications – can neither achieve a detection probability of 100% nor a false alarm rate equal to zero.

1.2   MAIN FEATURES

The main features of the sensor are:

- Variety of applications
- Lane-specific detection
- Individual object tracking
- Flexible installation
- Statistics and event trigger modules
- Easy-to-use Traffic Management Configurator (TMC) software

1.3 PRINCIPLE OF OPERATION

Each radar sensor directly measures the following parameters of all moving objects simultaneously in the field of view, relative to the sensor:

- Direct unambiguous Doppler measurement (speed)
- Direct range measurement
- Direct azimuth angle measurement (horizontal angle)
- Direct elevation angle measurement (vertical angle)

Those data are stabilized by tracking algorithms. Stopped objects are kept in the tracking memory. The true vector of the relative speed is calculated and a data transformation into Cartesian coordinates is performed. Those tracked and transformed data are then transmitted via the chosen communication interface.

The interface to the superior system (detector card, PC, or similar) is a list of tracked objects transmitted via RS485, Ethernet, or another interface.

Each sensor comprises RS485 as standard interface for communication and an Ethernet or CAN interface, of which CAN is deactivated by default.

FLEXIBILITY OF THE RADAR WAVEFORM

The radar sensor supports a variety of stand-alone or combined radar waveforms. The operational mode can be determined via the firmware.

1.4 TRACKED OBJECT INTERFACE

The result of tracking is an object list with the following parameters:

- X-position
- Y-position
- Absolute velocity
- Heading angle
- Length
- Object ID and more

In any case, a visualization of objects is possible using the Traffic Management Configurator (TMC) software in any PC equipped with a CAN, RS485 or Ethernet interface. A visualization of targets can be enabled on request.[1]

For further information on the performance and communication options of the radar sensor, please refer to the respective datasheet on our website.

OBJECT OUTPUT IN WGS84 COORDINATE SYSTEM

From firmware version 6.5.0.0 and upwards, the sensor has the capability to calculate the object position in WGS84 coordinates. This feature is only available for port-based communication via RS485 or Ethernet.

Note: It is not allowed to rotate the world map (e.g., Google Maps) in the TMC.

For this feature it is mandatory to set the sensor position in WGS84 coordinates with the following parameters:

Name	Description	UAT Version	Par No.	Default	Action	Types	Typical Values
tm_wgs84_latitude_intPart	latitude integer part gps position	4	56	0	2000	Parameter, Integer	-90…90
tm_wgs84_latitude_fracPart	latitude decimal gps position	4	57	0	2000	Parameter, Integer	-1…1
tm_wgs84_longitude_intPart	longitude integer part gps position	4	58	0	2000	Parameter, Integer	-180…180
tm_wgs84_longitude_fracPart	longitude decimal gps position	4	59	0	2000	Parameter, Integer	-1…1

1 Depending on the interfaces provided by the radar sensor; please check the system requirements of the TMC.

Example:

> Headquarter:

>> Latitude: 52.31105

>>> tm_wgs84_latitude_intPart = 52

>>> tm_wgs84_latitude_fracPart = 0.31105

>> Longitude: 10.538137

>>> tm_wgs84_longitude_intPart = 10

>>> tm_wgs84_longitude_fracPart = 0.538137

Further information for the data output can be found in the corresponding documentation for data communication protocol.

1.5   STATISTICS MODULE FEATURES

The Statistics Module is a software extension, which is based on the tracked object list. The tracked objects provide a high update rate of data per vehicle, which are interpreted and accumulated by the Statistics Module to reduce the amount of data transferred to the user. It also allows for the transfer of data at user-selectable time intervals. The user can select the statistics data separately.

Basic features are:

- Lane-specific reports
- Reports per measurement zone (max. 32 measurement zones)
- Report of statistical data
    - Volume
    - Occupancy
    - Average speed

Extended features are:

- Reports per vehicle class
- Report of statistical data
    - 85 percentile speed
    - Headway
    - Gap
- Capability to either polling or reporting activities

Please contact us for a detailed documentation.
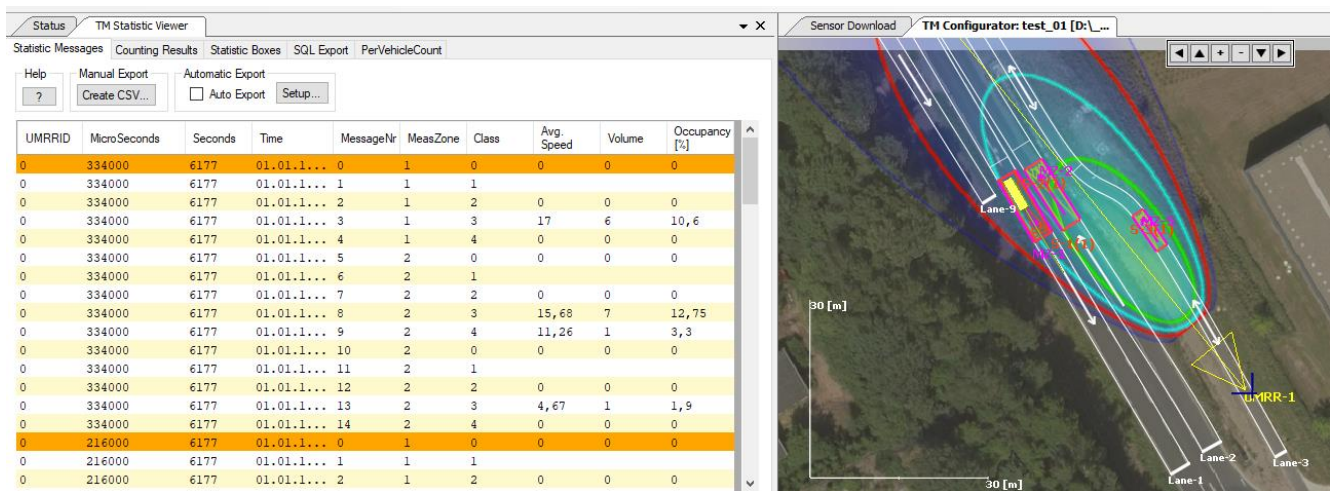
Figure 1-1: Example of the Statistics Module output in the TMC

Please refer to chapter 6 which describes the Statistics Module features, the output ports, and the available commands.

1.6   EVENT TRIGGER MODULE FEATURES

The Event Trigger Module is a software extension, which is based on the tracked object list. With a focus on certain events, the user can define and select from a variety of trigger conditions for each zone. Those triggers can be assigned to virtual relays. Each sensor supports up to 64 virtual relays. The user can select the output from the virtual relay status conditions separately. The output rate is also user selectable.

Figure 1-2: Example of the Event Trigger Module setup and output in the TMC

The following features are provided:

-   Lane-specific reports
-   Reports per zone (max. 32 zones)
-   Up to 64 virtual relays are triggered
-   Types of trigger
    -   Presence
    -   Speed
    -   Estimated Time of Arrival (ETA)[2]
    -   Vehicle class
    -   Wrong way driving
    -   Queue length estimation
    -   Custom trigger
-   Individual delay and extension of trigger signals

Please refer to chapter 6 which describes the Event Trigger module features, the output ports, and the available commands.

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[2] For the United States, a one-time ETA is provided.

1.7 SENSOR INTERFACES

The sensor supports the following interfaces:

- RS485 full-duplex
    - 115kbps per default, higher baud rate is possible
- CAN 2.0b
    - High-speed, 500kbps
- 100Mbps Ethernet per default

The interfaces can be accessed through the connector on the rear side of the sensor. Please refer to the sensor datasheet on our website for further details.

Figure 1-3: Rear side of the sensor

WIRELESS COMMUNICATION

Several GSM and HSDPA modems have been tested and validated to work with the sensor. Please contact us for further details.

1.8 SENSOR AND HARDWARE IDENTIFICATION

The sensor housing is tagged with a type sticker containing the product description and the serial number. It also indicates which side of the sensor is the top side.
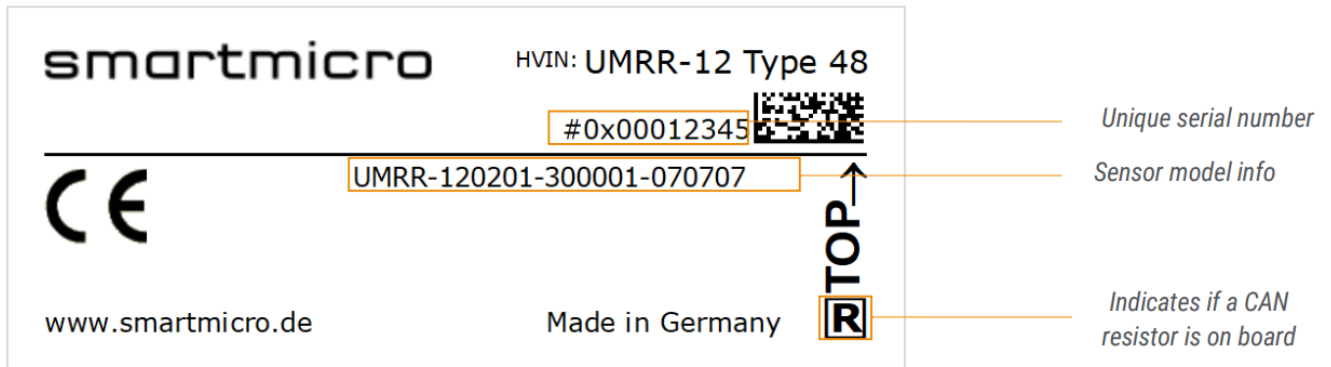
Figure 1-4: Sticker example

Each sensor is labelled with the respective sensor model information "UMRR-xxyyzz-aabbcc-ddeeff"

- UMRR   Universal Medium Range Radar developed by smartmicro
- -xx   DSP board generation
- -yy   DSP board derivative/version
- -zz   DSP board revision
- -aa   RF board (antenna)
- -bb   RF board derivative/version
- -cc   RF board revision
- -dd   Housing type
- -ee   Housing version
- -ff   Housing revision

Additionally, the DSP board and the RF board have their own unique serial numbers.

1.9 COORDINATE SYSTEM

The angle measurement of the sensor always refers to the x-axis and is always between +180° and -180°, depending on the direction of the speed vector.

Variables:

r_X − range in x-direction
r_Y − range in y-direction
v_X − speed in x-direction
v_Y − speed in y-direction
$|v|$ − speed magnitude
Ψ − heading

r_r − range radial
v_r − speed radial
α − angle

Figure 1-5: Drawing of the coordinate system

The center of the global coordinate system is shown by the orange „axis symbol" in the TMC

Figure 1-6: Angle signs in the coordinate system

1.10 GROUNDING REQUIREMENTS

The housing of the sensor is not grounded but connected to the negative supply voltage instead. To assure the correct operation of the sensor, please contact us for grounding instructions.

1.11 CABLE SPECIFICATIONS

The cable requirements for the installation of the sensor are:

- For the utilization with a smartmicro Junction Box (J-Box):
    - Outer diameter of 9mm to 13mm or 9.35in to 0.51in
    - Cable outlet also available for 6.5mm to 9.5mm or 0.26in to 0.37in
- Power wires:
    - AWG18, or rather cross section of 1mm² or larger recommended[3]
    - For all installations, the minimum voltage indicated in the datasheet needs to be granted for the operating unit
    - For NEMA cabinet installations, a voltage drop by less than 14V is required
- Data wires:
    - Twisted pair for CAN 2.0b and RS485 full-duplex
    - Four wires, two wires each as twisted pair for RS485 full-duplex and 10/100 Mbps Ethernet
    - Z can vary from 100 Ohm to 120 Ohm at 100kHz/1MHz
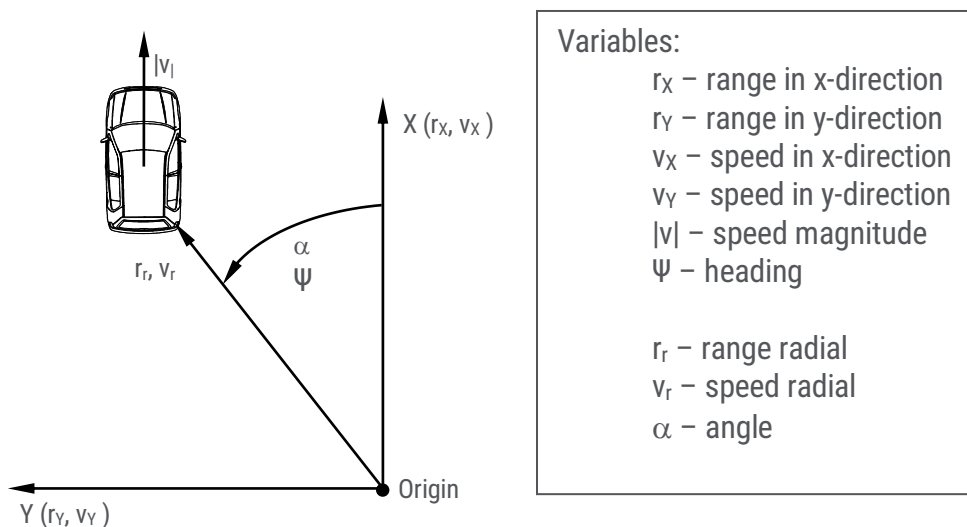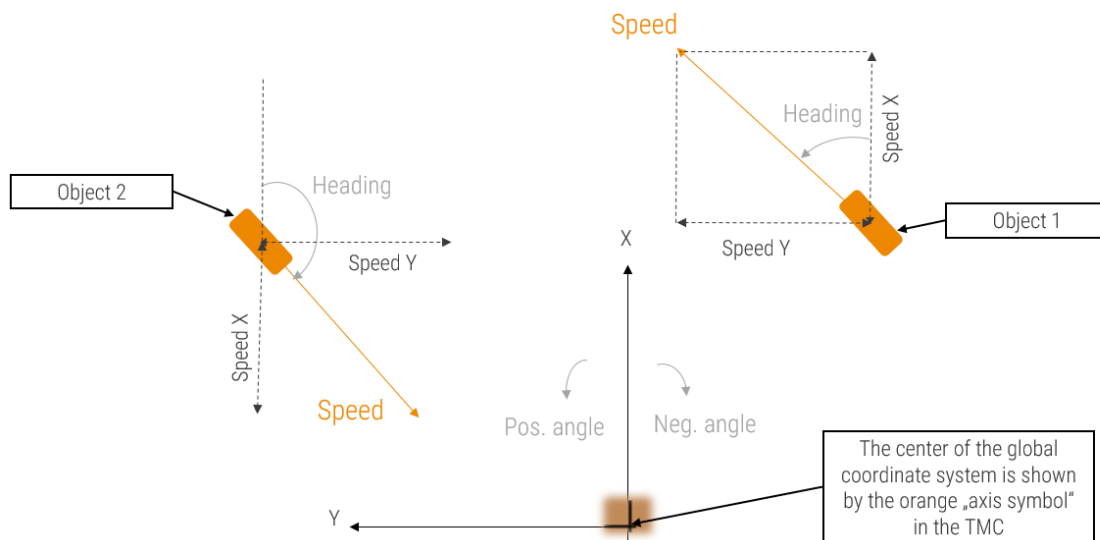   - AWG24, or rather cross section of 0.22mm² or larger
    - Loop resistance better than 190 Ohm/1000m

Please note that smartmicro can give no warranty on cable types other than those verified by smartmicro throughout testing and recommended as such. It is the customer's own responsibility to test and verify other cables for their particular purpose and installation variants, especially regarding communication capabilities.

TESTED CABLES

The following field cables have been verified throughout testing by smartmicro, please contact us for further information.

- Lapp UNITRONIC BUS YV COMBI IBS 3x2x0.22, 3x1.0 ROHS
    - Manufacturer part no. 2170217
    - Rated for direct burial or natural UV resistance
    - Tested distance: 161m or 528ft
- Lapp UNITRONIC LAN 1000 s/FTP Cat. 7 (L) PE 4x2xAWG 23/1
    - Manufacturer part no. 2170198; Cat.7 cable
    - Rated for direct burial
    - Tested distance: 100m or 328ft
- Draka cable UC300 CAT5e AWG23
- Draka cable UC900 CAT7 AWG24

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[3] For the utilization with a J-Box, a conductor reduction at the clamp by 0.5mm² is required.

2   ACCESSORIES

The sensor is enriched by a set of accessories to meet various customer needs. The following products are only a brief selection, for a complete list please visit our website.

2.1   BRACKET

To facilitate the mounting and adjusting of the sensor, we offer two types of brackets. Our standard brackets allow for adjusting the elevation angle of the sensor. They are designed to facilitate the mounting on a pole or wall, as well as the usage of the sensor on a tripod. Our advanced brackets allow for adjusting both azimuth and elevation angle. They are designed to further cover both horizontal and vertical pole mount, as well as straight or angled orientation. For further information, please refer to the datasheet on our website.

2.2   SHIELD

Our protective shields protect the sensor radome surface from adhering rain drops, snow or ice build-up. However, the shield is not intended to serve as a full enclosure and will therefore not prevent all such accumulation. For further information, please refer to the datasheet on our website.

2.3   JUNCTION BOX

The smartmicro Junction Box (J-Box) offers a simple and reliable way to connect smartmicro radars to any home-run cable, connecting the sensor to the cabinet. It can accommodate a wide range of cables inside a water-tight sealing and connects the cables to a terminal block. The J-Box also protects the radar from voltage surges and overvoltage. It can be easily added to the back of the sensor. A simple J-Box is available for RS485 only and a full J-Box version is available for all interfaces. For further information, please refer to the datasheet on our website.

2.4   RS485 TO USB CONVERTER

By means of the RS485 to USB converter, you can easily connect the sensor to a PC at low cost. For 24/7 installations, an industrial solution like Moxa Uport 1130I or 1150 is suggested. Please visit our website for further information.

2.5   ALIGNMENT TOOL

The Electronic K-band Target Simulator Doppler Generator (EKTSDG) is battery-powered, handheld, and portable. It was specifically developed to work with our 24GHz sensors and is capable of simulating a moving target in distances of up to 100m or 328ft and speeds between 1-300kph or 0.6-187mph. It can be used for installation, alignment, calibration or function testing of sensors in the field or lab. For further information, please refer to the datasheet on our website. Please contact us for further instructions on how to setup the sensor for using the EKTSDG, since the sensor has to be set in a special mode.

2.6   CABINET INTERFACES

2.6.1   TRAFFIC MANAGEMENT INTERFACE BOARD

Our Traffic Management Interface Board (TMIB) connects up to four sensors at an intersection and enables their connection to any type of traffic controller. The data lines from multiple connected radars are made available on one single Ethernet interface. For the US market, there are NEMA TS1/TS2 compliance and SDLC interfaces available. For further information, please refer to the datasheet on our [website](#).

2.6.2   CABINET INTERFACE OPTION

The smartmicro Cabinet Interface Option (CIO) is an interface panel that provides power surge protection for up to four radar sensors and a Traffic Management Interface Board (TMIB). The typical installation of a CIO includes a TMIB that provides RS485 connectivity to the radar sensors.

The interface panel has individual power on/off switches and LED indicators for each radar sensor to simplify the installation. The CIO provides both electrical connectors for the cables coming in from the four sensors outside the cabinet and multiple stages of electrical surge suppression to protect the cabinet equipment from external surges and noise. This surge protection includes Gas Discharge Tubes (GDTs), Transient Voltage Suppression diodes (TVSs), high-speed resettable electronic fuses (TBUs) and a replaceable fuse. Power is 110V or 220V AC to the replaceable power supply on the interface panel, typically wired from the protected side of the cabinet power distribution. No supplemental surge suppression is required.

The CIO consists of a Rail, one CIO Module, power supply, circuit breaker, terminal blocks and end brackets. It comes with power signals pre-wired from the factory and has the following features:

-    Inbuilt surge and power protection
-    Four LEDs indicate the power status of each sensor/channel
-    One LED indicates the status of the main power supply
-    Two LEDs per sensor to indicate RS485 communication link and activity

For further information, please refer to the datasheet on our [website](#).

2.7   COMMUNICATION INTERFACES

2.7.1   RELAY OUTPUT OPTION

The smartmicro Sensor Relay Option (SRO) can be attached to the back of the sensor and offers 8 hardware relays and surge protection in addition to the sensor's CAN or RS485 or Ethernet communication interface. It is available as a separate accessory for the sensor and offers surge protection for all signals.

For further details, please refer to the datasheet on our [website](#).

2.7.2   CABINET RELAY OPTION

The smartmicro Cabinet Relay Option (CRO) is a hardware module that extends a smartmicro radar sensor by eight hardware relays via the standard RS485 communication interface.

It can be used to implement traffic applications without an additional controller unit being necessary and has the following features:

- Connector to a sensor cable
- Connector to power supply
- Connector for RS485 communication to a PC
- Eight configurable solid-state relays per sensor (normally-closed (NC) contacts)
- Surge protection on power, communication, and relay lines

The CRO Base consists of a rail, one CRO Module, power supply, circuit breaker, terminal blocks and end brackets. It comes with power signals pre-wired from the factory.

For the use of two, three or four sensors, the CRO Base can be extended with the respective number of CRO Modules. Please note that only the first CRO Module is pre-wired.

For further details, please refer to the datasheet on our website.

2.8   CIO AND JUNCTION BOX SURGE SUPRESSION

The surge protection of CIO and JBOX works as follows. Gas Discharge Tubes (GDTs) on all incoming power and data lines are used to protect against strong voltage spikes. At a second stage, Transient Voltage Suppression diodes (TVSs) eliminate any remaining unwanted voltage spikes. For all data lines, high-speed resettable electronic fuses (TBUs) offer an additional level of protection, which is not needed nor possible for power lines.

In case of a near-by lightning strike, all GDTs will ignite and divert the power surge away from the equipment. For this, they create an intentional short-circuit from the incoming wires to ground. Once the voltage on each wire has dropped below a threshold voltage of below 10 V (may vary slightly in different revisions), the protection mode is ended, and normal operation is resumed. For all data lines, this is instantly the case after the power surge has ended. On the positive supply line however, the voltage provided by the power supply may keep the protection mode running. As connected radars will not receive enough voltage while the GDT is still in protection mode, the power supply may need to be switched off and then on again to retain normal radar operation.

3 TRUGRD PRODUCTS

Within our premium product line there are multiple TRUGRD Products that will be described in the following.

3.1 TRUGRD (UMRR-12 TYPE 48)

TRUGRD (UMRR-12 Type 48) is a new premium product and the follow-up radar sensor of UMRR-0C Type 42. It is a 24GHz radar sensor for multi-lane, multi-object tracking traffic management applications that features 4D/UHD+ technology. The sensor features, for example, improved technical capabilities, an improved performance in dense traffic scenarios, as well as web connectivity and remote access using embedded Linux.

Figure 2 1: TRUGRD (UMRR-12 Type 48)

3.2 TRUGRD STREAM

TRUGRD Stream combines a video camera with a 24GHz radar. The video camera and the radar are integrated into one housing. The radar sensor and the video camera act as independent devices. The radar sensor carries out the detection.

The camera stream functions as an additional sensor modality to get an overview of the current traffic situation and to visually validate the output of the radar sensor.

Figure 3-1: TRUGRD Stream

3.2.1 GENERAL CAMERA SETTINGS

The following table show the default settings of the IP camera of TRUGRD Stream

TRUGRD Stream default IP camera settings (Table 3-1)

Parameter	Value
DHCP	Off
IP	192.168.17.168
Subnet Mask	255.255.0.0
Full Stream URL	rtsp://192.168.17.168:553/stream
Protocol	RTSP
Port	553
Video1 Encoding:	H-264
Resolution	1920x1080

Note: The video is a UDP multicast stream that can be accessed using the TMC, the VLC Player, or a web browser.

Note: Please make sure to clean the camera lens before use

3.2.2 HOW TO ACCESS THE CAMERA

Open a web browser and type in 192.168.17.168

✓ Click Login
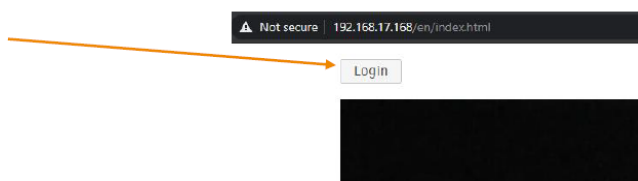
Figure 3-2: Camera login

The sign-in page will appear
- Default username: integrator
- Default password: integrator
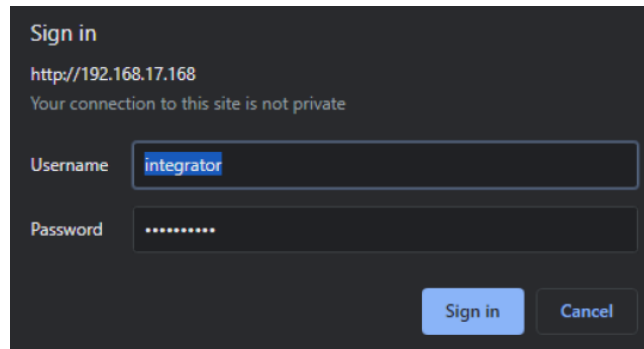
Figure 3-3: Camera sign in

Once you are signed in, the network and encoder settings can be accessed via the navigation bar on the left.
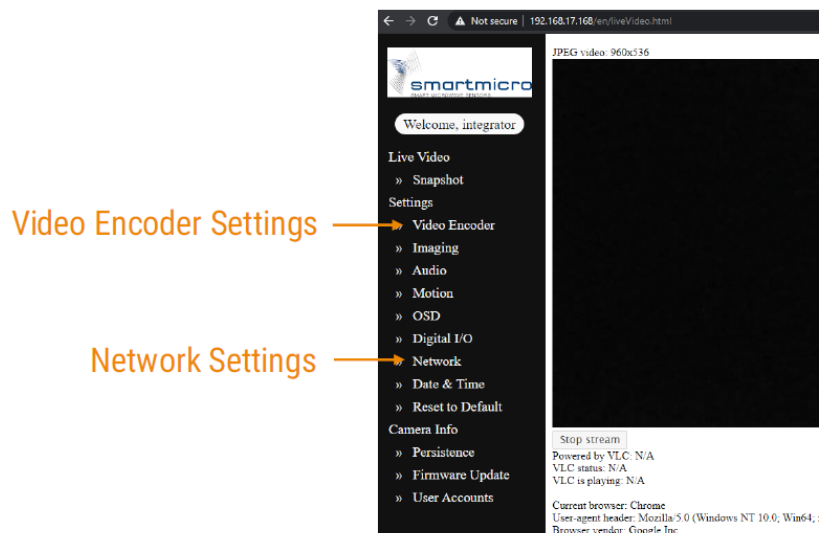
Figure 3-4: Camera navigation menu

The video encoder and network settings are as follows:

Figure 3-5: Video encoder setting

Figure 3-6: Network setting

4   SELECTING THE SENSOR MODEL AND LOCATION

Please note that frequency regulations may vary from country to country and that the usage of the lower power mode of the sensor may be necessary.

4.1   SELECTING THE RIGHT SENSOR MODEL

This sensor model is the right choice if one or more of the following situations apply:

- More range than achievable with UMRR-11 Type 44 or 45 is desired
- More than six lanes need to be covered
- Traffic density is very high
- Best possible detection and classification accuracy is required under challenging conditions
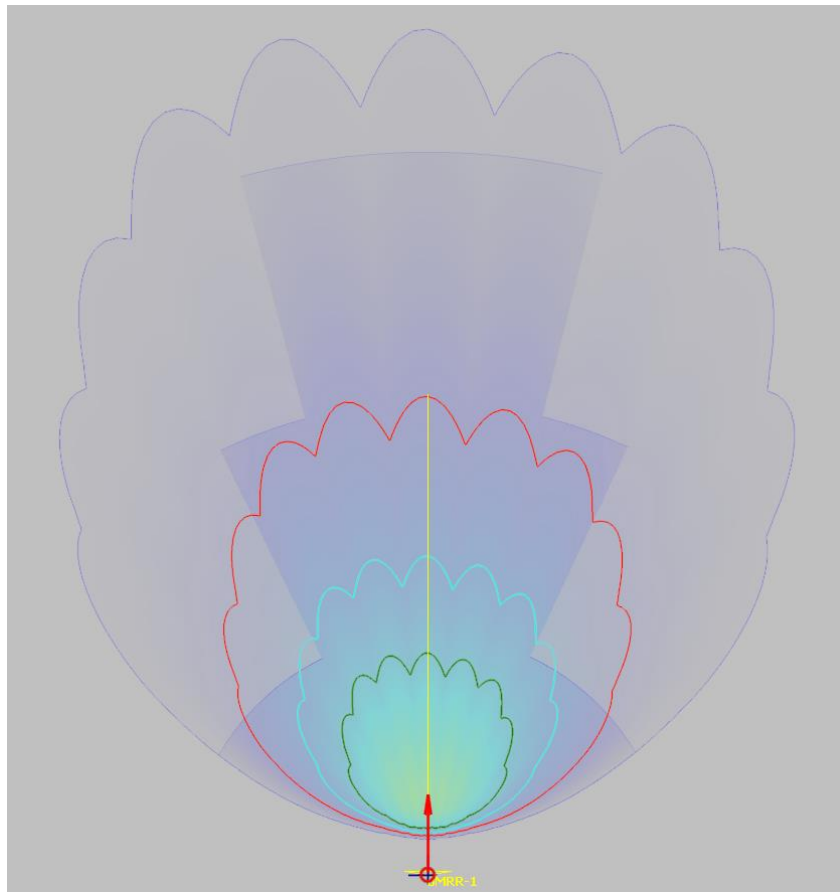
Figure 4-1: General characteristics of the antenna (waveform 0)

COMPARISON OF LOW AND HIGH POWER MODE

The edge of the colored beam pattern indicates the limit of the signal processing. The radar may detect beyond that distance, but objects would neither be calculated, nor displayed.
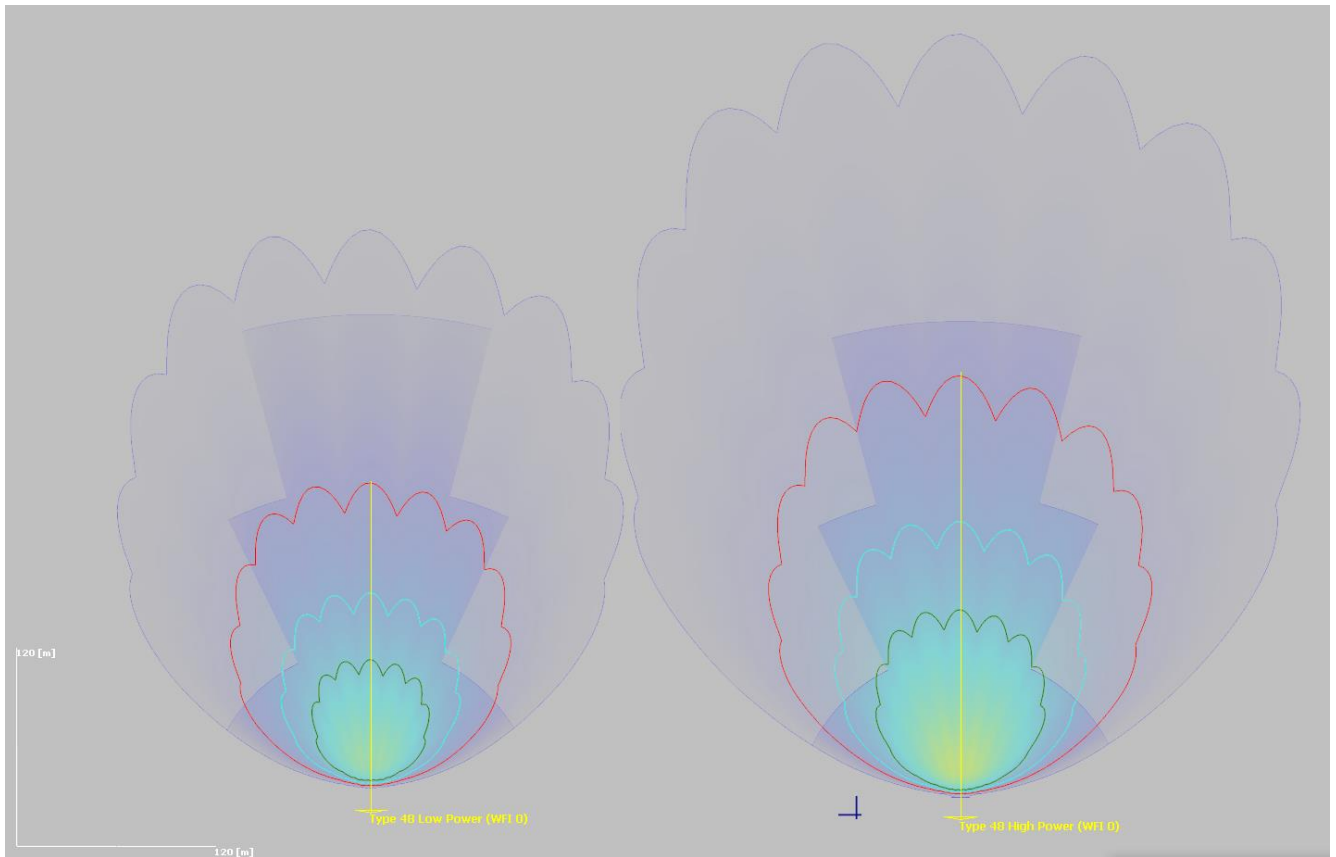
Figure 4-2: Low (left) and high (right) power mode

The high power mode allows for a higher detection range but please note that within the light blue region no detection is possible.

4.2   SELECTING THE RIGHT MOUNTING POSITION

To achieve the best radar performance, the adequate location needs to be chosen carefully. The responsible person for installing the sensor needs to go through the following steps:

- Verify that there are >20m or >65ft between the maximum range and the area of interest.
- Verify that the lanes are fully covered, including some allowance at the beam limits. The illustration below shows that the example (B) is selected too tight.
- Verify that the horizontal angle to the road is within -25° and +25°.[4]
- Verify that the vertical angle to the ground is within -8° and +3°. Typically, -12° to +5° are plausible.
- Mount the radar at suitable height, typically at 6m or 19.6ft.[5]
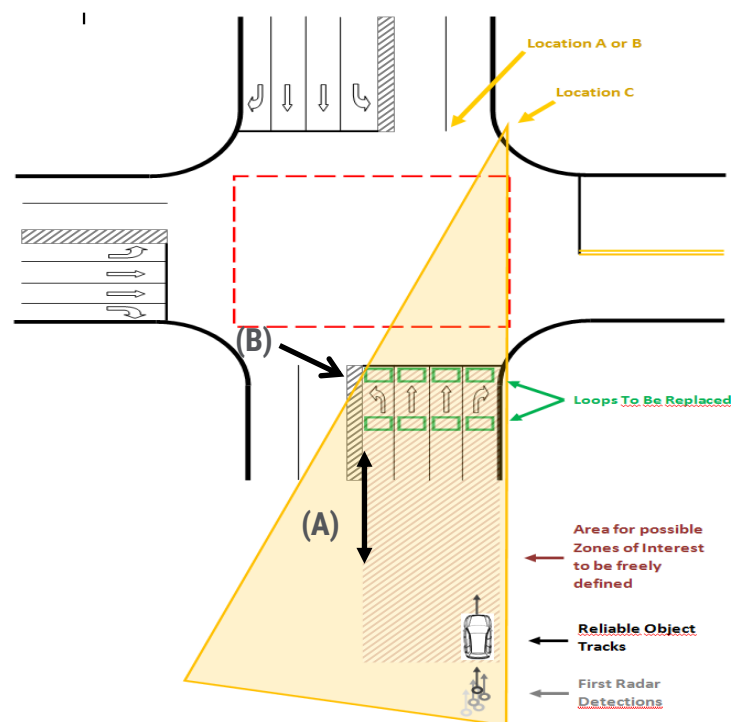
Figure 4-3: Select Area of Interest

Also, the sensor should be mounted on a stiff and solid mounting base. The smaller the angle towards the stop bar, the better. A smaller angle improves the utilization of the sensor beam and occlusion of vehicles in adjacent lanes becomes less likely. This means, that mounting the sensor on a mast arm is usually better than mounting it close to the ground. However, the mast arm must not move due to wind or other environmental influences. If it does, a position of the mast arm needs to be chosen, where the movement is kept to a minimum.

Please note that vibration, oscillation, or any other kind of movement will reduce the sensor performance.

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[4] A steeper elevation angle is possible but limiting the maximum range. A negative elevation angle means that the sensor is pointing towards the road.
[5] The mounting height may affect the maximum detection range. Occlusion needs to be considered.

On existing infrastructure, the sensor can be mounted in the following positions:
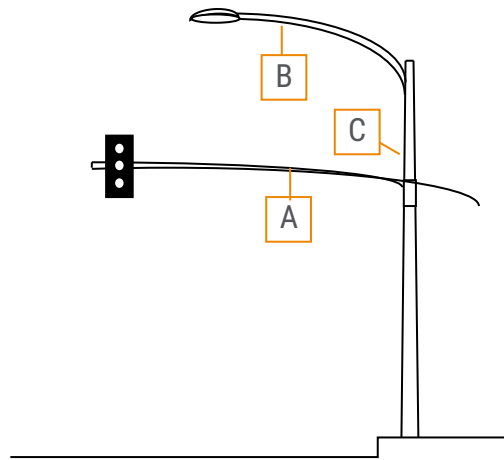
Figure 4-4: Mounting positions on existing infrastructure

A) On the mast arm close to the vertical pole (ideal position)

B) Adjacent to a luminaire

C) On a vertical pole

We recommend position (A) for best performance, since a stiff and motion-free mounting base is required and a small angle towards the detection zone is recommended. If the structural conditions of the luminaire or the mast arm allow for a stiff attachment of the sensor, position (B) or (C) are potential alternatives.

Please refer to the respective sensor datasheet for a recommendation of the distance to the stop bar or the area of interest, as well as the azimuth and elevation angle that should be used to achieve the best performance.

4.3 COVERING THE AREA OF INTEREST

The radar beam covers an oval shaped area on the ground. The responsible person for the installation has to verify that the measurement point is located inside the area covered by the beam.

The following aspects need to be verified:

- (A) On all lanes there need to be >20m or >65ft covered by the beam between the area of interest and the maximum range of the sensor.
- (B) The lanes need to be fully covered by the beam. The stop bar zones should be fully covered by the cyan beam.
- (C) The green beam should not cover too much additional area on the right or left side of the stop bar. However, some allowance should be included at the outer lines of the beam on all lanes.

For recommended mounting parameters, please see chapter 4.5.
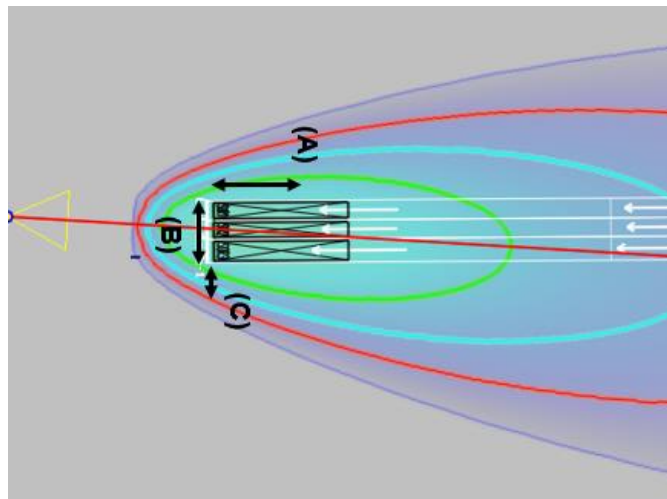
Figure 4-5: Verify the beam coverage

4.4   USING A VERTICAL INSTALLATION ANGLE

The radar beam has a limited vertical field of view, as shown in the figure below.
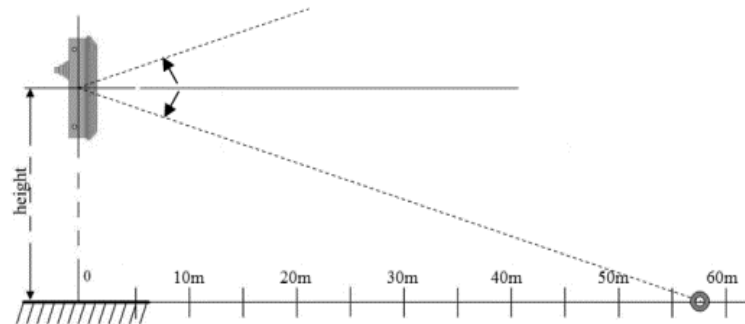
Figure 4-6: Vertical opening angle of the radar beam

The responsible person for installing the sensor needs to check the following steps:

- Possible mounting heights are 1m to 10m or 3ft to 33ft above the ground.
- The minimum detection range depends on the mounting height and the elevation angle.
- The beam simulation of the TMC software can be used to verify the coverage of your area of interest

The TMC software has been designed to simulate[6] the radar beam on the road according to the height, vertical and horizontal angle, as well as the selected antenna.
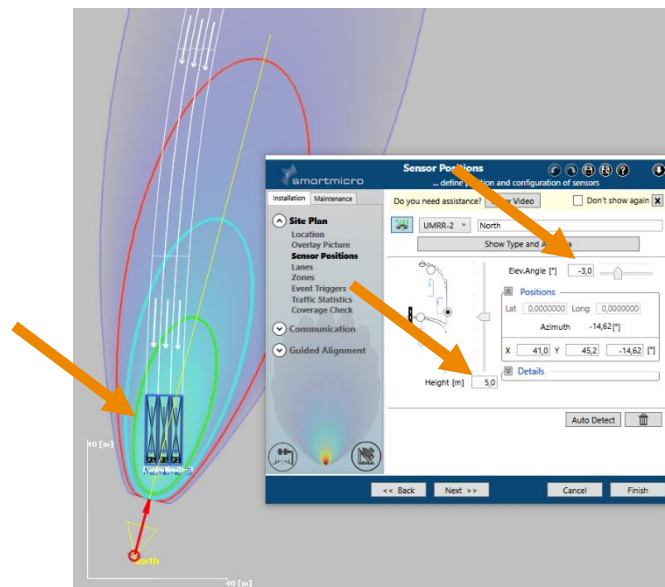
Figure 4-7: TMC beam simulation

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[6] Please note that this is a simulation only aiming to provide guidance but not guaranteeing the detection within the area displayed.

4.5   STANDARD SETTINGS

For the best possible counting and classification performance of the sensor, the following settings should be used:

- Sensor height: 6m or 19.6ft
- Vertical angle: -2°, -3°, -6°, or -8° towards the road
- Horizontal angle: -10° to 0°
- The detection zones should be placed at the following distances:
    - At 25m or 82ft (20m to 90m or 65.6ft to 295ft) for approaching traffic
    - At 120m or 393.7ft (50m to 150m or 164ft to 492ft) for receding traffic

For further details, please refer to the sensor datasheet on our website.

4.6 TMC BEAM SIMULATION

The TMC (see section 7.6) provides a beam simulation for the responsible person to install the sensor which helps to predict the beam coverage of the road.

- Enter the sensor model information
- Select the right waveform for the application
    - Waveform 0 for Stop+ Advance
    - Waveform 1 for Forward+
    - Waveform 2 for Red-Light and Speed Enforcement
- Expand "Details" to choose high or low power setting[7]
- Enter the mounting height and the elevation angle towards the road. The elevation angle towards the road should be within -12° and +3°
- The TMC will simulate the beam
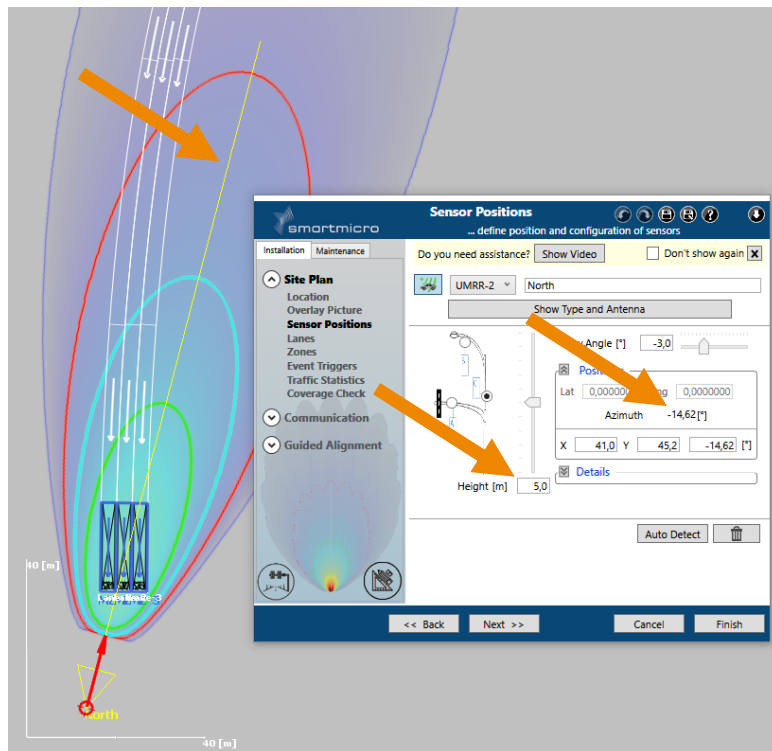
Figure 4-8: TMC beam simulation

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[7] Not all power modes are available for every country.

5 DATA COMMUNICATION

The data communication protocol for the sensor is described separately, please contact us for further details and note that a Non-Disclosure Agreement (NDA) is required to obtain this document.

The user can parameterize the sensor by setting parameter instructions.

All instructions related to RS485 communication are UAT V4 instruction type. Make sure that UAT V4 is selected within the drop-down menu in the sequence commander. All instructions related to Ethernet communication are port-based instructions.
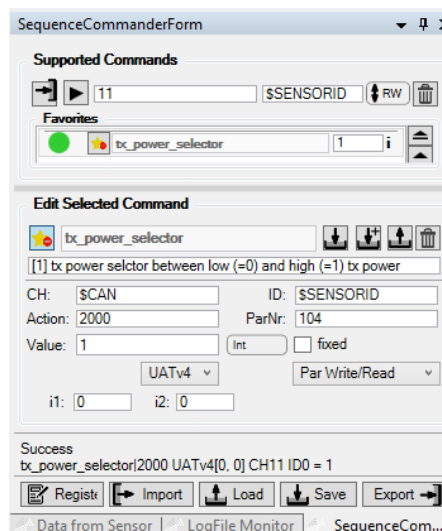
Figure 5-1: Sequence Commander window (UAT V4)

5.1 SENDING AN INSTRUCTION WITH THE TMC

Important instructions are provided within the sequence commander window. A list of important instructions can also be imported as .param, .status, or .command file. The TMC software is recommended for transmitting instruction messages to the sensor.

For sending instructions, please follow these steps:

1. Define a name for the instruction, for example "TestCommand"
2. Hit "+" button to add the instruction
3. Action (=Section), ParNr (=ID)., Value and UAT can be entered
4. Click "Save"
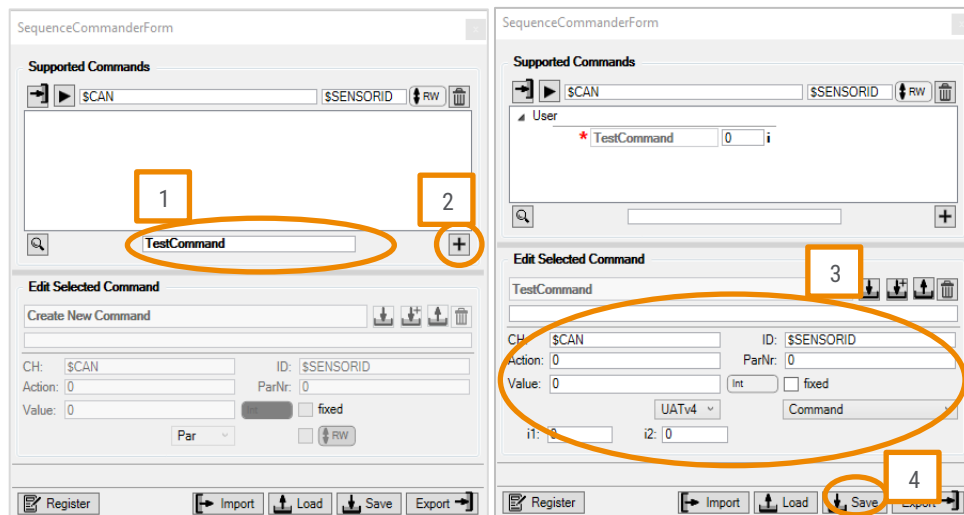
Figure 5-2: Steps one to four

5. The instruction can now be executed by clicking on the play button
6. The value can be changed directly in the upper part of the window
7. A predefined instruction can be loaded or exported
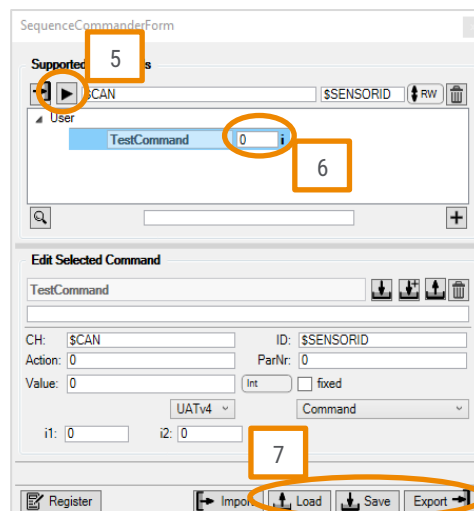
Figure 5-3: Steps five to six

In the installation folder of TMC 3.1 or higher version, for example "C:\Program Files (x86)\TMConfigurator_V31_2G_ALL_REG\Interfaces\" , you can navigate to the interface version supported by the firmware and import it the command configurator. The firmware version 6.4.1.0 support for example the interface 6.2.1

5.2 BASIC INSTRUCTIONS

The following instructions are often used as user input, the TMC software (see also section 7.6) sets those instructions in alignment mode. Please note the indications that some instructions are required for managing installations with multiple radar sensors and some instructions are suggested to experienced users only.

Basic instructions – UAT V4 (Table 5-1):

smartmicro
SMART MICROWAVE SENSORS

Name	Description	ID	Default	Section	Types	Typical Values
Set Unix Time[8][9]	Sets a new unix time as sensor time	8	0	2020	Command, Integer	Min.: 1. January 2018 00:00:01 → 1514764801
CAN Output	Activates the CAN interface	10	0	2000	Parameter, Integer	0 = deactivated 1 = activated
RS485 Output	Activates the RS485 interface	11	1	2000	Parameter, Integer	0 = deactivated 1 = activated
Ethernet Output	Activates the Ethernet interface	12	1	2000	Parameter, Integer	0 = deactivated 1 = activated
Output Control Target List[8]	Activates the output of the detection target list	200	0	2000	Parameter, Integer	0 = disabled 1 = enabled
Output Control Object List[8]	Activated the output of the object list	201	1	2000	Parameter, Integer	0 = disabled 1 = enabled
Output Control Trigger Messages[8]	Activates the output of the trigger messages	202	1	2000	Parameter, Integer	0 = disabled 1 = enabled
Output Control Statistic Messages[8]	Activates the output of the statistic messages	203	1	2000	Parameter, Integer	0 = disabled 1 = enabled
Output Control PVR Messages[8]	Activates the output of the PVR messages	204	1	2000	Parameter, Integer	0 = disabled 1 = enabled
Output Control Queue Length Messages[8]	Activates the output of queue length messages	205	1	2000	Parameter, Integer	0 = disabled 1 = enabled
Object Simulation	Activates the object simulation mode	62	0	2004	Parameter, Integer	0 = deactivated 1 = simulation on straight lines 2 = simulation along splines/ lanes

[8] Suggested to experienced users only.
[9] Not available yet.

Object Simulation Number of Lanes	Number of simulated lanes	63	4	2004	Parameter, Integer	Up to 64 lanes
Object Simulation Number of Objects per Lane	Number of simulated objects per lane	64	5	2000	Parameter, Integer	Up to 64 objects per lane
Relay Simulation	Trigger output simulation	303	0	2000	Parameter, Integer	0: simulation off 1: submode 1 (individual trigger setting) 2: submode 2 (running trigger, in turn)
active_relays_part1	Defines active relays (bit-coded) for relay simulation 1 (relay1…32)	319	1	2000	Parameter, Integer	Default: 1
active_relays_part2	Defines active relays (bit-coded) for relay simulation 1 (relay33…64)	320	0	2000	Parameter, Integer	Default: 0
Number of Simulated Relays	Defines number of simulated relays for relay simulation 2	321	8	2000	Parameter, Integer	0 to 64

In order to set the network parameters for the sensor, it is necessary to set the sensor to "Configuration mode" via the following command instruction:

Network instructions – UAT V4 (Table 5-2):

Name	Description	ID	Default	Section	Type	Typical Values
Config Mode	switches TRUGRD sensor to Config Operational Mode	12	1	2020	Command, Integer	1

Name	Description	ID	Default	Section	Type	Typical Values
IP Adress byte 0	First Byte of IP Address	0	192	2021	Parameter, Integer	192
IP Adress byte 1	Second Byte of IP Address	1	168	2021	Parameter, Integer	168
IP Adress byte 2	Third Byte of IP Address	2	11	2021	Parameter, Integer	11
IP Adress byte 3	Fourth Byte of IP Address	3	11	2021	Parameter, Integer	11
Subnet Mask Byte 0	First Byte of SubNet Mask	4	255	2021	Parameter, Integer	255
Subnet Mask Byte 1	Second Byte of SubNet Mask	5	255	2021	Parameter, Integer	255
Subnet Mask Byte 2	Third Byte of SubNet Mask	6	255	2021	Parameter, Integer	255
Subnet Mask Byte 3	Fourth Byte of SubNet Mask	7	0	2021	Parameter, Integer	0
Broadcast Byte 0	First Byte of Broadcast	8	192	2021	Parameter, Integer	192
Broadcast Byte 1	Second Byte of Broadcast	9	168	2021	Parameter, Integer	168
Broadcast Byte 2	Third Byte of Broadcast	10	11	2021	Parameter, Integer	11

Broadcast Byte 3	Fourth Byte of Broadcast	11	255	2021	Parameter, Integer	255
Default Gateway Byte 0	First Byte of Default Gateway	12	0	2021	Parameter, Integer	
Default Gateway Byte 1	Second Byte of Default Gateway	13	0	2021	Parameter, Integer	
Default Gateway Byte 2	Third Byte of Default Gateway	14	0	2021	Parameter, Integer	
Default Gateway Byte 3	Fourth Byte of Default Gateway	15	0	2021	Parameter, Integer	
Destination Client ID	Destination Client ID (target)	16	0x100 0001	2021	Parameter, Integer	

Please note, that it is important that all network parameters will be set with valid values.

Now, please switch back to the "normal mode" with the following command:

Name	Description	ID	Default	Section	Type	Typical Values
Normal Mode	switches TRUGRD sensor to Normal Operational Mode	11	1	2020	Command, Integer	1

The sensor will now use the new network setup parameters after the reboot.

Tracking parameters – UAT V4 (Table 5-3):

Name	Description	ID	Default	Section	Types	Typical Values
Execute Tracking[10]	Execute tracking	0	1	2004	Parameter, Integer	0 = deactivated 1 = activated
Output Position on Spline	Object always moves on a spline	127	1	2004	Parameter, Integer	0 = deactivated 1 = activated
Convert Class into Length	Class is coded in object length	60	2	2004	Parameter, Integer	0 = only length estimation 1 = only class

[10] Suggested to experienced users only.

						2 = class & length estimation
Max_hold_time	Maximum time to hold an object	40	180	2004	Parameter, IEEE Float	0 to 65535s
Min_age_for_hold	Minimum age of cycles to hold an object	41	35	2004	Parameter, IEEE Float	0 to 65535 cycles

Mounting parameters – UAT V4 (Table 5-4):

Name	Description	UAT Version	ID	Default	Section	Type	Typial Valus
xPos	X-position of the sensor in the Cartesian coordinate system	4	50	0.0	2000	Parameter, IEEE Float	-300.0 to +300.0m
yPos	Y-position of the sensor in the Cartesian coordinate system	4	51	0.0	2000	Parameter, IEEE Float	-300.0 to +300.0m
zPos	Z-position of the sensor in the Cartesian coordinate system	4	52	5.0	2000	Parameter, IEEE Float	-20 to +20m
xy Orientation	Azimuth angle	4	53	0.0	2000	Parameter, IEEE Float	-180.0 to 180.0°
xz Orientation	Elevation angle	4	54	0.0	2000	Parameter, IEEE Float	-90.0 to 90.0°
yz Orientation	Turned upside down	4	55	0.0	2000	Parameter, IEEE Float	-180 to 180° 0°=unturned 180°=turned

5.3   SPECIAL INSTRUCTIONS

The following command instructions are available for the sensor:

Name	Description	ID	Section	Type	Typical Values
Factory Reset	Sensor reset to default configuration	2	2020	Command, Integer	1
Sensor Reset	Restart without delay	3	2020	Command, Integer	1
UNIX Time	set the unix time [s]	8	2020	Command, Integer	Unix time [s]
Reset TM Statistics	reset tm statistic module	10	2020	Command, Integer	1
Normal Mode	switches TRUGRD sensor to Normal Operational Mode	11	2020	Command, Integer	1
Config Mode	switches TRUGRD sensor to Config Operational Mode	12	2020	Command, Integer	1
Reset on Error	Configures the locked device to reset on error	13	2020	Command, Integer	1
No Reset on Error	Configures the locked device to not reset on error	14	2020	Command, Integer	1

5.4   POLYGON FEATURE

This section describes the parameter setup for the polygon feature without using the TMC. Please also see the section describing how to use the polygon feature.

Polygon parameters are UAT V4 formatted arrays. The array dimensions are defined as follows:

- i1 = polygon = polygon number [0<=i1<= 15]
- i2 = corner = corner number [0<=i2<=7]

If the array has no dimensions (none), i1 and i2 are set to value 0.

General polygon settings (Table 5-5):

Name	Description	ID	Dimen-sions	Default	Section	Types	Typical Values

Active Polygon	Bit field for active polygons	90	none	1	2004	Parameter, Integer	0 to 16
usage _default _track	Usage of settings for tracks outside of all polygons	91	none	0	2004	Parameter, Integer	bit field: 0x0000001: delete_tracks 0x0000002: dont_transmit_tracks 0x0000004: deactivate_tracks 0x0000008: slow_moving_track[11] 0x0000010: can_hold 0x0000020: not used 0x0000040: use_apriori_hypo _axes 0x0000080: use_apriori_spline 0x0000100:hypo_track_spacing_active
usage _default _target	Usage of settings for target outside of all polygons	92	none	0	2004	Parameter, Integer	bit field: 0x00001: ignore_targets 0x00002: dont_init_tracks 0x00004: dont_associate_with_track 0x00008: stat_tgt_can_init_track 0x00010: hypo_0_inactive 0x00020: hypo_1_inactive 0x00040: hypo_2_inactive 0x00080: hypo_3_inactive 0x00100: no_init_tracks_hypo_axes 0x00200: no_init_tracks_spline 0x00400: stat_tgt_can_update_track 0x00800: not used 0x01000: not used 0x02000: init_tracks_radial

Polygon settings (Table 5-6):

Name	Description	ID	Dimensions	Default	Section	Types	Typical Values
Number of lines	Number of lines or points	0	Polygon	4	2009	Parameter, IEEE Float	0 to 8
Priority	Priority of the polygon	1	Polygon	1	2009	Parameter, IEEE Float	1 to 16
vel_x_min	Minimum speed limit in x direction (relative or abso-	2	Polygon	-83.33	2009	Parameter, IEEE Float	-88.0 to +88.0 m/s

[11] Suggested to experienced users only.

	lute, depending on control flags)					
vel_x _max	Maximum speed limit in x direction (relative or abso-lute, depending on control flags)	3	Polygon	83.33	2009	Parameter, IEEE Float
						-88.0 to +88.0 m/s
Vel_y _min	Minimum speed limit in y direction (relative or abso-lute, depending on control flags)	4	Polygon	-50.00	2009	Parameter, IEEE Float
						-88.0 to +88.0 m/s
Vel_y _max	Maximum speed limit in y direction (relative or abso-lute, depending on control flags)	5	Polygon	50.0	2009	Parameter, IEEE Float
						-88.0 to +88.0 m/s
Usage Track Inside Speed Limit	Bit-coded usage of track inside the speed limit	7	Polygon	400	2009	Parameter, IEEE Float
						bit field: 0x0000001: delete_tracks 0x0000002: dont_transmit _tracks 0x0000004: deactivate_tracks 0x0000008: slow_moving _track[12] 0x0000010: can_hold 0x0000020: not used 0x0000040: use_apriori _hypo_axes 0x0000080: use_apriori_spline 0x0000100: hypo_track _spacing_active
Usage Track Outside Speed Limit	Bit-coded usage of track outside the speed limit	8	Polygon	405	2009	Parameter, IEEE Float
						bit field: 0x0000001: delete_tracks 0x0000002: dont_transmit _tracks 0x0000004: deactivate_tracks 0x0000008: slow_moving _track[12] 0x0000010: can_hold 0x0000020: not used 0x0000040: use_apriori_hypo _axes 0x0000080: use_apriori_spline

[12] Suggested to experienced users only.

| Usage target | Bit-coded usage of settings for targets | 9 | Polygon | 480 | 2009 | Parameter, IEEE Float | 0x0000100: hypo_track _spacing_active

bit field:
0x00001: ignore_targets
0x00002: dont_init_tracks
0x00004: dont_associate _with_track
0x00008: stat_tgt_can_init _track
0x00010: hypo_0_inactive
0x00020: hypo_1_inactive
0x00040: hypo_2_inactive
0x00080: hypo_3_inactive
0x00100: no_init_tracks_hypo _axes
0x00200: no_init_tracks_spline
0x00400: stat_tgt_can_update _track
0x00800: not used
0x01000: not used
0x02000: init_tracks_radial |

Polygon parameters (Table 5-7):

Name	Description	ID	Dimensions	Section	Types	Typical Values
Corner X-Position of Polygon	Unit[m]	0	Polygon, corner	2007	Parameter, IEEE Float	Interval [2046 to -2046]
Corner Y-Position of Polygon	Unit[m]	1	Polygon, corner	2007	Parameter, IEEE Float	Interval [2046 to -2046]

Polygon status (Table 5-8):

Name	Description	ID	Dimen- sions	Section	Types	Typical Values
Polygon Version	Version of the polygon feature	11	none	2008	Status, Integer	
max_nof _polygons	Maximum number of possible polygons	12	none	2008	Status, Integer	
max_nof _lines	Maximum number of possible lines or points for each polygon	13	none	2008	Status, Integer	
Polygon_0_7_status	Polygon status of the polygons 0 to 7	14	none	2008	Status, Integer	bit field (4 bits for each polygon): 0x0=inactive 0x1=invalid 0x2=temporarily inactive 0xF=active
Polygon_8_15_status	Polygon status of the polygons 8 to 15	15	none	2008	Status, Integer	bit field (4 bits for each polygon): 0x0=inactive 0x1=invalid 0x2=temporarily inactive 0xF=active

Reset hardware or software by command (Table 5-9):

Name	ID	Default	Section	Types	Typical Values
Error Diag. Condition	322	17	2000	Parameter, Integer	0..31

5.5 PARAMETERS FOR TRACK AND TARGET HANDLING

The settings parameters define the behavior of each polygon, or the area beyond all polygons, regarding raw targets[13] or tracked objects. Each parameter is bit coded.

Bit-coded settings for track handling (Table 5-10):

Bit	Name	Description
0	Delete tracks	Tracks will be completely deleted
1	Don't transmit tracks	The object tracking will work normally but no tracked object are reported
2	Deactivate tracks	Track will be deactivated
3	[Irrelevant]	[Irrelevant]
4	Tracked objects can hold	Tracks will not be deleted after a full stop
5	[Irrelevant]	[Irrelevant]
6	Use apriori heading from hypo axes	Needed for tracking via hypo axes or main direction of movement
7	Use apriori heading from splines	Needed for tracing via splines
8	Hypo track spacing active	Keep the default setting

Bit-coded settings for target handling (Table 5-11):

Bit		Description
0	Ignore targets	The raw targets will not be used for the tracking
1	Don't initiate tracks	Targets cannot open new tracks
2	Don't associate with tracks	Keep the default setting
3	[Irrelevant]	[Irrelevant]
4	Hypo 0 inactive	Needed for tracking via hypo axes
..	..	..
8	No init tracks hypo axes	Needed for tracking via splines
9	No init tracks splines	Needed for tracking via hypo axes
10	[Irrelevant]	[Irrelevant]

[13] A raw target is an early pre-stage of a tracked object.

The default values for a standard polygon vary depending on what kind of movement prediction method should be used for the tracking algorithm:

- For tracking via splines, the movement of an object is predicated using the course of the closest defined lane
- For tracking via hypo(thesis) axes, the movement is predicated using the sensor's zero-degree axis as the main direction of movement.

Default values (Table 5-12):

Polygon	Tracking Method	Default Value	
		Decimal	Bits = 1
Track handling beyond all polygons	both	0	All bits are 0
Target handling beyond all polygons	both	1	Bit 0
Track handling inside defined speed range in a polygon	via splines	400	Bit 8, 7, 4
	via hypo axes	336	Bit 8, 6, 4
Track handling outside defined speed range in a polygon	via splines	23	Bit 4, 2, 1, 0
	via hypo axes	23	Bit 4, 2, 1, 0
Target handling in a polygon	via splines	488	Bit 8, 7, 6, 5, 3
	via hypo axes	744	Bit 9, 7, 6, 5, 3

5.6   FAIL-SAFE CAPABILITIES [14]

The sensor offers diagnostics for different classes of failures. They are called error diagnostic conditions. Please note that not all possible failures can be detected by the onboard diagnostics, and that the diagnostic features neither have 100% detection rate nor 0% false alarm rate.

The event trigger relay module can be configured to activate all virtual relays of the sensor simultaneously under certain conditions detected by the sensor diagnostic and self-test module. The error diagnostic conditions can be configured by the parameter instruction:

Fail-safe mode parameter (Table 5-13):

Name	ID	Default	Section	Types	Typical Values
Error Diag. Condition	322	16	2000	Parameter, Integer	0..31

Possible parameter values (bitwise OR) (Table 5-14):

[14] Not available yet

Error Diagnostic Condition	Description	Value
disabled	Error Diagnostic output is not active	0
precipitation	Falling rain or snow (default)	1
interference	Interference by another sensor or other radar sensor[15]	2
reserve	-	4
reserve	-	8
sensor blind	Material detected in front of the sensor antenna, that significantly reduces sensor's detection capabilities.	16

The values are bitwise OR. For example, the default value 9 means that the error diagnostic output is activated for rain and critical errors only.

RAIN DETECTION

The rain detection algorithm provides a set of parameters that can be adjusted to trigger the rain flag only at certain rain levels and optionally set the relay output to fail-safe state, which means that all relays are activated.

6   STATISTICS MODULE

In the following, the Statistics Module V2 is described as a top-level application running on the Traffic Management sensor.

6.1   OBJECTIVES OF THE STATISTICS MODULE V2 (SM2)

The Traffic Management sensor generates an output of tracked object lists. That output is versatile but unhandy for the end user. Furthermore, it requires comparatively high data communication bandwidth whereas the user may have low-performance microcontrollers on the backend.

The Statistics Module V2 is the 2nd generation module which is much more flexible and optimized for the customer's requests than the first generation. It is optimized for the latest and upcoming sensor generation structure.

Consequently, the Statistics Module V2 has the following capabilities:

- Executed on the sensor's processor
- Providing the sole communication interface to the user
- Significantly reducing the amount of information transmitted to the user
- Generating results directly exploitable for the user, without any further interpretation

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[15] Please note that passing cars equipped with radar sensors may trigger the interference detection without decreasing the radar performance. Therefore, it is not recommended to use the interference feature as error diagnostic condition.

- Supports up to 32 zones which can be freely placed or assigned to lanes
- Supports up to 16 vehicle classes[16]
- Providing statistics results on a per zone and per vehicle class basis with:
    - Volume output
    - Occupancy output
    - Average speed output
    - 85 percentile speed output
    - Headway output
    - Gap output
- Providing event trigger results on a per zone and per vehicle class basis with:
    - Support for multiple event trigger applications which can be set for each zone separately
    - 64 relay outputs which can be freely assigned to all 32 available zones

[16] Note: The firmware may support less classes than the Statistics Module can handle.

6.2 SPECIFICATIONS

In the following, the features and the capabilities of the Statistic Module are described.

6.2.1 TOP LEVEL CONSIDERATIONS

- The module supports monitoring of 32 zones in total
- The zones can be freely placed or assigned to predefined splines
- For each zone the statistics can be collected
- For each zone an event trigger can be defined
- The module keeps the last time stamp and calculates the time passed between last call and recent call
- The module sends the following data though its communication interface:
    - Instantaneous or **Event Trigger output**:
        - Presence trigger
        - ETA trigger
        - Speed trigger
        - Queue Length Measurement (QLE) trigger
        - Wrong direction trigger
        - Custom trigger
        - Trigger extension & delay time can be set for each zone separately
        - Single pulse trigger can be set for each zone separately
        - 64 outputs which can be freely assigned to all 32 available zones
    - Every interval period or **Statistics output**:
        - The statistic interval for the module is selectable between 1s and 3600s.
        - It checks every sensor cycle if the configured interval time is reached
        - General statistics information (number of zones, synchronized time, …)
        - Volume counting, vehicle class specific
        - Occupancy
        - Average speed
        - 85 percentile speed
        - Headway
        - Gap
- Support of up to 16 vehicle classes (depending on the used sensor hardware). Actual pre-defined classes are. The class number correspond to the number sent by the radar:
    - Undefined: class 0

- o Pedestrian: 1.0m length, class 1
- o Bike: 1.6m, class 2
- o Motorbike: 2.6m length, class 3
- o Passenger car: 4.6m…5.4m length, class 4
- o Delivery/pickup: 5.6m…9.4m length, class 6
- o Short truck: 9.0m…13.8m, class 7
- o Long truck: 14.0m…25m, class 8

The TRUGRD and TRUGRD Stream sensor family also supports classification by object length which covers the ROSAVTODOR (EUR6-based) and GOST 32965-2014 (EUR7-based) standard.

Table 15 ROSAVTODOR (EUR6-based)

class	Class number	Class length
Passenger car	4	Up to 4,5m
Minibus, delivery/pickup	6	5m…8m
Short truck	7	8m…11m
Bus	10	11m…13.5m
Medium Truck	9	13.5m…22m
Long truck	8	>22m

Table 16 GOST 32965-2014 (EUR7-based)

class	Class number	Class length
Motorbike	3	2.5m
Passenger car	4	2.6m… 4.5m
Minibus, delivery/pickup	6	5m…8m
Short truck	7	8m…11m
Bus	10	11m…13.5m
Medium Truck	9	13.5m…22m

Long truck	8	>22m

Further information for activating the optinal classification can be found in the corresponding "HowTo_use_Russian_Highway_Classification" documentation.

6.2.2   ZONE SPECIFICATIONS

Statistics Module V2 uses up to 32 zones which can be placed freely within the coverage area from the used sensor. A zone can be optionally docked to one or multiple lanes.

A zone will be formed from multiple two-dimensional **segments** (x & y position).

A zone consists of at least two segments, the number of used segments for each zone can be dynamically increased. The heading of a zone will be defined by the used segment points, starting from the first segment to the next one and so on. See chapter 6.3.3 and 0 for the zone and segments parameters.

Examples:

- 32 zones used with 4 segments per zone

- One zone used with 128 segments

- Two zones used with 1x 96 segments and 1x 32 segments

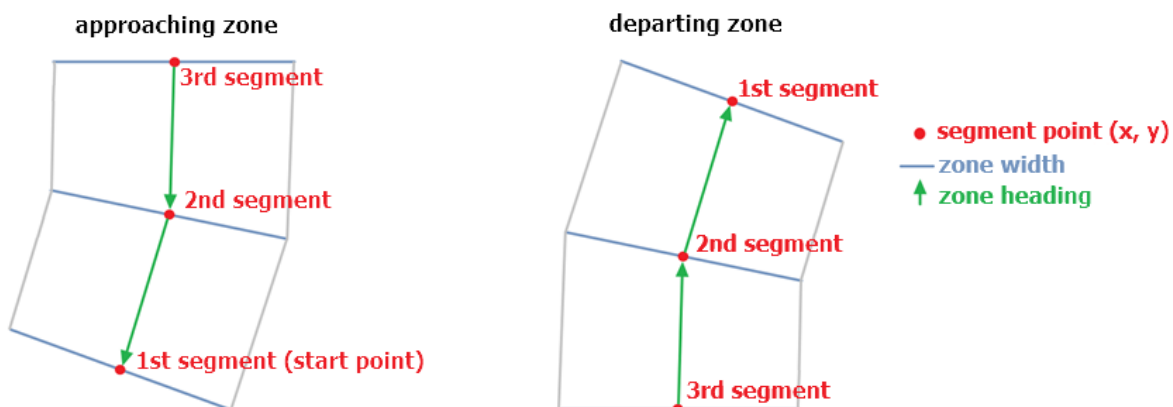The sensor supports up to 128 segments in total.

Figure 6-1: A zone is composed of >1 segment

A **zone** consists of the following components:

- Zone width
- Number of used segments
- Segments (X & Y positions)

- Used trigger application
- Output assignment
- Used statistics
- Used classes for statistics
- Used classes for trigger application
- Trigger type (presence or single pulse trigger), trigger delay & extension
- Trigger conditions (like ETA offsets, min. & max. speed)

For each zone, the number of used segments can be dynamically adjusted. The minimum number of segments to make a zone is 2. If, for example on a curved road, more than two segments are necessary, additional segments can be added. In total up to 128 segments are available for up to 32 zones.

6.2.3 CONFIGURATION DATA

Please make the following settings:

- Number of zones
- Definition of the zones
    - o Width, number of segments, segment points
    - o For what kind of application, the zone shall be used
- Operational Mode
    - o **Statistics output** for a specific zone
        - Volume counting
        - Average speed
        - 85th percentile speed
        - Occupancy
        - Headway
        - Gap
- Used classes for statistics
- Statistics interval time
    - o **Trigger application** for a specific zone
        - Presence trigger, speed trigger, ETA trigger, queue length trigger, and wrong direction trigger supported
        - Trigger application parameters

- ▪ Used classes for event trigger

6.2.4 STATISTIC FEATURE SPECIFICATION

The Statistic Module sends its output data for every zone which is configured to be used for statistics gathering. The statistic interval time can be adjusted by a parameter. When the interval time is reached the statistical data will be transmitted by the sensor.

In order to reduce the amount of transmitted data, the module reports the statistics for each zone separately within a cycle (up to 32 cycles if 32 zones are used).

6.2.4.1 Statistic Output: Volume

This application is a class-specific count per zone.

Whenever the zone is occupied by a tracked object at a function call, its track ID will be processed and recorded to an object-class dependent variable. When the track ID is unequal to the recorded track ID, a counter will be incremented. This solution prevents multiple counting of one object.

- Supports count by class
- The resolution of the counter is in second
- The counter will be reset when the statistics interval time is reached
- Data amount: 16 bits per zone

6.2.4.2 Statistic Output: Occupancy

This feature is a counter per time that specifies the occupancy of the zone during the interval time. Whenever the measuring point is occupied by a tracked object at a function call, a counter will be incremented. When the interval time is reached the occupancy will be calculated. The result is a percentage.
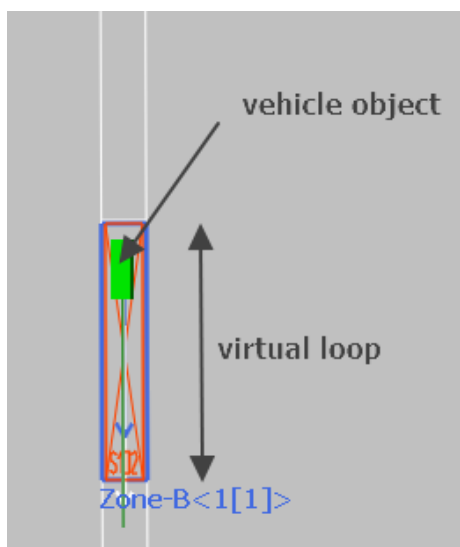
- Supports occupancy calculation by class
- The resolution is [0.05%].
- The output will be reset when the interval time is reached
- Data amount: 11 bits per zone

Calculation of the occupancy follows the formula:

$$Occupancy = \frac{\sum on - time}{\text{report interval}}$$

Explanation and details:

The on-time is calculated as the time that any portion of a vehicle object is inside the virtual loop. It is measured with the increment of the sensor cycle time, i.e., at approximately 56ms. The following example depicts a vehicle object that enters the virtual loop highlighted in red below. As long as there is an overlap of the red vehicle object and the virtual loop, the on-time is incremented.

The report-interval is the report time set to the sensor, e.g., 5 minutes by default.

6.2.4.3   Statistic Output: Average Speed

This feature yields an average speed per zone.

Whenever the zone is occupied by a new tracked object having the same class at a function call, its speed will be added to an object-class dependent variable and a counter will be incremented. When the interval time is reached, the average speed for each zone will be calculated.

- Supports average speed calculation by class
- The resolution is [0.01 {m/s}].
- The output is valid from 0m/s to 89m/s absolute.
- The average speed will be reset when the interval time is reached
- Data amount: 16 bits per zone

6.2.4.4   Statistic Output: 85th Percentile Speed

This feature yields the 85th percentile of speed distribution per zone. It means that 85% of all registered vehicles having the same class within a zone go at the reported speed or less.

Whenever the zone is occupied by a tracked object at a function call, its speed will be added to an object-class dependent history variable and a counter will be incremented.

When the interval time is reached the final 85th percentile speed for each zone will be calculated.

- Supports 85th percentile speed calculation by class
- The resolution is [0.01 {m/s}].
- The output is valid from 0m/s to 89m/s absolute.
- The 85th percentile speed will be reset when the general reset flag is set.
- Data amount: 16 bits per zone

6.2.4.5   Statistic Output: Headway

This feature yields the average passing time between two vehicle's front-to-front in seconds per zone. Whenever the zone is overrun by a tracked object at a function call, a timer is started. When a new object crosses the zone, the elapsed time will be added to a sum time and a counter will be increased. When the interval time is reached the average Headway time for each zone will be calculated.

- The resolution is [0.055s].
- The output is valid from 0.00 s to 3600.00s.
- The average headway time and the previous timer will be reset when the general reset flag is set.
- Data amount: 16 bits per zone
- This output is without classification, it will be sent as class 0 (undefined)

6.2.4.6   Statistic Output: Gap

This feature yields the average passing time between two vehicle's rear-to-front in seconds per zone. Whenever the zone is overrun by the back side of a tracked object at a function call, a timer is started. When a new object crosses the zone, the elapsed time will be added to a sum time and a counter will be increased. When the interval time is reached the average Gap time for each zone will be calculated.

- The resolution is [0.055s].
- The output is valid from 0.00s to 3600.00s.
- The average gap time and the previous timer will be reset when the general reset flag is set.
- Data amount: 16 bits per zone
- This output is without classification, it will be sent as class 0 (undefined)

6.2.4.7 Statistic Output: Per Vehicle Record

If the Per Vehicle Record (PVR) is active, then each counted track will be transmitted with a PVR message immediately within the first cycle when the object enters the zone. This PVR message contains the following information for each registered object:

- Object ID (consistent during the lifetime of the object)
- Zone
- Object class
- Object speed [m/s]
- Optional "exclusive count" can be de/activated if PVR count is needed for each zone

6.2.5 EVENT TRIGGER FEATURE SPECIFICATION

The sensor can trigger (virtual or hardware) outputs for applications like

- Presence detection,
- Estimated Time of Arrival (ETA)
- Speed triggering
- Other applications

For each zone the user can select a desired application and change specific parameters which are:

- Trigger application
- Object classes to trigger
- Output assignment for up to 64 outputs
- Minimum/maximum time offset
- Minimum/maximum speed
- ETA: X, Y position
- Direction of traffic
- Presence or single pulse trigger type
- Pulse duration (if single pulse trigger is used)
- Trigger extension
- Trigger delay

6.2.5.1   Event: Presence Trigger

This application triggers an assigned output whenever the predefined detection zone is occupied by one or multiple objects. For this application, the following parameters can be selected:

- Zone extension & width
- Object classes to trigger
- Output assignment

6.2.5.2   Event: ETA Trigger

This application triggers an assigned output whenever the Estimated Time of Arrival (ETA) of one or multiple objects is within the predefined timeframe. For this application the following parameters can be configured:

- Zone extension & width
- Object classes to trigger
- Time offset for ETA calculation (min/max time of the triggering timeframe)
- Output assignment
- Option: X, Y position to which ETA shall be calculated; default X, Y position is the first segment of the zone

6.2.5.3   Event: Speed Trigger

This application triggers an assigned output whenever one or multiple objects in the measuring zone are moving within a predefined speed interval. For this application the following parameters can be selected:

- Zone extension and width
- Object classes to trigger
- Speed interval (min/max speed of the triggering interval)
- Output assignment

6.2.5.4   Event: Wrong Direction Trigger

This application triggers an assigned output whenever the predefined detection zone is occupied by an object that is driving in opposite direction. The used direction of movement will be set within the "zones" section of the Traffic Management Configurator (TMC) software.

Please note that the used lanes should be configures for bi-directional movement otherwise the sensor will only track objects for the configured lane-direction.

For this application the following parameters can be selected:

- Zone extension & width

- Object classes to trigger

- Speed Interval for triggering (min/max speed of the triggering interval)

- Minimum travelled distance for triggering

- Output assignment

6.2.5.5   Event: Queue Application Trigger

This application triggers an assigned output whenever the minimum configured queue length is achieved. You can configure the minimum queue length in the Traffic Management Configurator (TMC). It is also possible to set the maximum allowed speed of the objects to be considered.

- Maximum speed of the objects considered

- Minimum queue length to trigger

6.2.5.6   Event: Custom Trigger

This application is a logic AND-combination of the presence-, speed- and ETA-trigger. It triggers an assigned output whenever all preset requirements (minimum and maximum allowed speed; minimum and maximum allowed time) are fulfilled. You can configure all required parameters within the Traffic Management Configurator (TMC).

- Zone extension & width

- Object classes to trigger

- Speed interval (min/max speed of the triggering interval)

- Time offset for ETA calculation (min/max time of the triggering timeframe)

- Output assignment

- Option: x, y position to which ETA shall be calculated; default x, y position is the first segment of the zone

6.2.5.7 Fail-Safe Mode

Statistics Module V2 comes with an integrated failsafe trigger function which will activate all available output relays as long as the detection performance is reduced.

The sensor supports failsafe mode for the following diagnostic functions:

- Heavy rain detection
- Interference detection
- Blind detection

The diagnostic flags will be transmitted within the statistics port header (port-based communication) and within the 0x780 statistic output – Info Message 1 (CAN-based communication).

Each diagnostic function can be activated or deactivated for fail-safe detection. If at least one fail-safe criterion is fulfilled all available output relays will become active. It is also possible to select the desired relays for the fail-safe function.
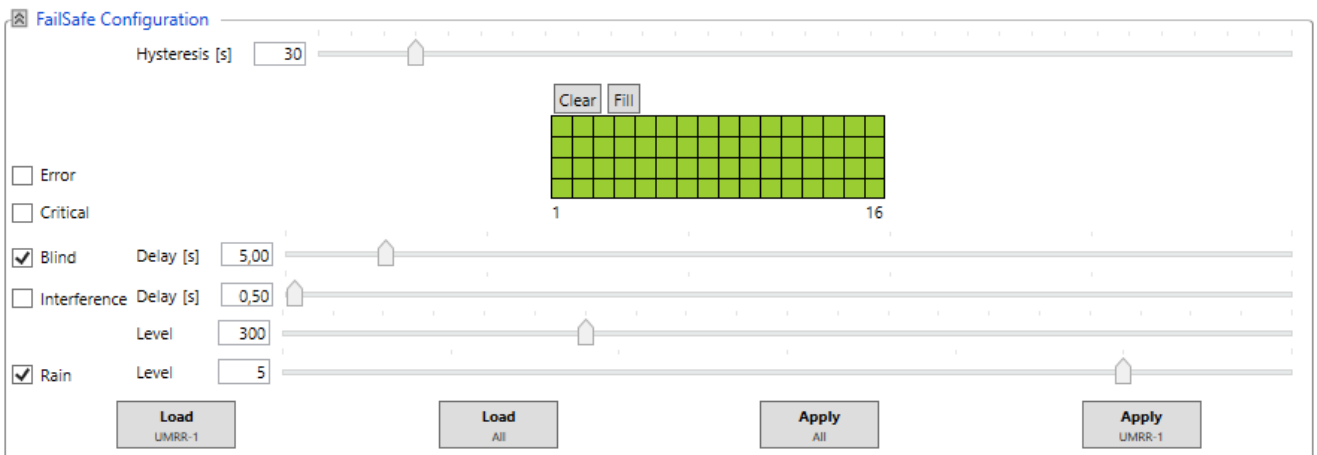

Figure 4: Failsafe configuration within the TMConfigurator

Important Notice:

Fail-safe mode and fail-safe features of the sensor are designed to cover as many fail cases as possible during the operation of the sensor. However, not all fail cases are covered: It is important to understand that the detection rate of the sensor is not 100%, that the false alarm rate is not zero, and that not all fail cases will be detected and reported and that some fail cases may be reported in error. The manufacturer disclaims all liability for the operation of the fail-safe mode.

6.2.5.8 Fail-Safe Mode: Heavy Rain Detection

In heavy rain or snow conditions it is possible that the general sensor performance is reduced. The included rain detection algorithm can detect these conditions and activate a rain flag if a certain amount of rain targets have been detected. The rain detection function can be adjusted by parameters if desired.

6.2.5.9 Fail-Safe Mode: Interference Detection

If another sensor or device works within the same frequency band of the sensor it is possible that it will interfere with the sensor and reduce the detection performance. The sensor recognizes if interference occurs and activates the interference flag if it occurs.

The Interference fail-safe function can be adjusted by parameters if desired.

6.2.5.10 Fail-Safe Mode: Blind Detection

If the sensor radome is covered with snow or ice, or the field of view is disturbed (e.g., by a wall in front of the unit), the sensor becomes blind or at least the detection performance is reduced.

The sensor analyses stationary and moving targets by different criteria (number of detected targets, signal to noise ratio, etc.). If the quality level is too low, then the blind flag will become active.

The blind fail-safe function can be adjusted by parameters if desired.

6.3 STATISTIC MODULE COMMANDS

The Statistic Module contains various useful commands, which are described below.

6.3.1 STATISTIC MODUL – STATUS COMMANDS (UAT V4)

The following commands must be sent as "status" commands. The sensor will send UAT V4 response messages which will deliver the requested status information.

Name	Description	Section	ID	Format
TM Status Interface major version	Defines the major version of the TM Status Module	2003	0	Int
TM Status Interface minor version	Defines the minor version of the TM Status Module	2003	1	Int
SW generation	TM software version generation	2003	2	Int
SW version major	TM software version major	2003	3	Int
SW version minor	TM software version minor	2003	4	Int
SW version patch	TM software version patch	2003	5	Int
Customer ID	Customer identifier	2003	6	Int
Antenna Type	Antenna Type	2003	7	Int
Region code	Region_code	2003	8	Int

Product serial	Sensor serial number	2003	9	Int
TM App major	Major version of the app_tm module	2003	14	Int
TM App minor	Minor version of the app_tm module	2003	15	Int
TM App patch	Patch version of the app_tm module	2003	16	Int
TM App Variant	Variant of the app_tm module	2003	18	Int
Roll Angle	Roll angle status	2003	23	Int
Pitch Angle	Pitch angle status	2003	24	Int
Calibration Status	accelerometer indication if calibration is complete	2003	25	Int
Nof Tracking Classes	number of tracking classes	2003	30	Int
Region Code	TM region code: 0=EU 1=CH 2=US	2003	31	Int
TM Application	Traffic Management Application: 0=Stopbar+ 1=Forward+ 2=Speed Enforcement 3=Red-Light Enforcement	2003	32	Int

6.3.2 STATISTIC MODULE - BASIC PARAMETERS

Commands for basic parameters (Table 6-17):

Name	description	ID	Section	Type	min	max	default
can_active	[1] 0 = Interface Listen (RX only), 1 = Interface Active	10	2000	u8	0	1	0
rs485_active	[1] 0 = Interface Listen (RX only), 1 = Interface Active	11	2000	u8	0	1	1
eth_active	[1] 0 = Interface Listen (RX only), 1 = Interface Active	12	2000	u8	0	1	1
posX	[m] X position of the sensor in Cartesian coordinate system	50	2000	f32	-3000	3000	0

posY	[m] Y position of the sensor in Cartesian coordinate system	51	2000	f32	-3000	3000	0
posZ	[m] Z position of the sensor in Cartesian coordinate system	52	2000	f32	-200	200	50
xyOrientation	[deg] Orientation of the sensor in Cartesian coordinate system in X-Y plane (azimuth angle), valid interval (-180.f, 180.f], 0.f for positions on the Z axis	53	2000	f32	-1800	1800	0
xzOrientation	[deg] Orientation of the sensor in Cartesian coordinate system in X-Z plane (elevation angle), valid interval [-90.f, 90.f], 0.f for the origin of the coordinate system	54	2000	f32	-900	900	0
yzOrientation	[deg] Orientation of the sensor in Cartesian coordinate system in Y-Z plane (roll angle) (0.f: not turned, 180.f: turned upside-down), valid interval (0.f, 180.f]	55	2000	f32	-1800	1800	0
output_control_target_list	[1] output data control, 0 = disabled, 1 = enabled	200	2000	u8	0	1	0
output_control_object_list	[1] output data control, 0 = disabled, 1 = enabled	201	2000	u8	0	1	1
output_control_triggers	[1] output data control, 0 = disabled, 1 = enabled	202	2000	u8	0	1	1
output_control_statistics	[1] output data control, 0 = disabled, 1 = enabled	203	2000	u8	0	1	1
output_control_pvr	[1] output data control, 0 = disabled, 1 = enabled	204	2000	u8	0	1	1
output_control_queue_length	[1] output data control, 0 = disabled, 1 = enabled	205	2000	u8	0	1	1

nof_zones	number of used measuring zones	300	2000	u16	0	32	2
use_statistics_features	use statistics features. bit field: 0x0000001: volume_counting, 0x0000002: occupancy, 0x0000004: av_speed	301	2000	u16	0	255	0
use_trigger_features	activate or deactivate trigger module output	302	2000	u16	0	255	1
simulation_mode	tm simulation mode.	303	2000	u16	0	2	0
interval_time	used interval time [s] for calculating statistics	304	2000	f32	0	3600	300
statistics_flags	used statistic flags. bit field: 0x0000001: speed_scale_unit	305	2000	u8	0	1	0
exclusive_count	defines if an object should be counted only on the first zone (value 1) or on all zones where the object was detected (value 0)	306	2000	u8	0	1	0
count_mode	defines counting mode. Value 0 == without classification, 1 == with classification	307	2000	u8	0	8	1
occupancy_mode	defines occupancy mode. Value 0 == without classification, 1 == with classification	308	2000	u8	0	8	1
av_speed_mode	defines av. speed mode. Value 0 == without classification, 1 == with classification	309	2000	u8	0	8	1
85th_perc_speed_mode	defines 85th perc. speed mode. Value 0 == without classification, 1 == with classification	310	2000	u8	0	8	1
nof_simulated_objects_lane	defines number of simulated objects per lane	311	2000	u8	0	128	2

nof_sim_lanes	defines number of simulated objects	312	2000	u8	0	8	2
sim_lane_width	defines sim. lane width [m]	313	2000	f32	0	100	5
sim_lane_length	defines sim. lane length [m]	314	2000	f32	0	500	100
sim_speed	defines sim. object speed [m/s]	315	2000	f32	0	90	13889
sim_heading	defines heading [deg] for simulated objects	316	2000	f32	-360	360	360
start_sim_x_pos	defines starting x pos [m] for simulation	317	2000	f32	-500	500	100
start_sim_y_pos	defines starting y pos for simulation	318	2000	f32	-200	200	0
active_relays_part1	defines active relays (bit-coded) for relay simulation 1	319	2000	u32	0	0xffffffff	1
active_relays_part2	defines active relays (bit-coded) for relay simulation 1	320	2000	u32	0	0xffffffff	0
nof_simulated_relays	defines number of used relays for simulation 2	321	2000	u8	0	64	8
failsafe_mode	activate failsafe mode. Bit0: rain failsafe, Bit1: interference, Bit2:general,Bit3:critical, bit4:blind	322	2000	u8	0	255	16
reserve2	defines number of used relays for simulation	323	2000	u16	0	255	0
failsafe_relays_pt1	defines which relays (0...31) should be active in failsafe mode	324	2000	u32	0	0xffffffff	0xffffffff
failsafe_relays_pt2	defines which relays (32...63) should be active in failsafe mode	325	2000	u32	0	0xffffffff	0xffffffff
trigger_output	defines trigger output mode, 0 = no output, 1=	326	2000	u8	0	255	1

	trigger header output, 2 = to be defined						
statistics_output	defines statistics output mode, 0 = no output, 1 = statistics header output, 2 = header + targets	327	2000	u8	0	255	2
pvr_output	defines PVR output mode 0 = no output, 1 = PVR header output, 2 = PVR header + targets	328	2000	u8	0	255	2
synchronize_statistics	synchronized statistics output	329	2000	u8	0	1	0
interference_threshold	interference_threshold threshold	330	2000	u32	0	0xffffffff	300
failsafe_hysteresis	Failsafe hysteresis timer [s]	331	2000	u16	0	300	30
interference_delay_cycles	interference delay cycles for Failsafe activation[s]	332	2000	u16	0	10000	10
blind_delay_cycles	hysteresis timer for Failsafe activation[s]	333	2000	u16	0	10000	100
queueDistTwoObjects	the maximum distance between two cars in a queue	334	2000	f32	0	300	
queueDistFirstObject	the maximum distance for the first car in the queue from the beginning of the zone	335	2000	f32	0	200	
polling_mode	statistics polling mode. Value 0 == off, 1== send currently collected statistics.	336	2000	u8	0	2	1
85th_perc_classes	number of used 85th perc speed classes	337	2000	u8	1	9	1

6.3.3 STATISTIC MODULE - ZONE COMMANDS (UAT V4)

For each zone the following commands can be set separately.

In order to set a command for a specific zone it is necessary to set the zone number (0…31) within the 1st dimension ("i0"):

name	description	ID	Section	dim0	type	min	max	default
used_segments	number of used segments for the used zone	0	2002	0..31	u8	2	192	2
trigger_application	used trigger application, bit-coded	1	2002	0..31	u8	0	255	1
relay_assignment	defines which relay ## should be used for zone ##	2	2002	0..31	u8	0	255	0
trigger_flags	defines additional trigger flags	3	2002	0..31	u8	0	255	0
zone_width	width [m] for the used measuring zone.	4	2002	0..31	f32	0	1000	4
eta_x_point	ETA range offset [m] for the used measuring zone.	5	2002	0..31	f32	-1000	1000	0
eta_y_point	ETA range offset [m] for the used measuring zone.	6	2002	0..31	f32	-1000	1000	0
time_min_offset	min. time [s] offset for ETA calculation.	7	2002	0..31	f32	0	1000	0
time_max_offset	max. time [s] offset for ETA calculation.	8	2002	0..31	f32	0	1000	0
speed_min_offset	min. speed [m/s] for speed trigger.	9	2002	0..31	f32	0	90	0
speed_max_offset	max. speed [m/s] for speed trigger.	10	2002	0..31	f32	0	90	90
used_trigger_classes	used classes for zone ##	11	2002	0..31	u16	0	479	
used_statistics_classes	used classes for zone ##	12	2002	0..31	u16	0	479	
statistics_features	active statistics features, bit-coded	13	2002	0..31	u8	0	255	255

trigger_type	trigger type: 0 == default presence trigger; 1 == single pulse trigger	14	2002	0..31	u8	0	255	0
pulse_duration	pulse duration in [ms]	15	2002	0..31	u16	0	32767	0
trigger_extension	trigger extension in [ms]	16	2002	0..31	u16	0	32767	0
trigger_delay	trigger delay in [ms]	17	2002	0..31	u16	0	32767	0
min_mileage	minimum mileage [m] for wrong direction trigger	18	2002	0..31	f32	0	500	10
max_heading	max. tolerable heading between zone position and object	19	2002	0..31	f32	0	360	30
queueMinTriggerBorder	queue min trigger border	20	2002	0..31	f32	0	2550	300

6.3.4   STATISTIC MODULE - SEGMENTS COMMANDS (UAT V4)

For each segment of a zone, the following commands can be set separately. In total 128 segments are available which can be used for up to 32 zones. At least two segments are necessary for a zone.

In order to set a command for a specific segment it is necessary to set the segment number (0…127) within the 1st first dimension ("i0"):

name	description	ID	Section	dim0	type	min	max	default
pos_x	x position [m] for the zone segment.	0	2001	0…127	f32	-1000	1000	30
pos_y	y start position [m] for the zone segment.	1	2001	0…127	f32	-1000	1000	0

7   HOW TO'S

This chapter shows further capabilities and settings, which can be configured for the radar sensor.

7.1   CAPABILITIES OF SIMULATION MODES

The radar sensor has different simulation modes for sending synthetic simulated traffic objects or triggers. These modes can be activated and configured using the command view of the TMC software. In the following, the relevant simulation modes are described.

Simulation modes (Table 7-1):

Simulation Modes	Function	Benefits	Availability
1	Generates targets and objects on lanes	Simulates targets, objects, speeds and driving directions; tests trigger zones and statistic zones	No
2	Generates objects on lanes	Simulates objects on lanes; tests trigger zones and statistic zones	Yes
3	Radar Cube simulator	Verifies the function of the entire signal processing chain	No
4	Trigger outputs	Verifies the reception of digital triggers at the intersection controller, PLC, etc.	Yes

SIMULATION MODE 2: OBJECT SIMULATION

Simulation Mode 2 generates objects with different speeds per lane and random classes depending on the number of configured lanes.

This simulation is independent from the statistics module and the trigger module. You can adjust it to simulate straight lanes or for using the defined tracking lanes/splines. It provides up to 64 lanes, where the

speed, direction, and class for the first eight lanes can be chosen freely. The 9th lane and above will copy the setup of the 8th lane.

If the mode is set to "object simulation on lanes", a number of objects will be simulated on "invisible" lanes. They appear as close as possible along the boresight axis of the radar sensor. With a rising number of simulated lanes, the 1st lane will move to the right side, from the sensor's point of view.

With "object simulation on splines" objects will be simulated on the lanes defined with the TMC Installation Wizard. The defined number of simulated lanes has no effect in this case.

Simulation mode 2 commands (Table 7-2):

Name	Description	ID	Default	Section	Types	Typical Values
Object Simulation	Activates and deactivates the simulation	62	0	2004	Parameter, Integer	Object simulation: 0 = none <1 = on lanes 2 = on splines
sim_nof_lanes	Number of lanes for lane simulation mode	63	4	2004	Parameter, Integer	0…64
sim_objects_per_lane	Number of simulated objects per lane/spline	64	5	2004	Parameter, Integer	0…64
sim_obj_speed_laneX	Speed of simulated objects on lane/ spline X in m/s	11= lane 0 12= lane 1 … 18= lane 7	various	2004	Parameter, IEEE Float	>0 = in spline direction <0 = in opposite spline direction
sim_obj_class_laneX	class of simulated object on lane/ spline X	19= lane 0 20= lane 1 … 26= lane 7	various	2004	Parameter, Integer	0…8
Convert_classes_into_vehicle_length	Object length into the length or length by class	60	2	2004	Parameter, Integer	2 = default 3 = EUR6-based classification 4 = EUR7-based classification

SIMULATION MODE 4: TRIGGER OUTPUT SIMULATION

The trigger output simulation mode, also called relay simulation, is only available with the statistics module and the event trigger module of the radar sensor.

Simulation Mode 4 generates triggered outputs, for example, digital binary signals to test the reception of the intersection controller, Programmable Logic Controller (PLC), or another connected host.
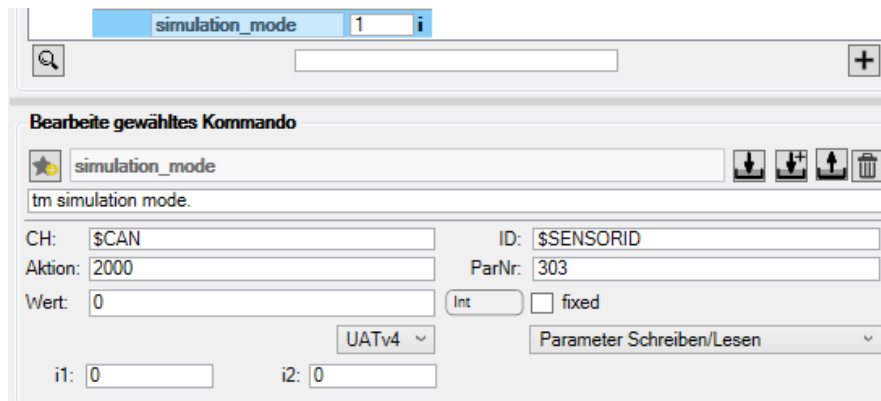
The trigger output simulation has two sub modes:

1) For setting individual triggers
2) For an automated scheme in turn, with, for example, triggers running from relay 1 to 32 and from 32 back to 1

Trigger simulation parameters (Table 7-3):

Name	Description	ID	Section UAT V4	Types	Typical Values
Relay Simulation	Trigger output simulation	303	2000	Parameter, Integer	0: simulation off 1: sub mode 1 (individual trigger setting) 2: sub mode 2 (running trigger)
active_relays_part1	Defines active relays (bit-coded) for relay simulation 1 (relay1…32)	319	2000	Parameter, Integer	Default: 1
active_relays_part2	Defines active relays (bit-coded) for relay simulation 1 (relay33…64)	320	2000	Parameter, Integer	Default: 0
Number of simulated Relays	Defines the number of simulated relays for relay simulation 2	321	2000	Parameter, Integer	Default: 8

The parameter, for example, for automated scheme of trigger output simulation, should be entered as follows:

Figure 7-1: Command example

7.2 CHANGING THE FREQUENCY BAND

The frequency band can be defined via the firmware. Especially, if multiple radar sensors are used, special care is necessary to avoid influences of interference among the sensors. The available frequency bands listed below depend on the configuration. The allowances to use a respective transmit power level and frequency band depend on the region of application.

In the table below, frequency approvals for the regions are labelled as follows:

- A1: EU (incl. Belgium, Latvia), Norway, Iceland, Switzerland, Korea, Japan
- B1: USA, Canada (Low Power, 12.7dBm EIRP)
- B2: USA, Canada (High Power, 20dBm EIRP)
- C1: China (Low Power)
- D1: Turkey

Frequencies for 24GHz sensors (Table 7-4):

Waveform Index	Application	Frequency	PRF Set ID	Transmit Power	Approval for Regions
0	Stop+Advance[17]	24.050 − 24.150 GHz	0 … 1	0 (low)	A1, B1, C1
				1 (high)	A1
1	Stop+Advance[17]	24.150 − 24.250 GHz	0 … 1	0	A1, B1, C1, D1
				1	A1, D1
2	Stop+Advance[17]	24.075 − 24.175 GHz	0 … 1	0	A1, B1, C1
				1	A1, B2
3	Stop+Advance, Forward+[18]	24.050 − 24.250 GHz	0 … 1	0	A1, B1, C1
				1	A1
4	Enforcement[18]	24.050 − 24.250 GHz	0 … 1	0	A1, B1, C1
				1	A1

To limit the effects of interference on two sensors facing each other, different frequency IDs should be used

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[17] Waveform with maximum range configuration
[18] Waveform with high resolution configuration

for every sensor on the same Pulse Repetition Frequency (PRF) set ID. For a second pair of sensors facing each other, the PRF is automatically incremented by the TMC.

Parameters for frequency changes (Table 7-5):

Description	UAT V4 Section	ID	Value	UAT	Types	Typical Values
Waveform Index[19] [20]	2000	100	0…4	UAT V4	Parameter, Integer	0,[21] 1, 3 or 4
PRF Set ID[19]	2000	101	0…1	UAT V4	Parameter, Integer	0 or 1
TX Power[19]	2000	104	0…1	UAT V4	Parameter, Integer	0 = low power 1 = high power

[19] Suggested to experienced users only.
[20] Please note that not all waveforms/frequency bands are available for all regions or software configurations.
[21] To be sure, please check the status parameter.
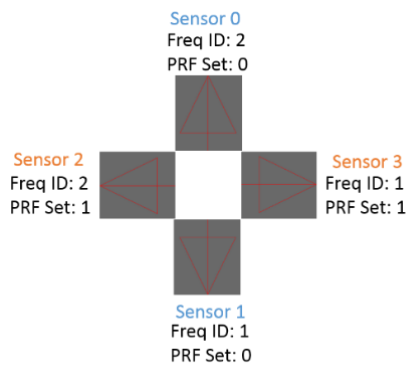
Figure 7-2 Parameter setup example for four sensors
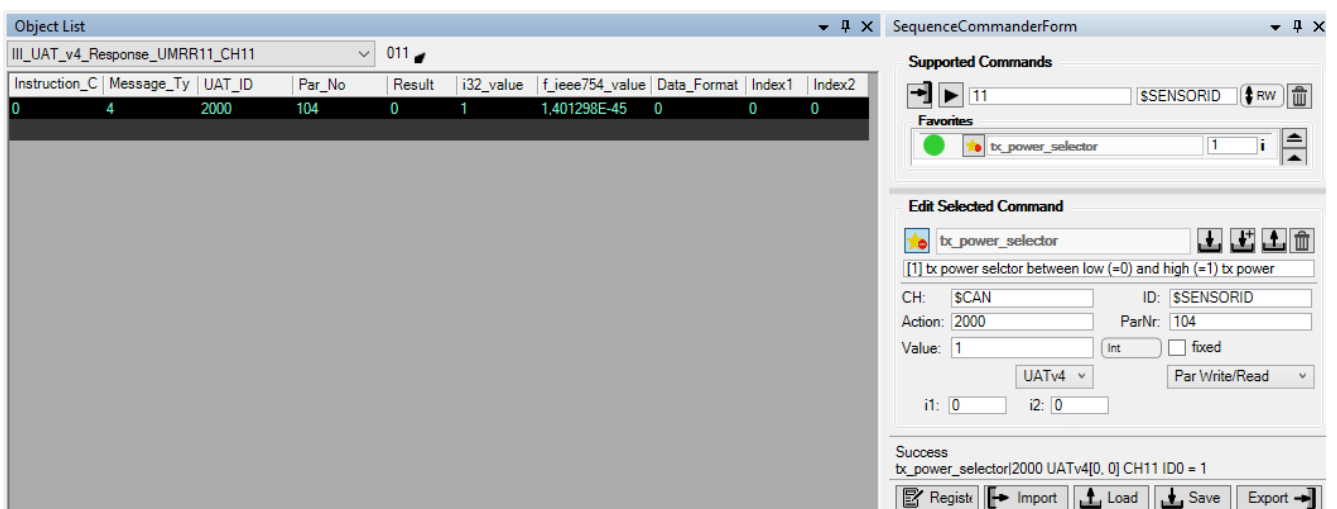
Figure 7-3 Command example to check the acceptation of frequency and TX-power

If the result value (i32_value) is 1, the set TX power seems valid. If the value is set to 0, the TX power and the frequency band combination is wrongful. In this example, the TX power was set to 0dBm by the sensor.

7.3 READING AND CHANGING SENSOR PARAMETERS

Please note that this section is for expert users only.

The sensor parameters can easily be read and changed with the sequence commander tool of the TMC software. To open the sequence commander window, please select "Views / CAN Data Views / sequence commander".

In order to read the current value of a parameter, please enter the parameter number (ParNr. = ID) and the action number (Section) into the command window. Please check if UAT V4 is selected, choose "read only" from the drop-down list, and enter the number format (Int or Float) of the parameter. By clicking "Send", the "ReadParameter" view in the "SensorTargetList" window will show the parameter as follows.
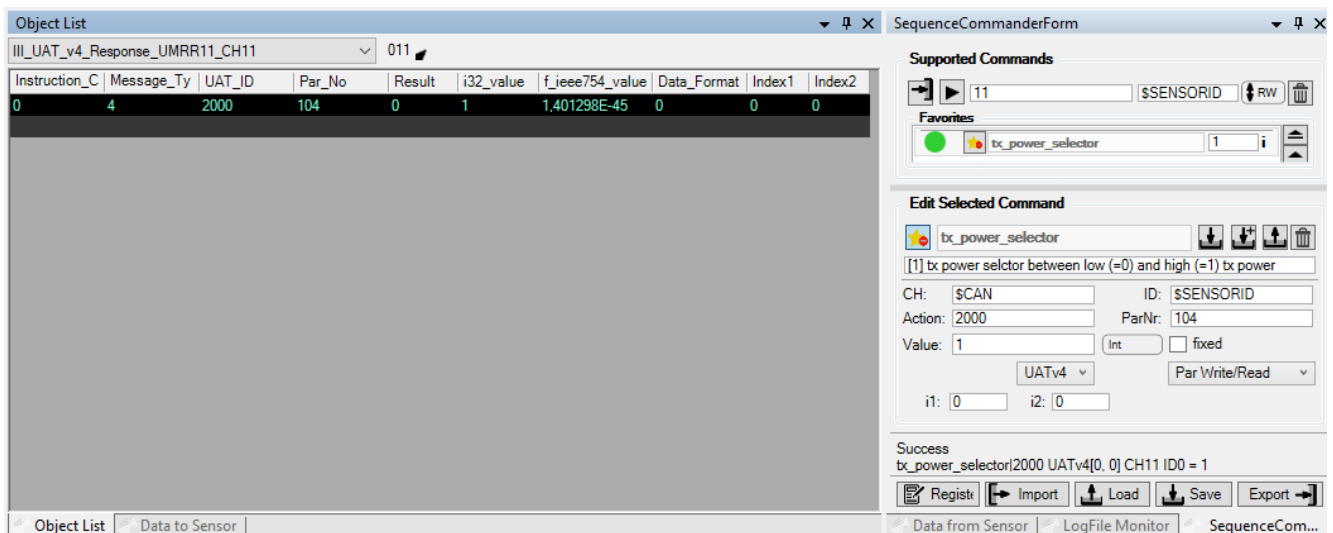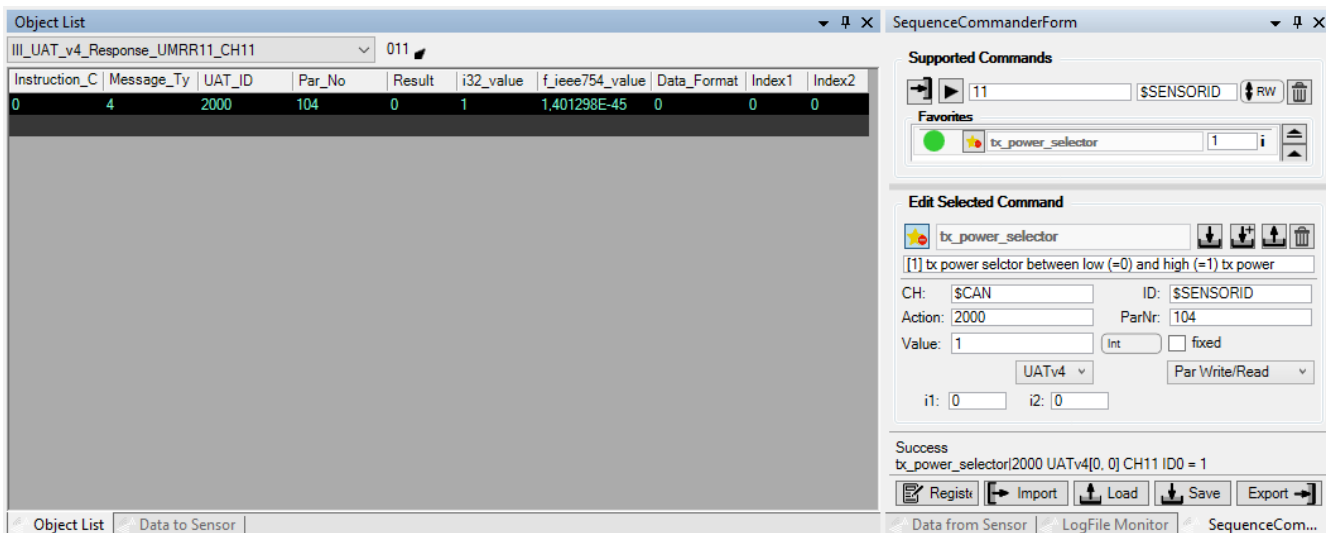
Figure 7-4: Reading and changing a sensor parameter

In order to change the value of a parameter, such as the orientation angle of the sensor, please enter the parameter (ID), the action number (Section), and the new value into the command window. Please check if UAT V4 is selected, choose "Par Write" from the drop-down list and send it to the sensor by clicking "Send". The parameter will be changed accordingly, as you can see below under f_value.

REQUEST STATUS

To read the parameter status, please enter the parameter number (ParNr. = ID) and the action number (Section) into the command window. Please check if UAT V4 is selected, choose "read only" from the drop-down list and enter the number format (Int or Float) of the parameter. By clicking "Send" the "ReadParameter" view in the "SensorTargetList" window will show the parameter as below.

Figure 7-5: Reading a sensor parameter

7.4 EXPORTING DATA TO CSV FORMAT

To export data to the .csv format, please select "Views / Interpreted CAN Data Views / CSV Export".
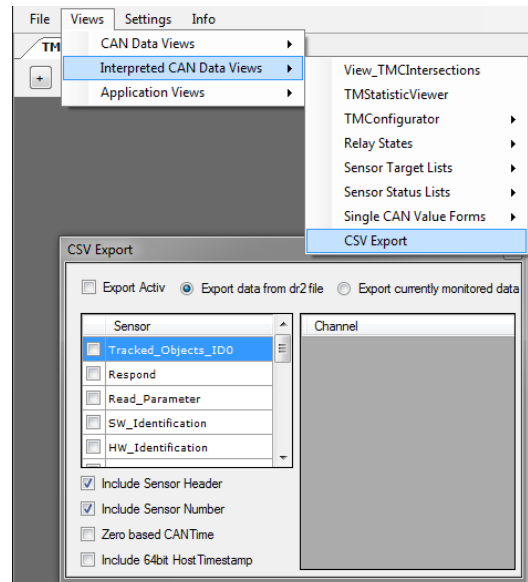
Figure 7-6: CSV Export

- To log tracked object data, select "Tracked Objects ID0"
- To log statistics data, select "TMStatistics ID0"
- To log Event Triggers, select "Relays ID0"

The export function can be activated by activating the "Export Active" checkbox in the upper left corner of the window. The .csv file will be named after the dr2-file and will be placed in the same location.
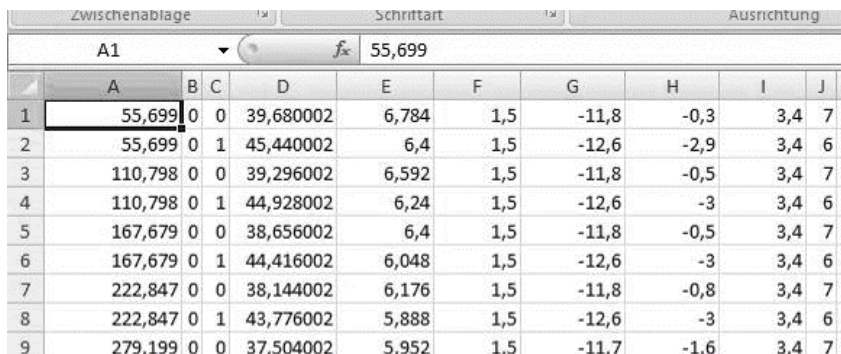
If the option "Include Sensor Header" is selected, there will be an additional .txt file with the column headlines.

The CSV export options are:

- Include Sensor Header: includes the header information (CAN ID 0x500, 0x501) in the .csv file
- Include Sensor No.: includes the sensor number in the .csv file
- Zero based CANTime: sets the CANTime to zero at the beginning of the .csv file
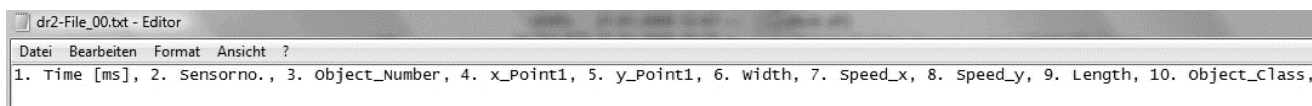
EXAMPLE OF A CSV FILE

After the export, a .csv file and a .txt file are generated. The .txt file contains the description of the exported data and it indicates the meaning of values within the columns. When exporting into .csv format, the information taken over for the .csv file is shown.

Figure 7-7: CSV export example in Excel

Figure 7-8: CSV export description

Exemplarily for line 1:

- Sensor Time: 55.699 ms
- Sensorno.:   0
- Object Number: 0
- X_Point: 39,680 m
- Y_Point: 6,784 m
- Width: 1.5 m
- Speed_x: -11,8 m/s
- Speed_y: -0,3 m/s
- Length: 3,4 m
- Object Class: 7

7.5 USING THE POLYGON FEATURE

Please note that this section is for expert users only.

With the polygon feature of the radar sensor up to eight zones can be defined and configured separately regarding the kinds of objects that should be processed in the algorithm.
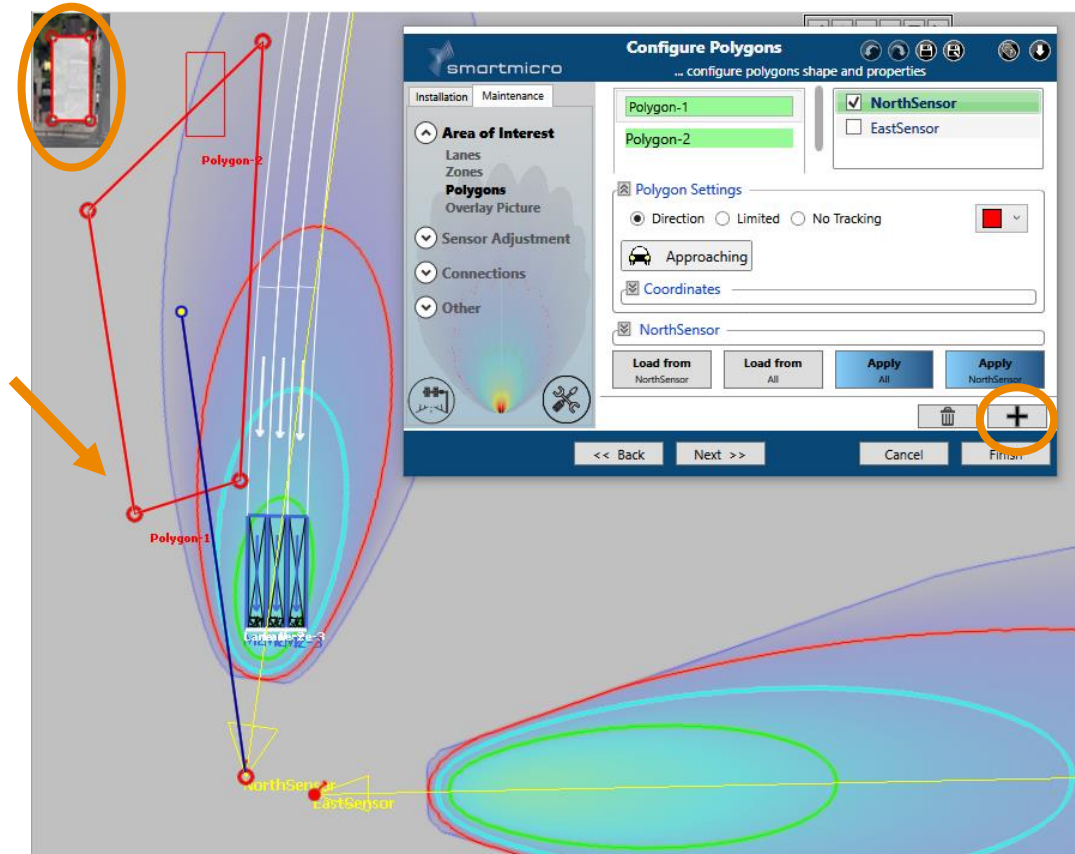
Figure 7-9: Polygon feature

7.5.1 CONFIGURATION OF POLYGONS

To configure polygons, please go to the "Maintenance / Area of Interest / Polygons".

- Polygons can be added or deleted per drag-and-drop or by clicking the plus icon
- The corner points of a polygon can be changed by selecting the relevant polygon within the polygon list and either moving the points or adjusting them in the point list
- The behavior of the polygon can be determined by the polygon settings
- Polygons need to be assigned to sensors individually, for example, to "NorthSensor"
- In case two or more polygons are covering the same are, their behavior can be handled by defining their priority. In the are where polygons are overlapping, the polygon with the highest priority will define the behaviour and the others will be ignored.
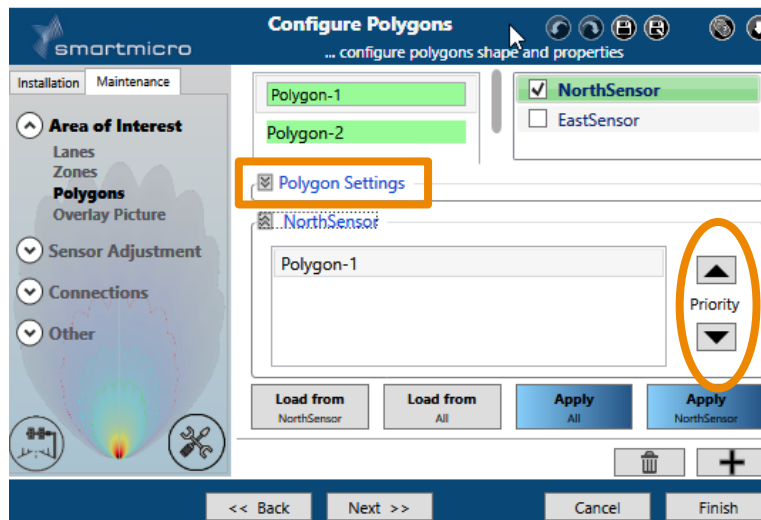
Figure 7-10: Polygon priority

7.5.2 POLYGON SETTINGS

There are three use cases for polygons:

1. Direction: The polygon will let the direction set as approaching or receding pass. The other direction will be blocked and not reported by the sensor.
2. Limited: The polygon will let all vehicle reports matching with the set speed limits pass. "Within limits", "outside limits" and "target options" are for the experience user only.
3. No Tracking: No tracking is performed inside the polygon.

To make the polygons effective, please click "Apply All" for sending all polygons to all sensors or click "Apply <Name>" for sending the polygon settings to a particular sensor.
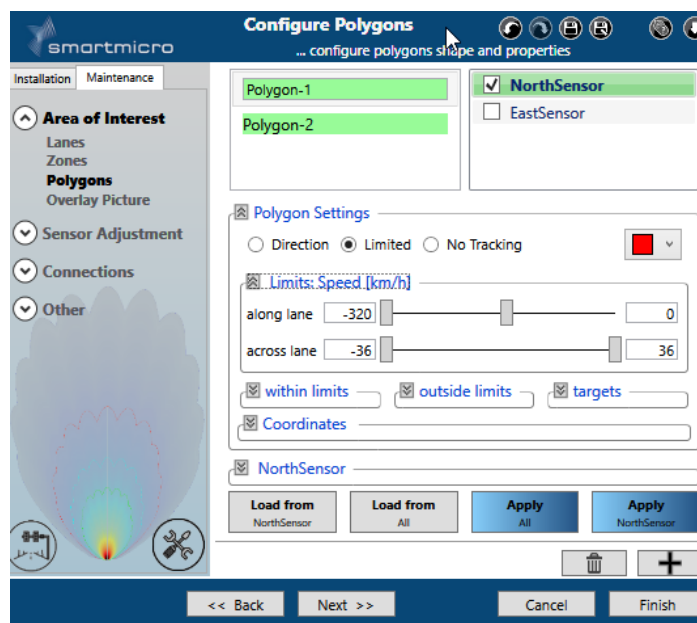
Figure 7-11: Polygon settings

7.5.3 LIMITED POLYGONS

The behavior of the polygon should be defined for the area within the limits and outside of the limits:

- Delete tracks: Object tracks will be deleted.
- Deactivate object tracking: The object tracking will be completely deactivated. As a result, vehicles will open up a new track after they leave the polygon area.
- Don't transmit tracks: The object tracking will work normally but no tracked object will be reported.
- Tracked objects can hold: Tracks will not be deleted after a full stop.

The target handling can be defined as follows:

- Don't initiate tracks: targets cannot open new tracks
- Don't associate with tracks: keeps the default settings
- Stationary targets can init track: no effect

7.6   SETTING A SPLINE

It is possible to define up to 22 splines. A single spline can have four to six spline nodes.

The number of splines and the spline nodes cannot be determined directly. The end of the spline is indicated with a special value, the float32 value 2047.0. For every node n with this value, the number of nodes for this spline is n-1. If the first node of a spline p contains this value, only spline 1 to spline p-1 exist.

Each spline node has x- and y-coordinates. A spline can be used for approaching, receding, or bi-directional traffic in relation to sensor. The sequence of the spline nodes determines the direction of the spline in single direction mode, based on the assumption that a vehicle drives from the first node to last node. Bi-directionality is set by a separate parameter.

7.6.1   SPLINE PARAMETERS

The spline parameters are UAT V4 formatted arrays. The array dimensions are defined as follows:

- i1 = spline = spline number [0 ≤ i1 < max. number of splines]
- i2 = node = spline node number [0 ≤ i2 ≤ 6]

Spline parameter overview (Table 7-6):

Name	Description	ID	Dimensons	Default Value	Section	Type	Typical Values
Spline Node X-Coordinate	Position on x-axis of a node to calculate a spline	0	Spline, node	various	2005	Parameter, Integer	-300 to +300 2047≡ invalid
Spline Node Y-Coordinate	Position on y-axis of a node to calculate a spline	1	Spline, node	-	2005	Parameter, Integer	-20 to +20 2047≡ invalid
Bi-Direction	Allows for traffic in both directions	4	Spline	1	2006	Parameter, Integer	0 or 1 0 = off, 1 = on
Bicycle_spline	Flag for bicycle spline	5	Spline	0	2006	Parameter, Integer	0 or 1

7.6.2 SPLINE EXAMPLE

First, please create one lane in the TMC and send it to the sensor. This is useful to make the spline visible in the TMC. Secondly, please change the values of the lane as below.

Values and the shape of the exemplary spline (Table 7-7):

Name	ID	i1	i2	Value	Type	Section
1. Spline node x-coordinate	0	0	0	0	Parameter, Integer	2005
1. Spline node y-coordinate	1	0	0	-2	Parameter, Integer	2005
2. Spline node x-coordinate	0	0	1	50	Parameter, Integer	2005
2. Spline node y-coordinate	1	0	1	14	Parameter, Integer	2005
3. Spline node x-coordinate	0	0	2	75	Parameter, Integer	2005
3. Spline node y-coordinate	1	0	2	24	Parameter, Integer	2005
4. Spline node x-coordinate	0	0	3	100	Parameter, Integer	2005
4. Spline node y-coordinate	1	0	3	-2	Parameter, Integer	2005
Bi-direction	4	0	0	1	Parameter, Integer	2006
Bicycle spline	5	0	0	0	Parameter, Integer	2006
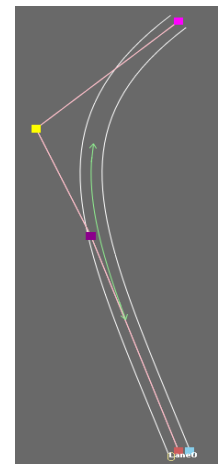
8 TMC SOFTWARE

The Traffic Management Configurator (TMC) software is the most convenient way to set up radar sensors, as well as smartmicro's Traffic Management Interface Board (TMIB), Serial Relay Option (SRO), and Cabinet Relay Option (CRO) controller cards using a Windows-based computer.

Please contact us for more information about the system requirements, the supported hardware interfaces, as well as a detailed description on how to connect the sensor and how to download and install the firmware.

8.1 OVERVIEW

When starting the Easy Mode for the first time, the graphical user interface will appear as follows:
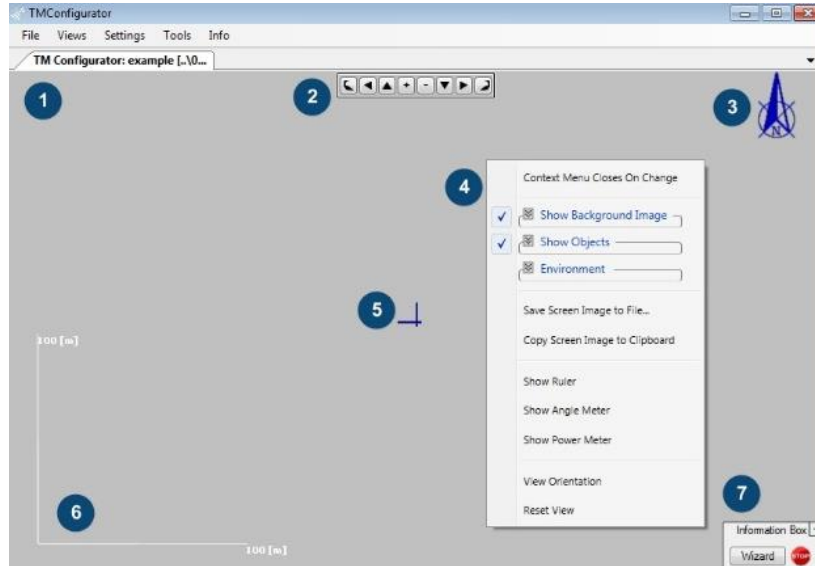

Figure 8-1: TMC Interface

The visualization and graphic user interfaces for the sensor setup and most traffic management applications is illustrated above. It contains the visualization of traffic data on a two-dimensional scale in which the objects, the vehicles, are represented by rectangles.

The key elements of the TMC are enumerated within the figure above and have the following functions:

1) With a click on the tab the views settings can be entered.
2) With the navigation bar the position, zoom and rotation of the area can be adjusted.
3) The compass indicates the alignment of the map in the background.
4) The context menu for highlighting or masking visualization settings can be opened by right click.
5) The crosshair indicates the origin of the area's coordinate system.
6) The scale on the lower left side shows the current zoom of the area.
7) To start the setup process, the wizard button on the information box can be used.

8.2 TMC INSTALLATION WIZARD

The TMC Installation Wizard simplifies the planning and field installation of smartmicro sensors with an intuitive step-by-step guide. The configuration includes site planning, sensor selection and configuration as well as physically installing radar sensors.

When the installation wizard opens, the following start screen is displayed:
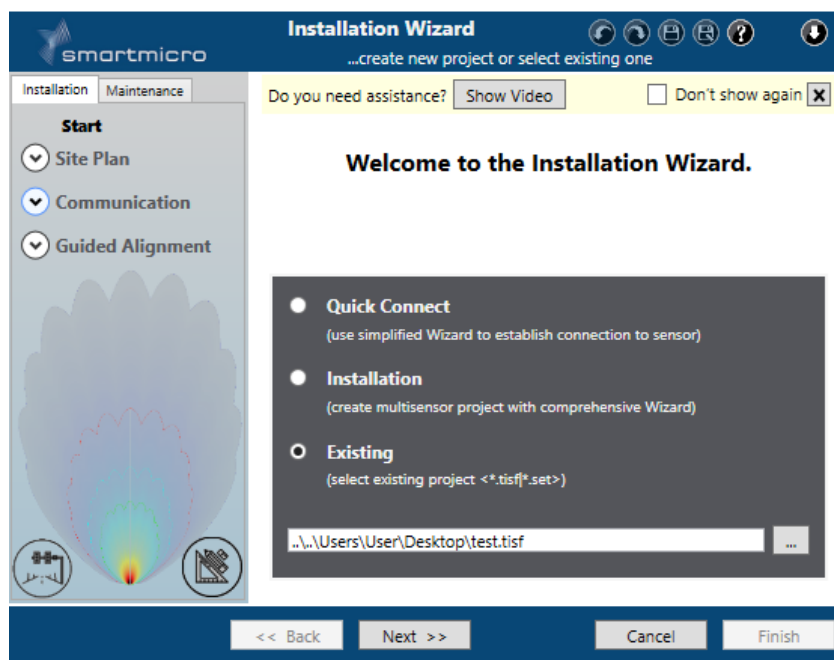
Figure 8-2: The TMC Installation Wizard

The menu on the left side indicates the current step of the setup process. While the installation tab includes all necessary settings and elements for the basic installation, the maintenance tab provides additional functions and allows for limited changes of settings.

On the top of the right side an explanatory video is provided for a better understanding of the functions of the current step. Below that, the display area shows the functions of adding elements and parameters to the installation.

8.3   NEW PROJECTS IN THE TMC

On the start screen of the TMC Installation Wizard there are for options of project types to choose from:

1. Quick Connect: intersection setup of one sensor and maximum one Traffic Management Interface Board (TMIB or TMIB2)
2. Installation: intersection setup using one or more sensors
3. New Speed Enforcement: setup of one enforcement sensor
4. Existing: selection of a project file (.tisf or .set) for editing

A project contains all setups of an installation and is saved as .tisf file. Projects are desktop independent, so every user can keep an own workspace, or rather desktop, and is able to switch between different projects.

8.4   STEP-BY-STEP SETUP WITH THE TMC

STEP 1) FINDING AN INSTALLATION LOCATION

The desired intersection or highway location can be found by using the search function like on Google Maps. Please enter the address, type in the latitude and longitude coordinates directly or navigate to the desired location by using the mouse. The TMC will load a map from different providers of which some maps are of high definition, already including lanes and stop bar positions.
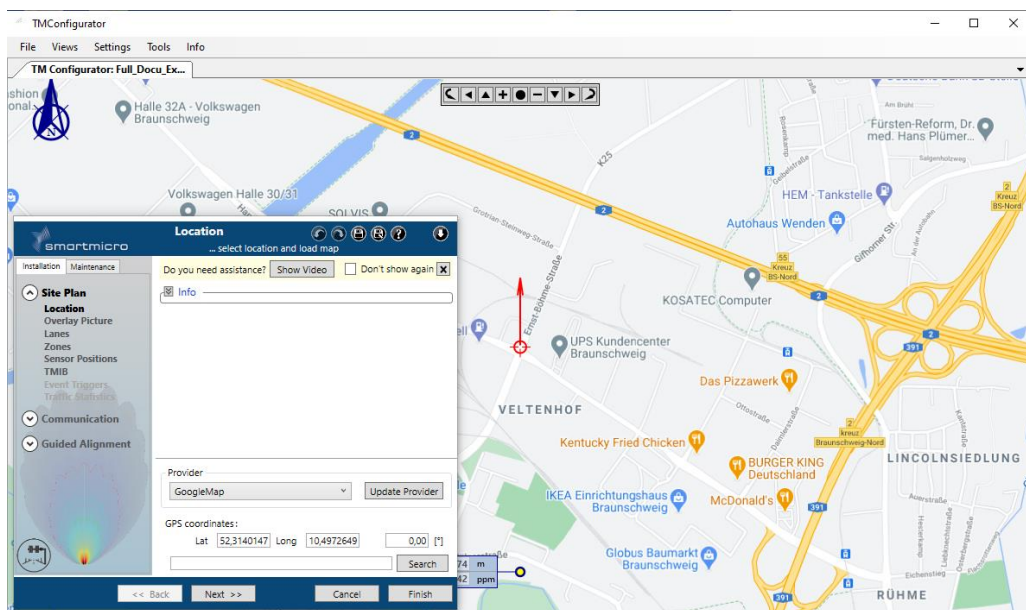

Figure 8-3: Step 1) Finding an intersection or highway location

STEP 2) LOADING A SATELLITE MAP

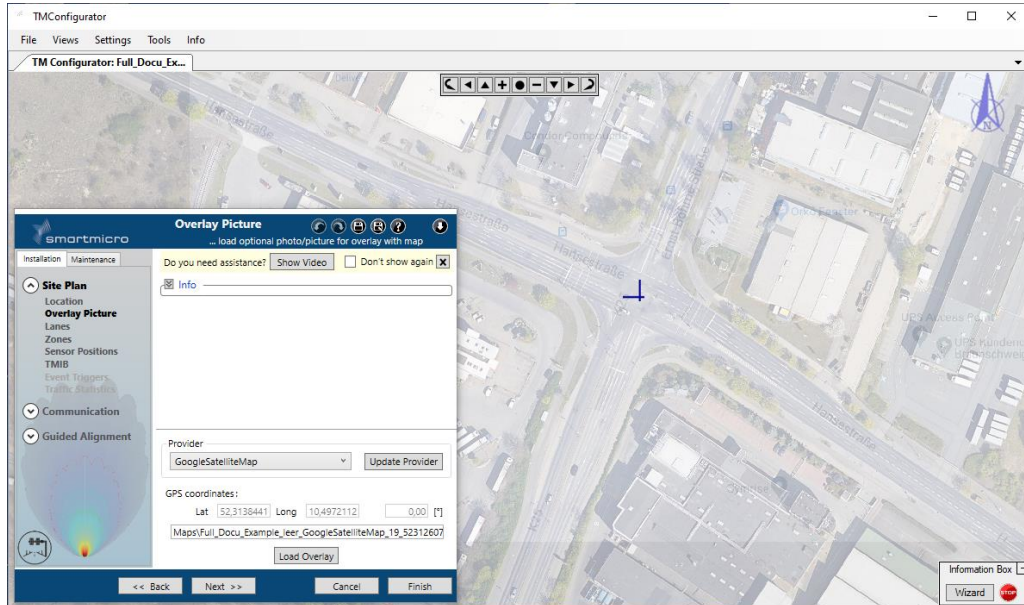Please load a satellite image or a cartographic image to overlay it with the map.

Figure 8-4: Step 2) Loading a satellite image

STEP 3) CONFIGURING LANES

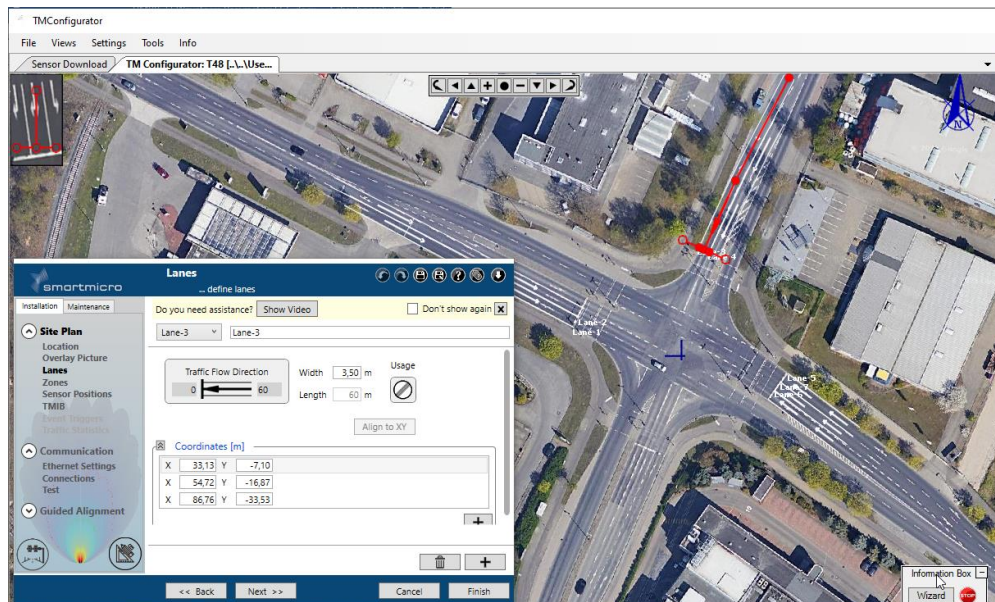Based on the satellite image the lanes can now be created.

Figure 8-5: Step 3) Configuring lanes

STEP 4) ADDING DETECTION ZONES

Detection zones can now be added to the location. To get default values for each application, please refer to the corresponding sensor datasheet.
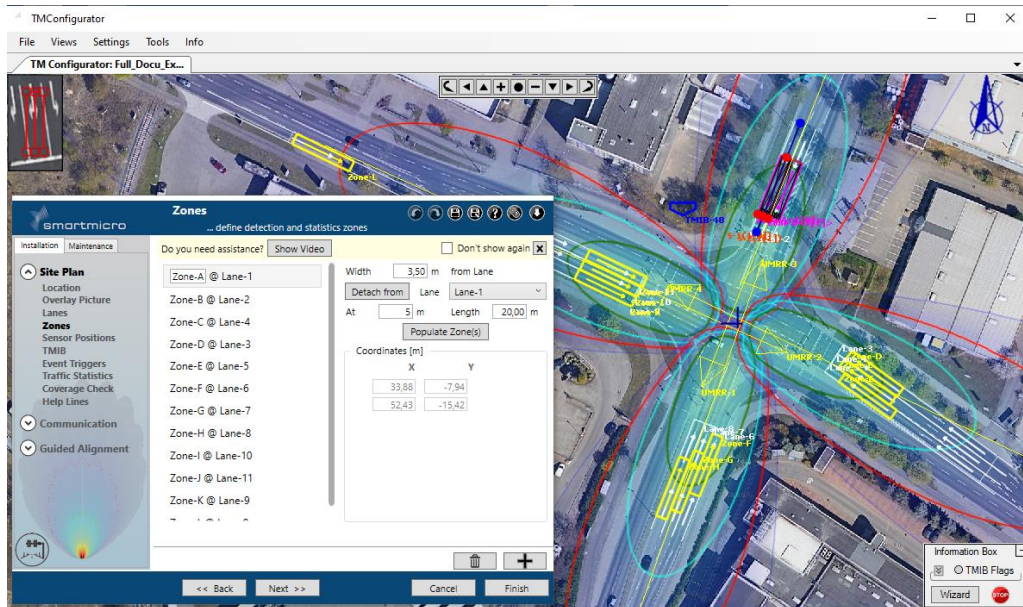

Figure 8-6: Step 4) Adding detection zones

STEP 5) ADDING A SENSOR

Radar sensors can be added to the image via drag-and-drop from a list of automatically proposed sensor types. Each sensor is preconfigured, so their field of view and detection range are visible immediately. Please adjust each sensor, so that the sensor beam covers all lanes. For stop bar detection it is recommended to locate the stop bars within the green part of the sensor beam. For further information on the default values for each application, please refer to the corresponding sensor datasheet.
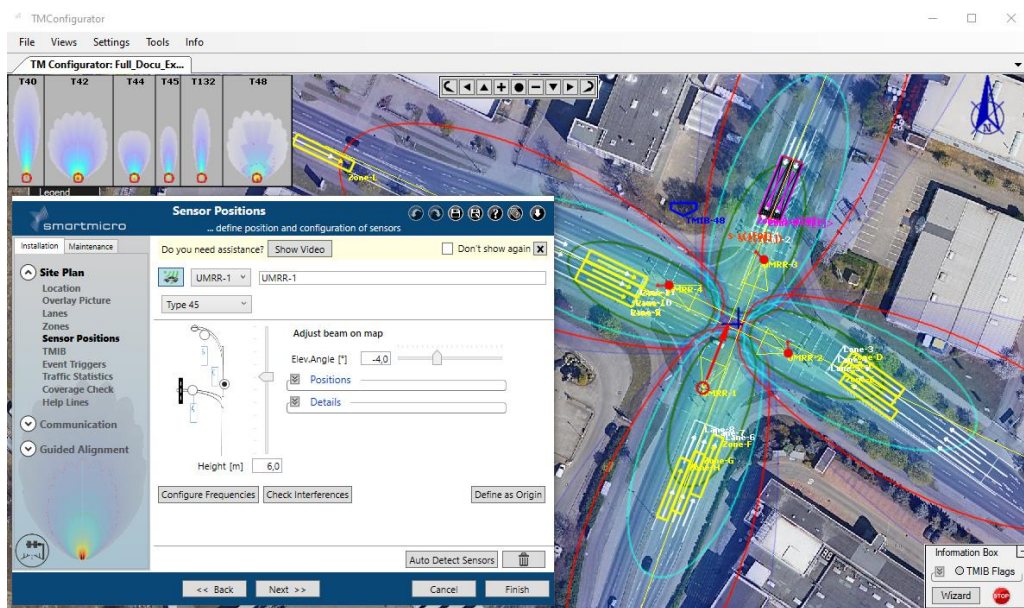
Figure 8-7: Step 5) Adding a sensor

STEP 6A) ASSIGNING RELAYS

Please assign the detection zones to each sensor, set the desired trigger configurations and assign relays.
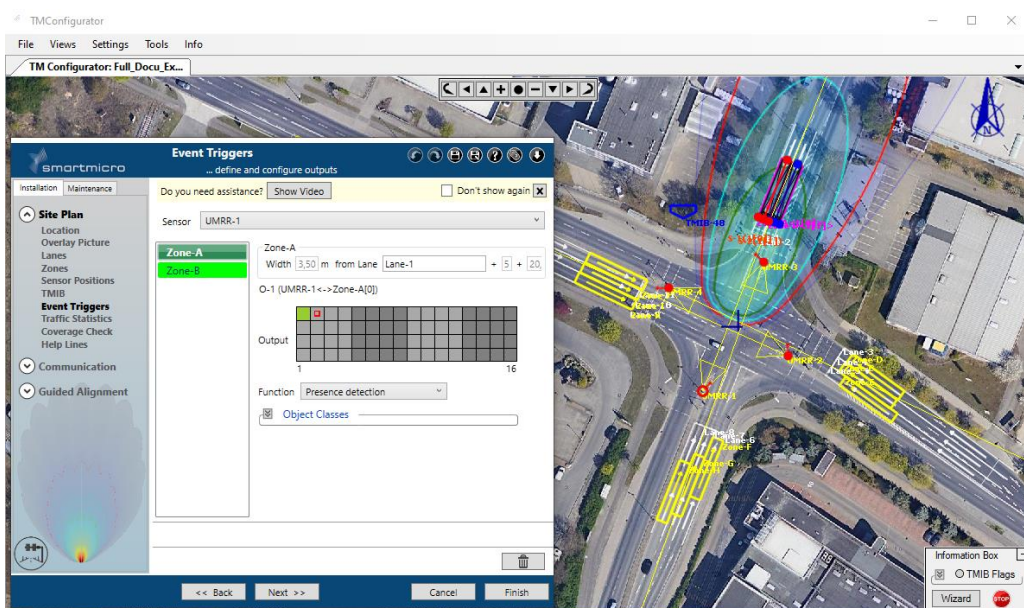

Figure 8-8: Step 6a) Assigning relays

STEP 6B) ASSIGNING TRAFFIC STATISTICS

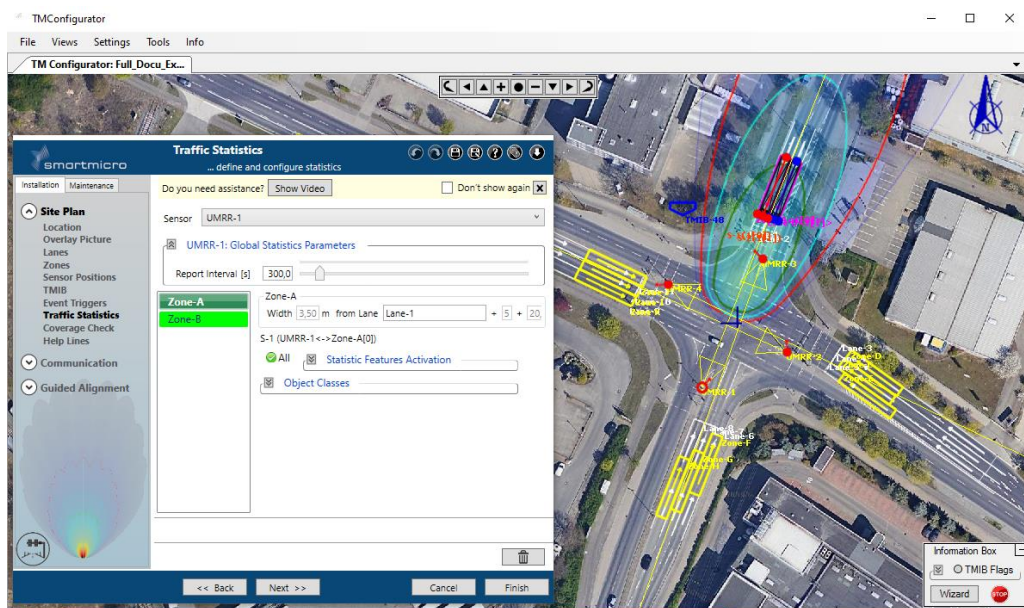Please set the traffic statistics to the desired detection zone.

Figure 8-9:Step 6b) Assigning traffic statistics

STEP 7) VERIFYING THE BEAM COVERAGE

After adding the lanes, sensors, and detection or counting zones to the project, the TMC will check the sensor beam coverage. In case of a misplacement, a remark will explain how to fix the beam coverage.
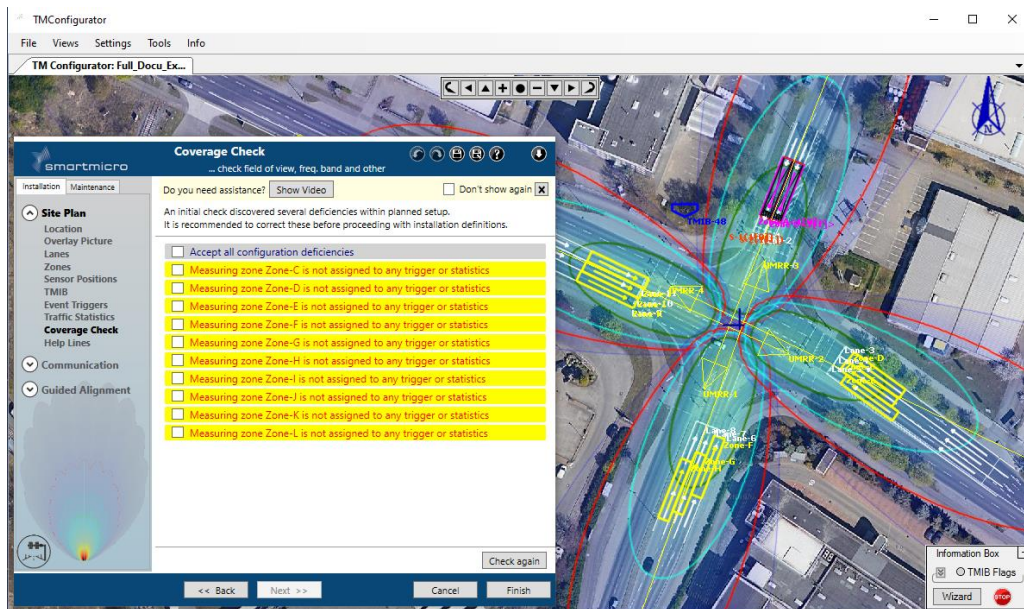

Figure 8-10: Step 7) Verifying the beam coverage

STEP 8) VERIFYING THE COMMUNICATION

Please physically connect all sensors and the TMIB, for the communication of all radar devices to be established automatically. The TMC will verify the communication of the sensors. If necessary, the sensor ID will be changed automatically to avoid interference.
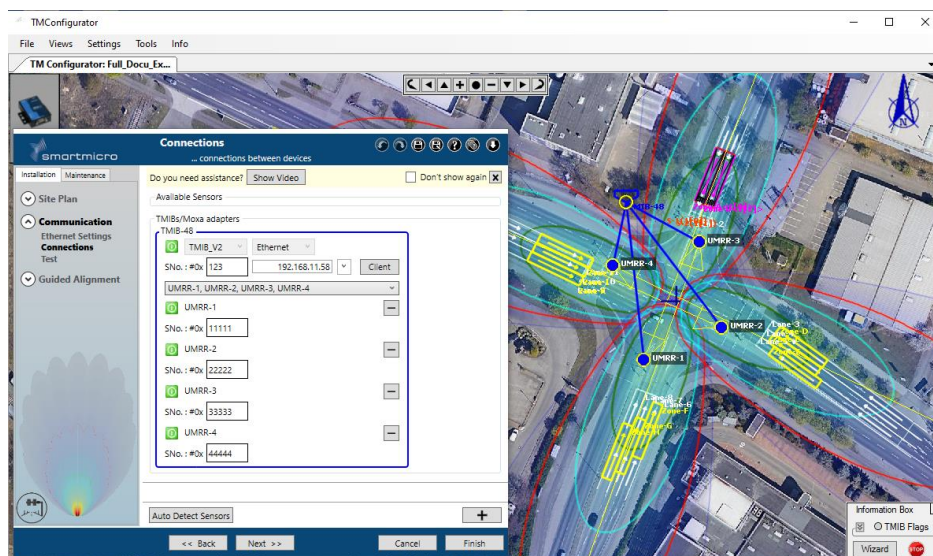

Figure 8-11: Step 8) Verifying the communication

STEP 9) VERIFYING PITCH AND ROLL ANGLE

The TMC will also give feedback if the sensor has the correct pitch and roll angle. The sensor position can be physically adjusted, and the software will immediately show if the angle is correct.
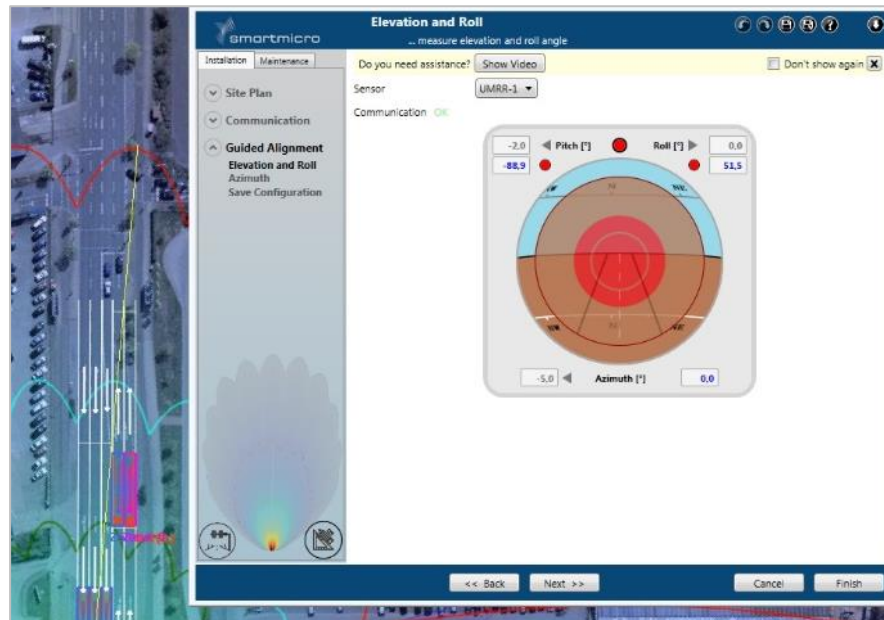

Figure 8-12: Step 9) Verifying pitch and roll angle

STEP 10) ALIGNING THE SENSORS

The sensors and the TMIB can now be installed on-site at the selected location. After the installation, please start the "Check orientation" test for each sensor. The TMC will analyze the traffic flow, and, based on this, give a recommendation to adjust the azimuth and elevation angle.
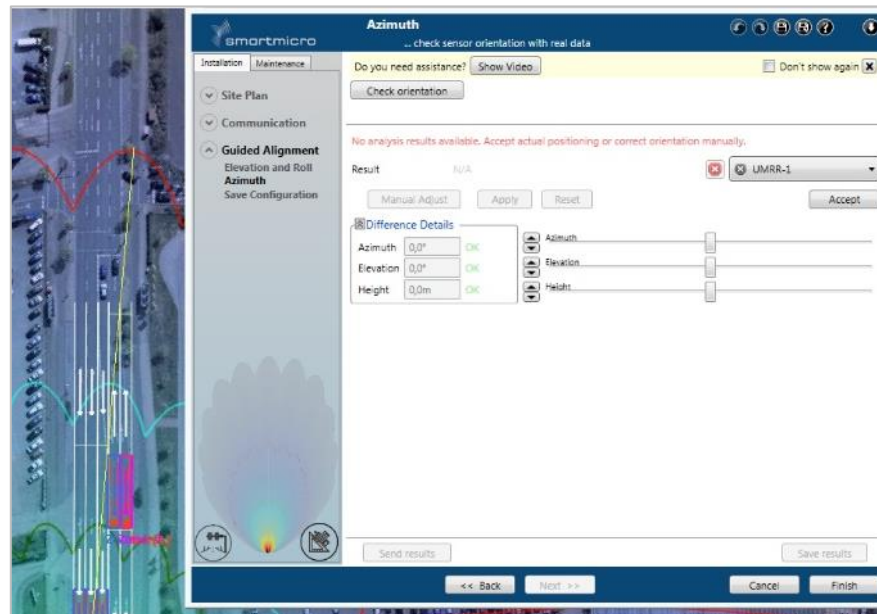
Figure 8-13: Step 10) Aligning the sensors

STEP 11) SETTING UP THE TMIB

The setup for the TMIB can be changed and activated, depending on the traffic controller NEMA TS1/TS2. Also, the relay output from the TMIB can be adjusted.
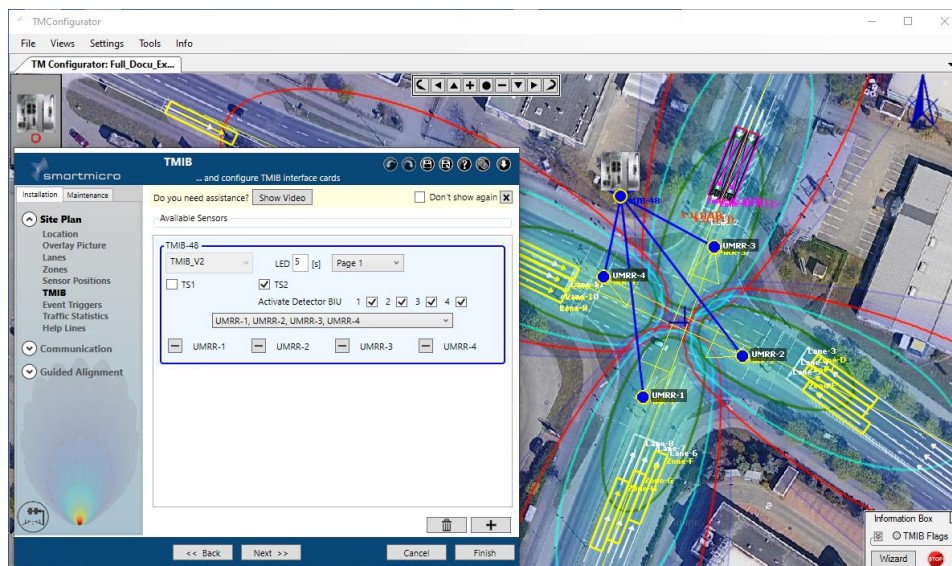

Figure 8-14: Step 11) Setting up the TMIB

8.5   FIRMWARE UPDATES FOR THE TMC

The download window of TMC can be used for firmware or software updates on smartmicro sensors. Firmware files can have as extension. cbx or .xml or .emc. To update the firmware, the connection to the sensor needs to be established for presetting the download feature. The sensor download window can be opened as follow
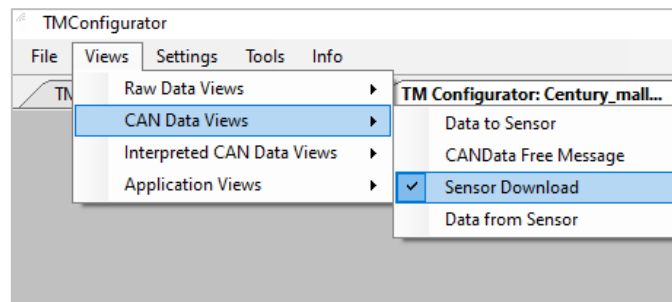

Figure 8-15: Choose and load a desktop

If the sensor is connected to the TMC, the Installation Wizard can be closed via the finish button. Now, please choose the file for the update.
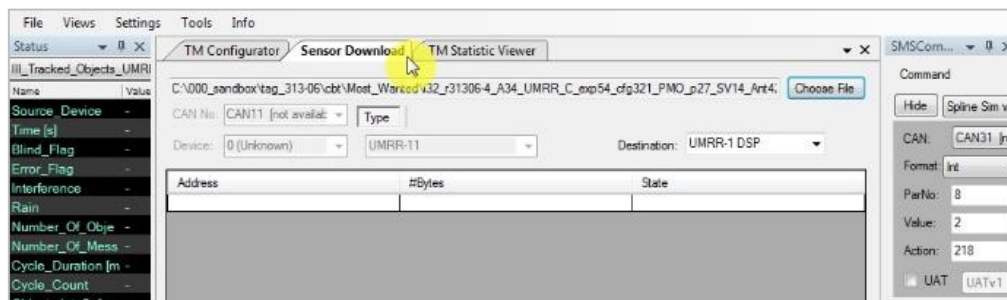
Figure 8-16: Download window

Please make sure that the automatic detection of the radar type and interface are selected correctly. If needed, "custom settings" can be chosen from the destination drop-down menu in order to change the sensor type and interface manually. Once the correct sensor type is selected, please click on "Start Download" to update the firmware.

8.6   DOWNLOAD VIA FTP

8.6.1   VIA COMMAND PROMPT

Use a command prompt and open e new ftp connection to the sensor with:

ftp 192.168.11.11 **(Sensor IP)**

User and password are:

user: anonymous

pass: guest

Load the new firmware file to the sensor with:

ftp> put FILE_IMAGE_NAME.img.enc

Now close the connection with:

ftp> close

(After closing the FTP connection with "close", the sensor will automatically restart and begin the firmware update)

➔ **Update takes about 4 minutes, please don't switch off the power!**
➔ If the firmware update was successful, the firmware will be deleted by the radar in the ftp folder. If the update is not successful, the radar will append 'FAILED' to the firmware file name

8.6.2   VIA WINDOWS EXPLORER

Open an explorer window. type ftp://192.168.11.11, hit enter

Copy the emc firmware file to the ftp folder

Once you close the explorer window the FTP connection will be also closed, the sensor will automatically restart and begin the firmware update)

➔ **Update takes about 4 minutes, please don't switch off the power!**
➔ If the firmware update was successful, the firmware will be deleted by the radar in the ftp folder. If the update is not successful, the radar will append 'FAILED' to the firmware file name

8.7   SENSOR CONFIGURATION PARAMETERS

Sensor configuration parameters are stored within the sensor's non-volatile memory and available upon sensor reboot or restart without external intervention. To amend an existing sensor's configuration, it is recommended that the computer has the sensor's configuration file available to facilitate simple and effective re-programming of the sensor's parameters. This configuration file is typically named as the location and suffixed by the ".TSIF" file type.

Simply open the TMC Software, open the relevant TSIF file and connect to the target sensor. You are then able to optionally retrieve the sensor's configuration parameters and change as required prior to saving back to the sensor.

Please note that the TSIF file carries the background map data, which is not saved to the sensor.

If you do not have the TSIF file available, you are able to auto-connect to the sensor and retrieve the configuration parameters by navigating to the Maintenance Tab, then navigate to the Sensor Alignment Tab, and retrieve all parameters. In this instance, you would not have the background map to verify lane placement. You would be able to perform all functions to change zones, output assignment, and lane assignments. Saving the configuration parameters would be performed in the normal way.

8.7.1 SENSOR CONFIGURATION DOWNLOAD (NO TISF)

If you do not have the TSIF file available, follow the below steps:

1. Load TM Configurator (TMC) program

2. Create a New TISF file by selecting installation mode

3. TMC will open to Site Plan -> Location by default

    a. Navigate down to the Sensor Positions Tab

4. In the bottom right of the wizard select the Auto Detect Sensors button

    a. If connect Directly to the sensor or TMIB, go to step 5

        i. Note: Your computer should be set as server IP 192.168.11.1

    b. If connect via TMIB in server mode go to step 6

        i. Note: You will need to know your TMIB IP and make sure your connected to that network.

5. Wait for the sensor to be detected

    a. Once you see a green check mark, and Type and Antenna Return values

    b. Hit the OK button at the bottom

    c. The sensors will be placed on the map

    d. Go to 7

6. Open the double down arrow next to Connect to Server at the bottom

    a. Un-check Ethernet, SMS Ethernet, RS485, and CAN

    b. Put in the IP of the TMIB in the first IP address slot

    c. Click Check button below

    d. Check mark the Ethernet at the top of the wizard

    e. Wait for all sensors to be found

    f. Click OK from the bottom

g. The sensors will be placed on the map

h. Go to 7

7. Navigate to Communication

    a. Navigate to Test

    b. Wait for test to complete

8. Navigate to Maintenance Mode Tab

    a. Navigate to Sensor Adjustments

    b. Navigate to All Parameters

    c. Select Load (All) - This will download all parameters from the sensors.

In these instances, you would not have the background map to verify lane placement. But you would be able to perform all functions to change zones, output assignment, and lane assignments. Saving the configuration parameters would be performed in the normal way.

9   FREQUENCY APPROVALS

smartmicro radar sensors are compliant with FCC, EU and other regulations and are notified in many countries. Please contact us to check the model-specific notification status at the time of the purchase.

9.1   DECLARATION OF CONFORMITY FOR THE USA

This product has been tested and found to comply with Part 15 Subpart C of the Federal Communications Commission (FCC) or the European RED directive, or other national rules, depending on the country where it may be in use.

 Operation is subject to the following two conditions:

- This device may not cause harmful interference.
- This device must accept any interference received, including interference that may cause undesired operation.

Usually this is followed by the following FCC caution:

Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment.

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may case harmful interferences to radio communications. However, there is no guarantee that interference will not occur in a particular installation.

If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more following measures:

- Reorient or relocate the receiving antenna
- Increase the separation between the equipment and receiver
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected
- Consult the dealer or an experienced radio/TV technician for help.

9.2 DECLARATION OF CONFORMITY FOR CANADA

9.2.1 DECLARATION OF CONFORMITY IN ENGLISH

This device complies with Industry Canada licence-exempt RSS standard(s).

Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

This equipment complies with IC RSS-102 radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with the minimum distance 20cm between the radiator & your body.

9.2.2 DÉCLARATION DE CONFORMITÉ EN FRANCAIS

Le present appareil est conforme aux CNR d'Industrie Canada applicables aus appareils radio exempts de licence. Léxploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Cet equipement est conforme aux limites d'exposition aux rayonnements IC établies pour un environnement non contrôlé. Cet équipement doit être installé et utilisé avec un minimum de 20cm de distance entre la source de rayonnement et votre corps.

9.3 DECLARATION OF CONFORMITY FOR EUROPE

The sensor has been marked with the CE mark. This mark indicates the compliance with the EC Directive 2014/53/EU. A full copy of the Declaration of Conformity can be obtained from s.m.s, smart microwave sensors GmbH, 38108 Braunschweig, Germany or via email at info@smartmicro.de.

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