User Manual

SMART TRAFFIC COMPACT

VEHICLE MONITORING

Product

Hardware: uRAD Smart Traffic Compact v2.0

Firmware: Vehicle Monitoring v2.1

Manufacturer

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Original document

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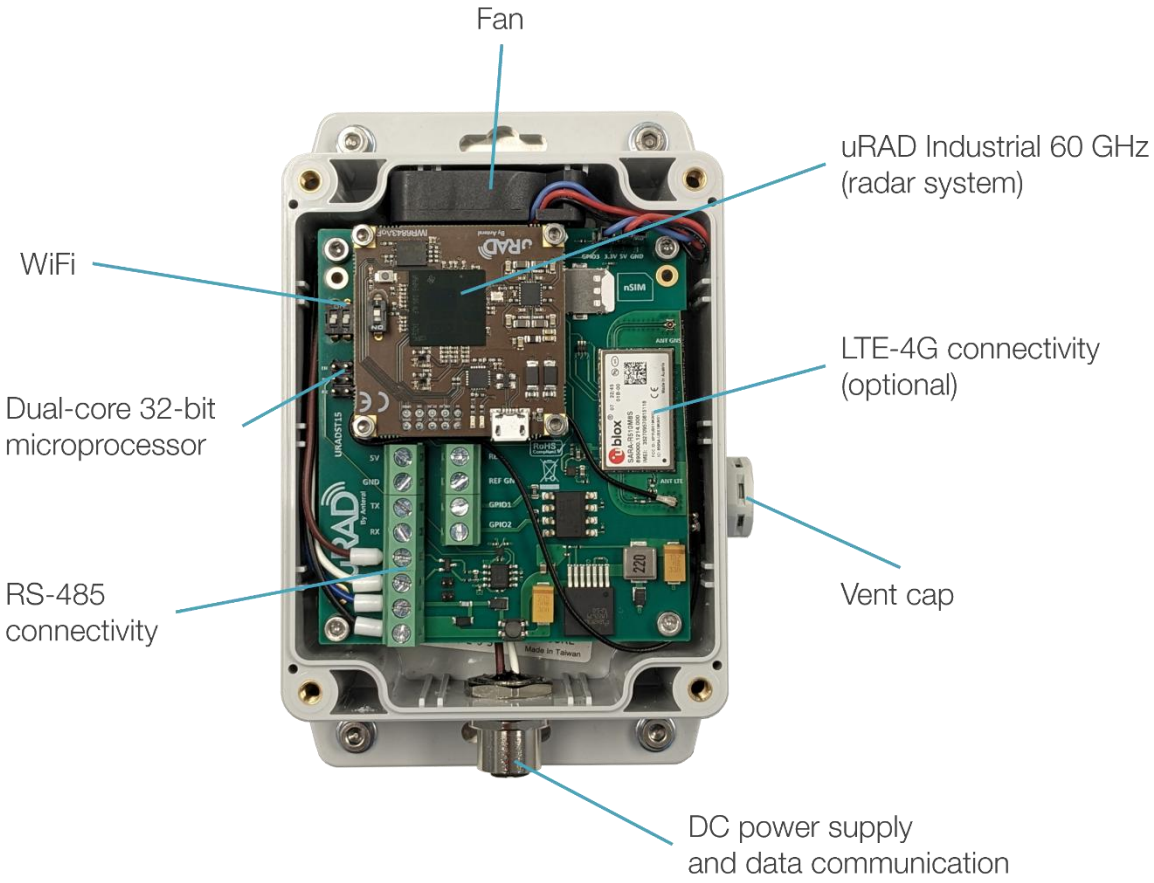
Components 1



Technical Features 2

RF Parameters	
Frequency	60 – 64 GHz (uRAD Industrial)
Modulation	FMCW
Emitting power	15 dBm
Field of view	160 º

Power Supply	
Voltage	8 – 42V DC (5V DC also available)
Connector	M12 circular female five-pole connector
Consumption	2.5 W

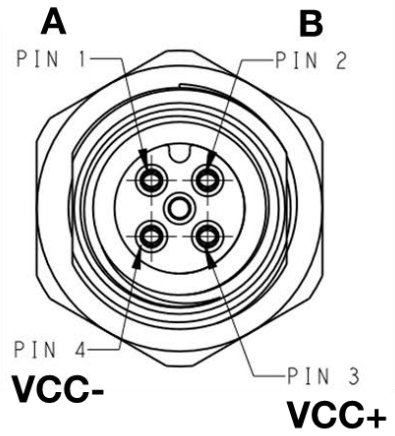
Mechanical Parameters	
Dimensions	115 x 90 x 65 mm
Weight	560 g
Material	Polycarbonate
Protection	IP66, NEMA 4X,12,13, UL-508, UL94 HB
Installation	Anchorage and clamps included. System for vertical adjustment.

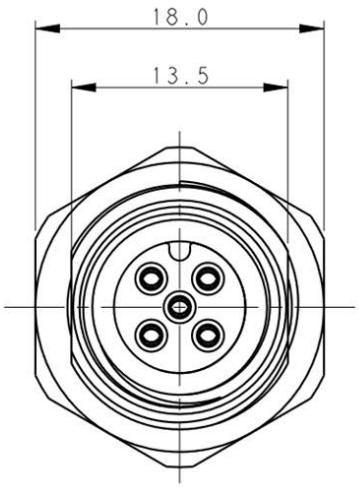
Other Parameters	
Wired Interface	RS-485 via MODBUS RTU protocol
Wireless Interface	WiFi (installation and configuration) LTE-4G via API (FIWARE compatible)
Core processor	Xtensa dual-core 32-bit, 240 MHz, 8MB Flash
Operating temperature	-20ºC a +80ºC

Performance	
Maximum velocity	180 km/h
Maximum distance	30 m (limited for accurate vehicle classification)
Side distance	±15 m

Connector 3

The device has a 5-positions (4 loaded) M12 female external connector with IP67 dust-tight and waterproof protection.





The pin connection is the following:

1. A: RS485+ / A / T+
2. B: RS485- / B / T-
3. VCC+: positive DC power supply between 8 and 24 V.
4. VCC-: negative DC power supply (GND).

   The central pin is not connected. (Some models are provided with a 4-pin connector).

The connector reference is:

- MPN: T4171310004-001 (T4171310005-001 also valid).
- Manufacturer: TE Connectivity AMP Connectors.
- Compatible MPN for assembly: T4111001041-000 (T4111001051-000 also valid).

Clamping Structure 4

A support bracket is included for the placement of the device outdoors in cylindrical supports.

The central articulation has one screw that allows to fix the angle of inclination necessary in the placement. Clamps are also included with the structure.

Installation 5

The system is very versatile and can be used in many counting scenarios:

- Urban or interurban roads.
- Velocity measurement up to 180 km/h.
- Up to 6 lanes monitoring with a single device.
- Counting vehicles with positive velocity (moving away) and negative velocity (approaching) at the same time.
- Dense or light traffic scenarios

Several aspects have to be taken into account when mounting your vehicle counting system:

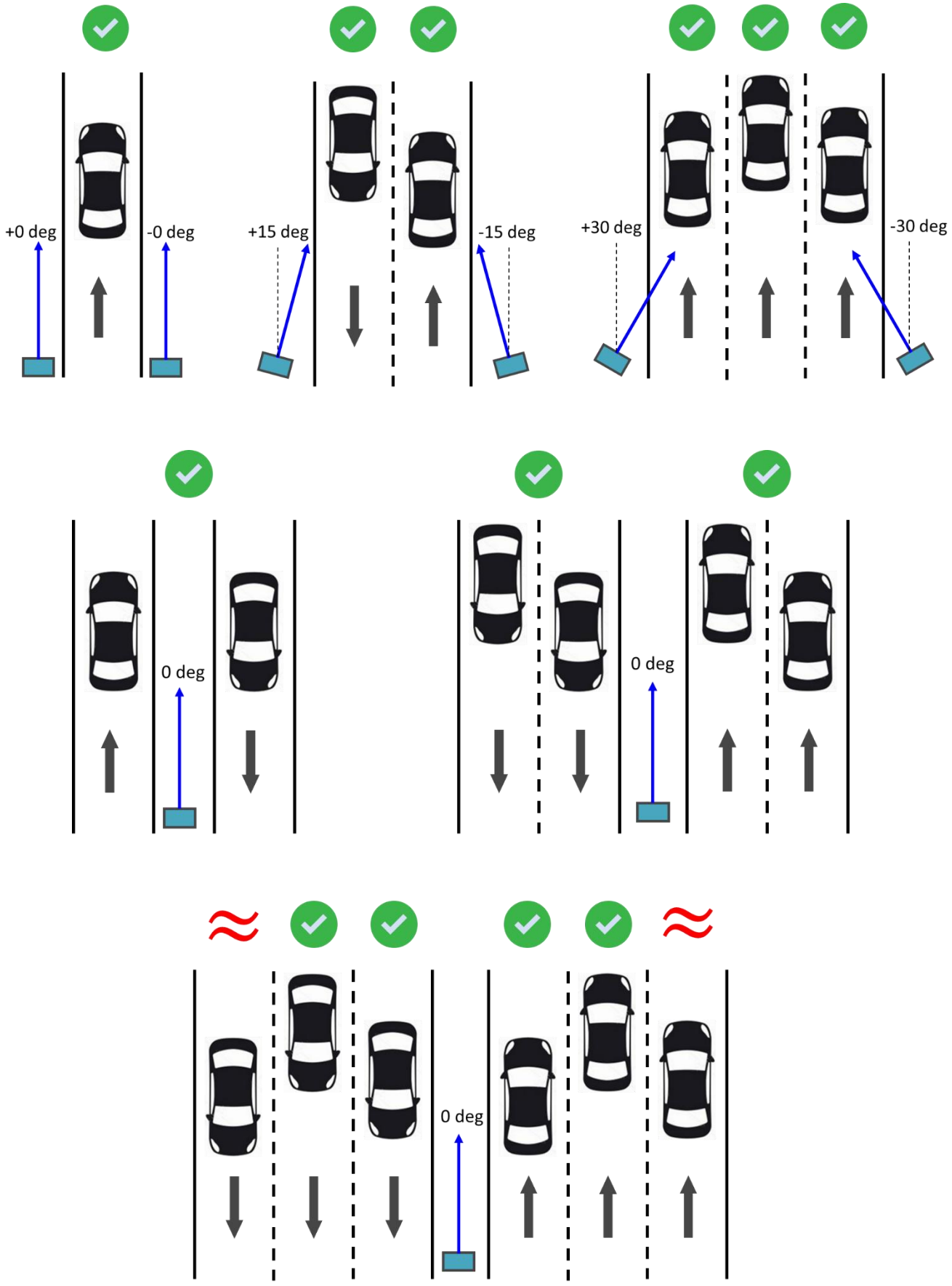
Device orientation

The device has to be mounted with the power supply connector downwards.

Position of the device relative to the road

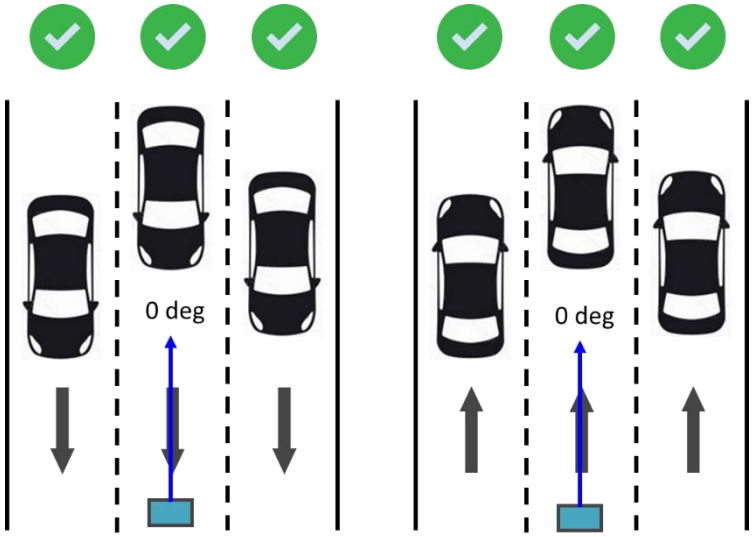
The device can be mounted on either side of the road, both to the left or to the right, or above it. Depending on the use case, the general mounting recommendation is as follows: to measure 1 lane on one side of the radar, mount it at an angle of 0 degrees; for 2 lanes, at an angle of 15 degrees; and for 3 lanes, at an angle of 30 degrees.

The following images illustrate the main use cases and how the radar should be mounted.

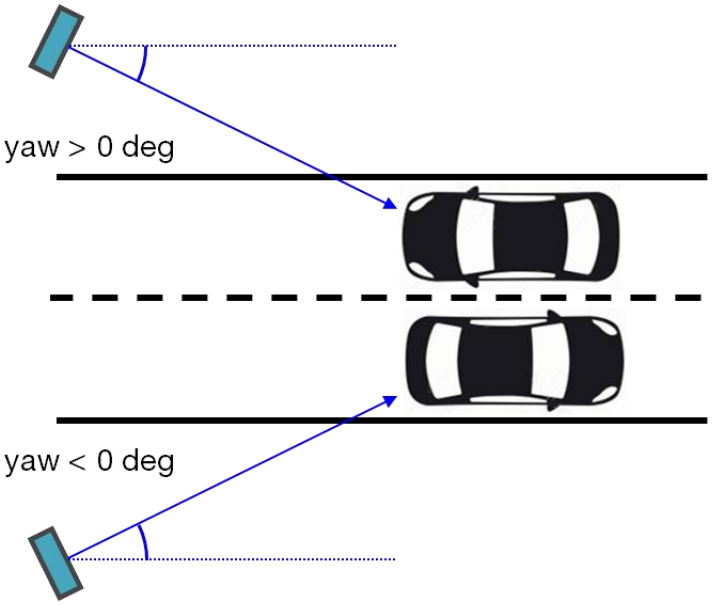

+0 deg
-0 deg
+15 deg
-15 deg
+30 deg
-30 deg
0 deg
0 deg
0 deg

In the use case of 6 lanes, counting accuracy in the outermost lanes may be compromised depending on lane size and traffic density. As a general rule, the device provides very good accuracy up to 8 meters of lateral distance.

For this case, we recommend one radar for each direction



If it becomes necessary to apply a YAW angle, for example, in the case of 2 or 3 lanes or because an object blocks the field of view, please consider the angle's sign for the configuration parameters according to the following image



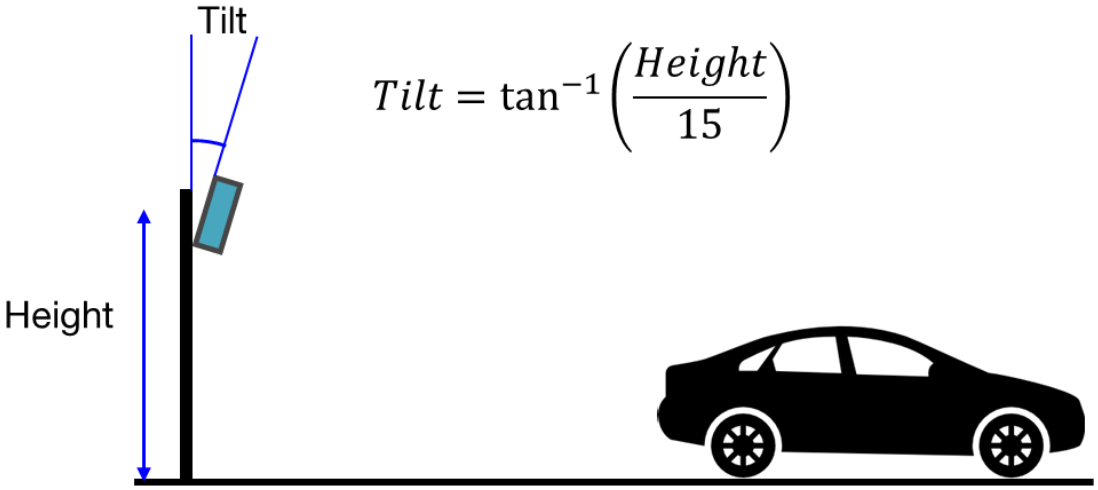
The radar is mounted on the left side of the roadway, so vehicles pass to the right of the radar (from the perspective of an observer placed behind the radar) → YAW angle with a positive sign.

The radar is mounted on the right side of the roadway, so vehicles pass to the left of the radar (from the perspective of an observer placed behind the radar) → YAW angle with a negative sign.

Device heigh and tilt

To achieve a proper view of the vehicles and therefore avoid one vehicle blocking another, the radar should be installed at a height of 3 meters or more. Depending on the mounting height, the radar should be tilted downward, but only slightly. Follow these recommendations

HEIGHT	TILT
3 m	11 degrees
4 m	15 degrees
5 m	18 degrees
6 m	22 degrees



Additionally, two conditions are important to consider during installation:

1. Install the device on a straight section of road within the detection range, i.e., between 0 and 25 meters from the radar. Avoid installation on curved sections.
2. Install the device on a section where vehicles do not stop within the detection range. If vehicles come to a complete stop, duplicates may occur.

Start-Up 6

General

The device creates a hidden Wi-Fi access point that allows the user to connect with a computer or mobile device to perform various tasks:

- Configure installation parameters.
- Check the device status.
- View real-time detections.
- Update the device firmware.
- Point cloud real-time visualization.
- Point cloud saving by UDP for debugging.

The Wi-Fi network name is as follows:

SSID: ST_Compact_SN<Serial-Number>

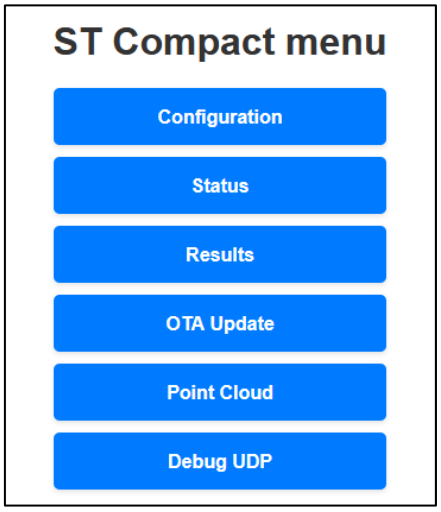
By default, the WiFi SSID is ST_Compact_SN1 and will change after is configured the serial number on the web configuration page.

This Wi-Fi network is hidden and must be added manually. The password is provided to each user upon purchase.

Once connected to the device's Wi-Fi network, access the following address in a browser:

http://192.168.4.1/

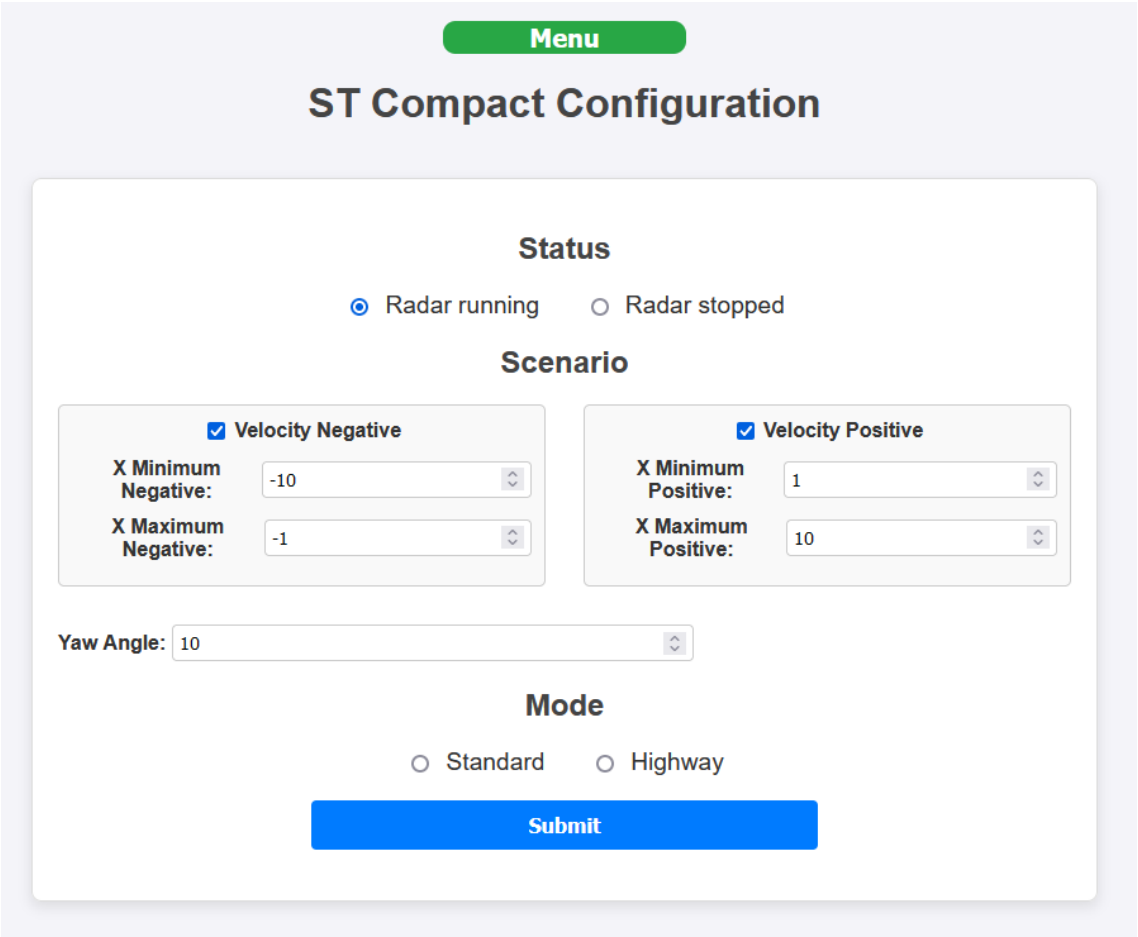
You will be taken to the main screen, from which you can access the different functions.



For security reasons, after 10 minutes, the device stops creating the Wi-Fi access point if no one connects to it. To recreate the access point, the device must be restarted.

Configuration parameters

From the main tab, use the Configuration button to access http://192.168.4.1/config, where the configuration parameters are set.



The screen displays the configuration parameters saved in the device's permanent memory. To apply any changes, click the Submit button. When powered on or restarted, the device loads the saved values from the permanent memory.

The configuration parameters are as follows:

- Status

When powered on or restarted, the device begins measuring automatically. Its default state is *Radar running*. The device can be stopped by changing the Status to *Radar stopped*. This action stops the RF power transmission from the radar transceiver, reducing power consumption.

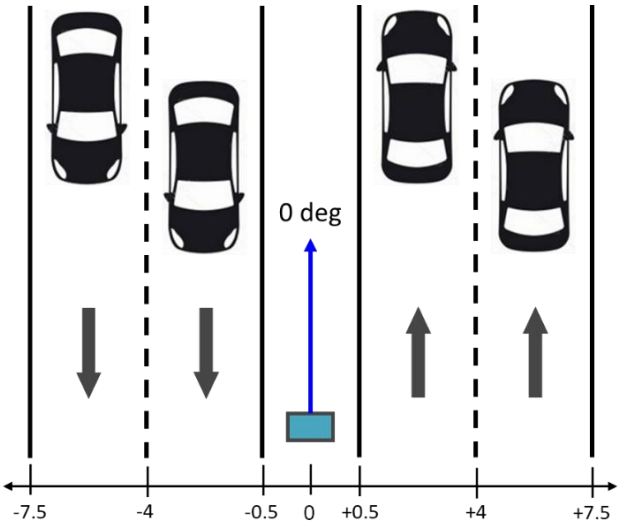
Note: If you change the Status to *Radar stopped*, this value is saved to the device's internal memory, and upon the next power-on or restart, the radar will remain stopped.

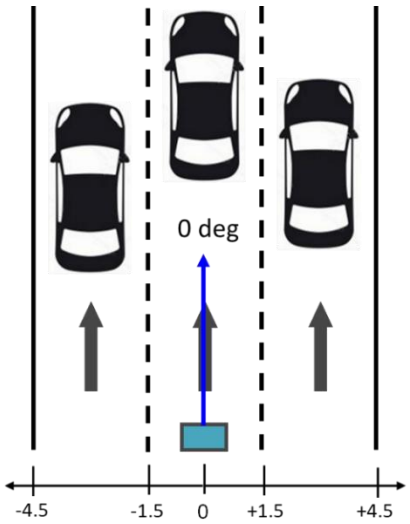
- Scenario

Scenario parameters are configured in this section.

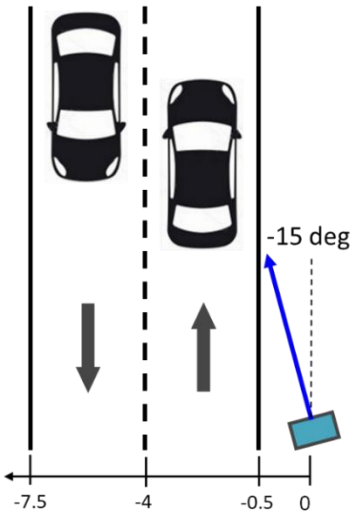
- Velocity Negative: check this box to measure vehicles approaching the radar.
- Velocity Positive: check this box to measure vehicles moving away from the radar.
- X Minimum Negative: defines the minimum distance in meters in the horizontal direction to consider for counting vehicles with negative velocity (approaching).
- X Maximum Negative: defines the maximum distance in meters in the horizontal direction to consider for counting vehicles with negative velocity (approaching).
- X Minimum Positive: defines the minimum distance in meters in the horizontal direction to consider for counting vehicles with positive velocity (moving away).
- X Maximum Positive: defines the maximum distance in meters in the horizontal direction to consider for counting vehicles with positive velocity (moving away).
- Yaw angle: Defines the pointing angle in the horizontal axis (yaw) relative to the road (in degrees). Follow the pointing recommendations in the installation chapter. Remember: to the left of the road positive yaw angle, to the right of the road negative yaw angle.

Refer to the following examples of use cases.





X_MINIMUM_NEGATIVE_VELOCITY = no aplica
X_MAXIMUM_NEGATIVE_VELOCITY = no aplica
X_MINIMUM_POSITIVE_VELOCITY = -4.5
X_MAXIMUM_POSITIVE_VELOCITY = +4.5



X_MINIMUM_NEGATIVE_VELOCITY = -7.5
X_MAXIMUM_NEGATIVE_VELOCITY = -4
X_MINIMUM_POSITIVE_VELOCITY = -4
X_MAXIMUM_POSITIVE_VELOCITY = 0

- Mode

Scenario parameters are set in this section.

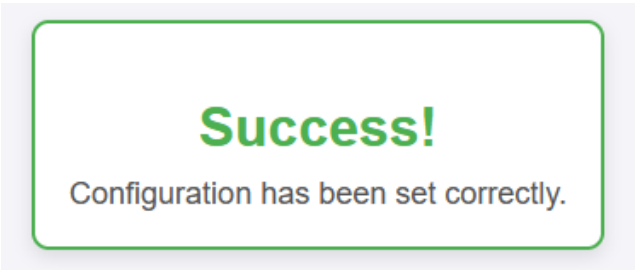
- Standard: For installations in urban or suburban environments where vehicles travel below 120 km/h. In this case, the configuration provides better spatial resolution at the cost of a lower maximum speed. Vehicle classification is more accurate.
- Highway: For installations on highways or high-speed roads where vehicles travel above 120 km/h. In this mode, the RF configuration allows higher speed detection but with lower spatial resolution. Vehicle classification is less accurate.

- Serial Number

Defines the device serial number. Only numbers must be set (e.g. 1234). It has effect on the WiFi SSID created by the device. This field can be checked via the UPDATE_STATUS action on the Web or Modbus.

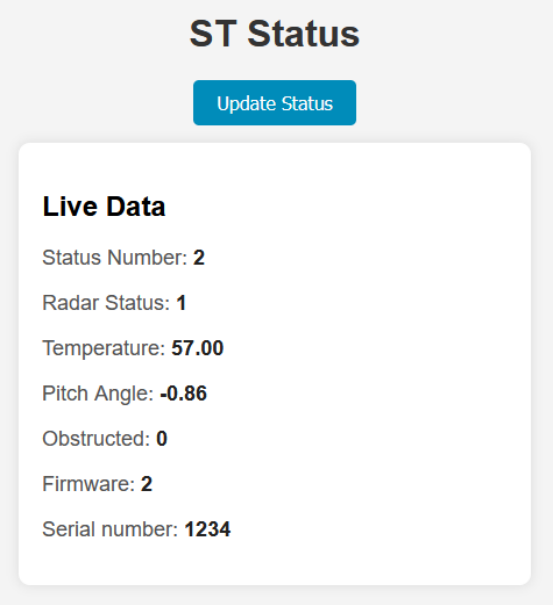
To apply any changes, click the Submit button.

If the changes have been successfully applied, a confirmation message will appear.



Device Status

From the main tab, clicking the Status button accesses the address http://192.168.4.1/status, which displays the tab where the device status can be checked.



The status variables indicate the device's state since the last time the UPDATE_STATUS action was executed. Therefore, to check the status correctly, follow these steps:

1. Read the value of STATUS_NUMBER.
2. Execute the UPDATE_STATUS action and verify that the confirmation message appears.
3. Wait 30 seconds for the device to perform internal checks, then return to the Status tab.
4. Check that the STATUS_NUMBER variable has increased by 1.
5. If it has increased by 1, the update was successful, and the status variables are now up to date.
6. If it has not increased and remains the same as in step 1, the update was unsuccessful, and you should return to step 2.

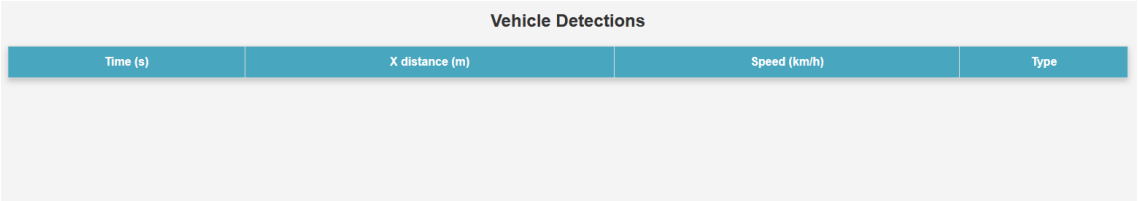
Notice that the status update lasts 10-15 seconds and during that time the tracking is stopped. Therefore, it is recommended to call the check status action every 2 minutes or more to have little influence on the boat count.

The status variables are:

- STATUS_NUMBER: each time the UPDATE_STATUS action is successfully executed, this value increases by 1. When it exceeds 32,000, it resets to 0. It serves to verify whether the status variables have been correctly updated and that the readings are reliable, ensuring they do not correspond to a previous state.
- RADAR_STATUS: status of the RF radar module. 0 = Not OK, 1 = OK.
- TEMP: radar temperature in degrees.
- OBSTRUCTED: indicates whether the radar is obstructed by an object. 0 = Not obstructed, 1 = Obstructed.
- FIRMWARE_VERSION: device firmware version.
- SERIAL_NUMBER: device serial number.

Results Visualization

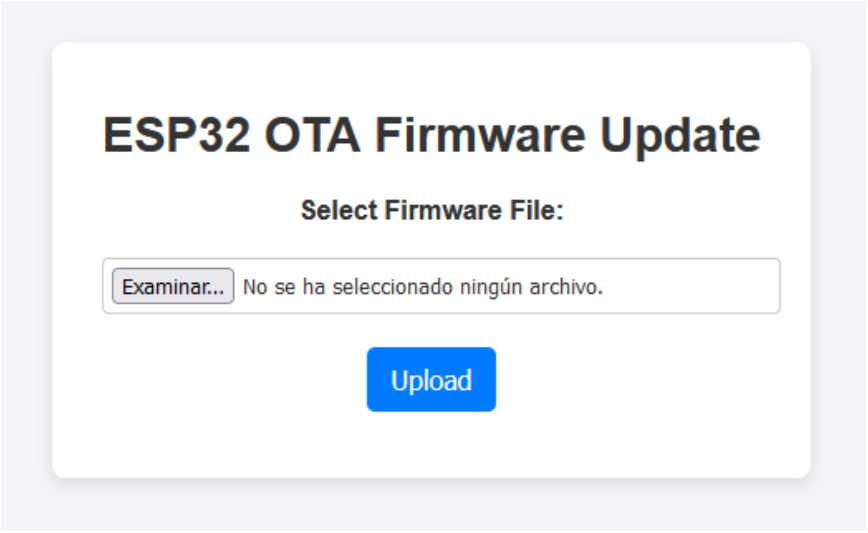
From the main tab, click the Show Results button to access http://192.168.4.1/results, which opens the tab for viewing real-time detections.



This tab allows you to verify the proper operation of the device.

Upload new firmware

From the main tab, click the OTA Update button to access http://192.168.4.1/update, which opens the tab for uploading new firmware to the device.



Point cloud Visualization

From the main tab, click the Real Time Visualizer button to access the addressn http://192.168.4.1/pointcloud which opens the tab where you can visualize in real-time the point cloud detected by the radar.

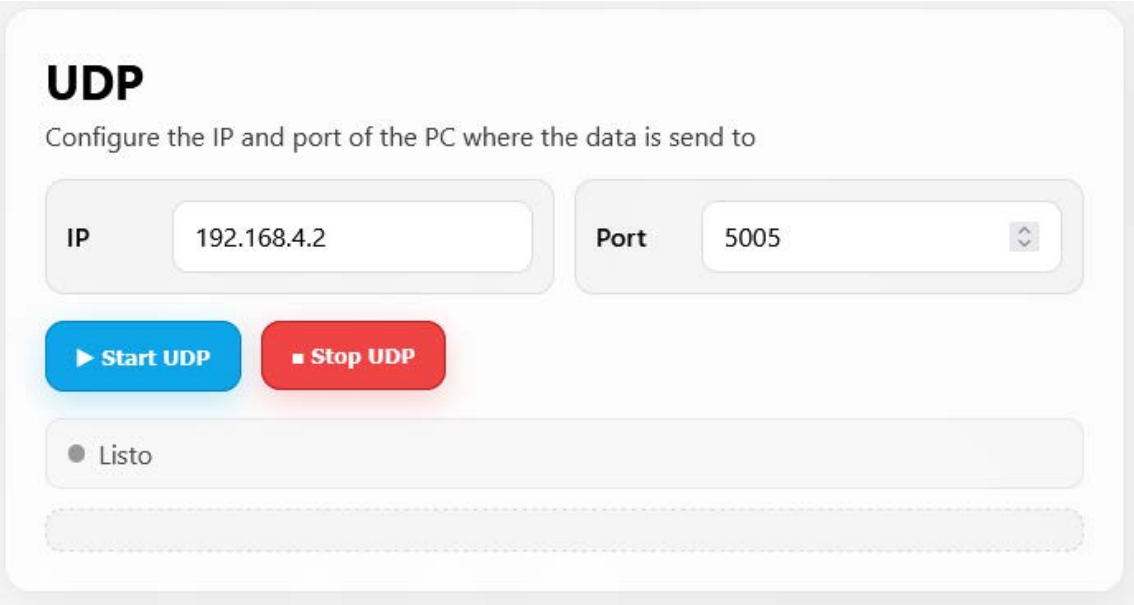
A graph is displayed with the detected points according to the configured settings. This can be very useful for identifying unwanted reflections and better defining the optimal operating area.

Point cloud UDP debug

From the main tab, click the Debug UDP button to access http://192.168.4.1/debug_udp, which opens the tab for saving the point cloud through WiFi by UDP.

On this tab it should be configured the IP and port of the device the data it will be send to.

For staring the debug session click on Start UDP and for finishing the session click on Stop UDP.



From the other side, on the PC it should be executed the script read_udp_to_csv.py, configuring on the side of the script the UDP_IP and UDP_PORT. In general, if only one pc is connected to the WiFi created by the device, it will have the IP 192.168.4.2.

For checking if the PC is receiving data the program prints the frame number of the radar data in the Python console.

Operating Modes 7

Summary

The device operates in two different modes for delivering results. Results can be provided either through a wired connection via the RS-485 interface or uploaded wirelessly to a database for later access via an API.

SOP connector

The device has a two-position dip switch, called SOP (sense-on-power), which determines the operating modes.

1. Wi-Fi: If position 1 is ON (up), the device is in Wi-Fi mode and, upon each restart, it creates the Wi-Fi network for accessing firmware uploads, configuration, etc. Keep in mind that the Wi-Fi access point will turn off if no one connects within 10 minutes. If it is in the OFF position (down), the device never creates the Wi-Fi network, and the only way to configure it is through RS-485 or the API.
2. RS-485: If position 2 is ON (up), the measured results are stored in the device's internal memory and can be accessed via a wired connection using the RS-485 interface through the MODBUS protocol. Chapter 7 explains the protocol and how to use the registers. If position 2 is OFF (down), results cannot be accessed through a wired connection, and RS-485 is disabled.

The radar module has another single-position DIP switch that should not be modified. It must always remain in the OFF position

SIM card

To upload results to the database, a nano SIM card must be inserted into the designated slot. To do this, open the front cover of the case by unscrewing the four front screws and insert the SIM card following the PCB's printed indications.

The device detects the presence of a SIM card with an active data plan and will automatically upload results to the database using the 4G-LTE module.

If you do not wish to upload results to the database, remove the SIM card and restart the device. The device checks for the presence of a SIM card only upon power-up.

Chapter 8 details the API functionality. By default, results are uploaded to the uRAD database, but if you wish to use a different database, contact contact@urad.es to discuss this further. The device is also compatible with the FIWARE standard.

The device can operate in both modes simultaneously; results are saved in the internal registers and uploaded to the database at the same time.

Power consumption

Power consumption varies depending on the operating mode. The following table shows approximate consumption values.

Consumption	Conditions
3.3 W	System = ON, Radar = ON, Wi-Fi = ON, 4G = ON
3 W	System = ON, Radar = ON, Wi-Fi = ON, 4G = OFF
2.5 W	System = ON, Radar = ON, Wi-Fi = OFF, 4G = OFF
0.6 W	System = ON, Radar = OFF, Wi-Fi = OFF, 4G = OFF

The RS-485 mode does not have a significant impact on power consumption.

Consumption with 4G assumes the module is always on. However, if you want to optimize power consumption with 4G, the power-on and power-off behavior of the module can be customized.

MODBUS Protocol 8

General

The Modbus RTU protocol is a master/slave serial protocol in which a master device (MASTER) polls one or more slave devices (uRAD) that are identified by a unique address.

In the Modbus RTU protocol, information is stored in registers that are 16-bit variables that can be read or written with specific functions defined by the Modbus standard.

The Modbus protocol design is based on 16-bit registers, so 32-bit variables must be represented by two consecutive registers. MASTER should interpret 32-bit variables as follows:

Example: Value 0x12345678, Registers 40202,40203 → Register 40202 = 0x1234, Register 40203 = 0x5678.

Modbus RTU protocol configuration

The uRAD device is the slave device and is configured as follows:

- Baud rate: 128000 bps
- Format: 8 bits of data and 1 bit of stop
- Parity: even
- uRAD slave address: 82 (decimal value for character "R")
- Address type: base 0

In order for the MASTER device to communicate with the uRAD device, the following Modbus RTU functions have been programmed:

- Function code 3: Read Holding Register, used by MASTER for reading the configuration of uRAD device. Requests with function code 3 have an offset of 40000. That is, to read register 40001, register 1 must be requested.
- Function code 4: Read Input Register, used by MASTER for reading the measurements of uRAD device. Requests with function code 4 have an offset of 30000. That is, to read register 30001, register 1 must be requested
- Function code 6: Write Single Register, used by MASTER for modifying the configuration of uRAD device stored in one Modbus register.

Requests with function code 6 have an offset of 40000. That is, to read register 40002, register 1 must be requested

- Function code 16: Write Multiple Register, used by MASTER for modifying several configuration parameters at the same time, stored in multiple consecutive Modbus registers. Requests with function code 16 have an offset of 40000. That is, to read registers starting from 40002, register 2 must be requested

Any other Modbus protocol function will be considered by MASTER as an illegal function.

The following exceptions are also contemplated, that the device returns when certain events occur:

- 01 Illegal function: try to perform an incorrect action at that moment, such as trying to start the radar when it is already started, stop it when it is already stopped and change the register that tells us what state it is in (40001).
- 02 Illegal data address: attempt to write to a register that is not used.
- 03 Illegal data value: Attempting to write an illegal value.

Since the maximum length of a Modbus PDU (Protocol Data Unit) is 253 (subtracted from the maximum Modbus ADU (Application Data Unit) length of 256 on RS485), only up to 125 registers can be requested at a time when RTU format is used

In the following link, very complete information on the MODBUS protocol can be found.

https://www.simplymodbus.ca/index.html

If you have any questions about the protocol, do not hesitate to contact us at contact@urad.es.

Functional Description of Communication

Communication is ALWAYS initiated by the MASTER, and uRAD does not send asynchronous notifications.

Once power is supplied to uRAD, it begins its operation by automatically initializing all its hardware components, loading the configuration saved in the device's non-volatile memory (default configuration the first time or the last saved configuration), and entering the state it was in before the device reset. If it is the first time, it will start taking measurements with the default configuration.

Once the MASTER sends the "Start Measuring" command, uRAD will begin normal operation, taking measurements and storing data according to its configuration. In this state, uRAD can be monitored through the measurement

reading registers. The device configuration can be modified both while the device is taking measurements and when it is paused.

Configuration registers

This section describes the uRAD configuration registers. Data is represented as 16-bit signed integers. These registers can be modified by writing with the Write Single Register (function code 6) or Write Multiple Register functions (function code 16).

If an attempt is made to set a configuration parameter with an incorrect value, an Illegal Data Value Exception (03) response will be returned.

Configuration parameter	Address	Type	Allowed values	Units	Scale factor	Default value
DIRECTION	40000	signed int16	0, 1, 2	-	1	2
X_MINIMUM_POSITIVE	40001	signed int16	[-200, +200]	metros	0.1	-200
X_MAXIMUM_POSITIVE	40002	signed int16	[-200, +200]	metros	0.1	+200
X_MINIMUM_POSITIVE	40003	signed int16	[-200, +200]	grados	0.1	-200
X_MAXIMUM_POSITIVE	40004	signed int16	[-200, +200]	grados	0.1	+200
YAW_ANGLE	40008	signed int16	[-450, +450]	grados	0.1	0
DETECTION_MODE	40009	signed int16	0, 1	-	1	0

- DIRECTION: 0 – count boats only moving away from the radar, 1 – count boats only approaching the radar, 2 – count boats in both directions.

The rest of the parameters are described in the start-up chapter.

The rest of the configuration parameters are the same as those detailed in the Start-up chapter.

Action registers

This section describes the uRAD action registers. Data is represented as a 16-bit unsigned integer. These registers can be modified by writing them, with the Write Simple Register function (function code 6), the value 256 (decimal) or 0x0100 (hexadecimal).

Trying to stop the radar when it is stopped it will not do anything, and trying to start the radar once is started it will restart the radar.

Action	Address	Value
START	40100	256 (decimal) o 0x0100 (hexadecimal)
STOP	40101	256 (decimal) o 0x0100 (hexadecimal)
UPDATE_MEASUREMENTS	40102	256 (decimal) o 0x0100 (hexadecimal)
DEFAULT_CONFIGURATION	40103	256 (decimal) o 0x0100 (hexadecimal)
RESET	40104	256 (decimal) o 0x0100 (hexadecimal)
UPDATE_STATUS	40105	256 (decimal) o 0x0100 (hexadecimal)
CLEAN_MEASUREMENTS	40106	256 (decimal) o 0x0100 (hexadecimal)

- START: start measuring. Start counting boats. uRAD saves the counting and average speed values in its internal records.
- STOP: stop measuring. Stop counting boats.
- UPDATE_MEASUREMENTS: Not in use. On firmware version 1.8 and previous ones used to write the data stored in the internal counting registers to the measurement read registers. Currently the data is stored on the registers automatically
- DEFAULT_CONFIGURATION: load default settings.
- RESET: the device is restarted, and all measurement records are cleaned up.
- UPDATE_STATUS: update the status registers to later read them and get the status of the device.
- CLEAN MEASUREMENTS: clean the individual and general measurements registers. The procedure to get the measurements is the following one:
  1. Read all measurements registers.
  2. Execute CLEAN MEASUREMENTS action.
  3. Read MEASURE_FLAG until has the value 1. To read this status register it is not necessary to execute the “UPDATE_STATUS” action.
  4. All the measurement registers are cleaned.

Status register

This section describes the status registers, which indicate the status or information of certain uRAD features. The data is represented as a 16-bit signed integer. These records cannot be modified.

Status	Address	Type	Units	Scale factor
STATUS_NUMBER	40200	signed int16	-	1
RADAR_STATUS	40201	signed int16	-	1
TEMPERATURE	40202	signed int16	grados	0,1
PITCH_ANGLE	40203	signed int16	grados	0,1
OBSTRUCTED	40204	signed int16	-	1
FIRMWARE_VERSION	40205	signed int16	-	0,1
SERIAL_NUMBER	40206	signed int16	-	1
INTERNAL_COUNTER	40207 & 40208	signed int32	-	1
MEASURE_FLAG	40209	signed int16	-	1

- STATUS_NUMBER: Each time the UPDATE_STATUS action is successfully executed, this value increases by 1. When it exceeds 32,000, it resets to 0. This helps verify whether the status variables have been correctly updated and ensures that the readings are reliable, meaning they do not correspond to a previous state. The procedure to check the device status is as follows:
    1. Read the STATUS_NUMBER value.
    2. Execute the UPDATE_STATUS action.
    3. Wait 30 seconds for the device to perform internal checks.
    4. Read the STATUS_NUMBER value again and verify that it has increased by 1.
    5. If it has increased by 1, the update was successful, and the status records can now be read.
    6. If it has not increased by 1, the update was unsuccessful, and you should return to step 2.
- RADAR_STATUS: status of the RF radar module. 0 = Not OK, 1 = OK.
- TEMPERATURE: radar temperature in degrees.

- OBSTRUCTED: indicates whether the radar is obstructed by an object. 0 = Not obstructed, 1 = Obstructed.
- FIRMWARE_VERSION: device firmware version.
- SERIAL_NUMBER: device serial number.
- INTERNAL_COUNTER: counter that indicates the number of seconds that have elapsed since the last device reboot. This register automatically updated every second. It is not necessary to execute the UPDATE_STATUS action to update its value. Actually, it occupies two registers, with #40207 being the MSB and #40208 being the LSB of the complete number in int32 format.
- MEASURE_FLAG: Indicates that it is possible to read the measurement registers. After the CLEAN_MEASUREMENT action, this register is set to 0 indicating that the measurement registers are being cleaned and the information inside them could be invalid. After 30 seconds, this register is set to 1, indicating that it is possible to read the measurement registers correctly. This register is automatically updated after executing the CLEAN_MEASUREMENT action. It is not necessary to execute the UPDATE_MEASUREMENT action to updated its value

Measurement read registers

uRAD saves the measured values of the vehicle count in Modbus input registers.

Registers 30000 to 30019 store the total values.

- In the vehicle number registers, the count of the number of vehicles that have been detected since the last time the UPDATE_MEASUREMENTS action was executed is kept.
- In the average speed registers, the average speed of all vehicles that have been detected since the last time the UPDATE_MEASUREMENTS action was executed is kept.

Therefore, each time the MASTER sends the UPDATE_MEASUREMENTS action command, the count and speed registers are updated with the data measured ONLY since the last time that same action was executed. So don't forget to read the registers before UPDATE_MEASUREMENTS or you will lose the saved data as the count resets.

All registers are encoded as 16-bit signed integers and to obtain their floating-point representation, a scale factor MUST be applied to the raw integer value.

The value "DEC -32767" or "HEX 0xFFFF" is used to represent that there is no data available for the given parameter (NaN).

Parameter	Address	Units	Scale factor
Number of regular vehicles in positive direction	30000	vehicles	1
Average speed of regular vehicles in positive direction	30001	km/h	0,1
Number of regular vehicles in negative direction	30002	vehicles	1
Average speed of regular vehicles in negative direction	30003	km/h	0,1
Number of medium vehicles in positive direction	30004	vehicles	1
Average speed of medium vehicles in positive direction	30005	km/h	0,1
Number of medium vehicles in negative direction	30006	vehicles	1
Average speed of medium vehicles in negative direction	30007	km/h	0,1
Number of long vehicles in positive direction	30008	vehicles	1
Average speed of long vehicles in positive direction	3000	km/h	0,1
Number of long vehicles in negative direction	30010	vehicles	1
Average speed of long vehicles in negative direction	30011	km/h	0,1
Number of motorcycles/bicycles in positive direction	30012	vehicles	1
Average speed of motorcycles/bicycles in positive direction	30013	km/h	0,1
Number of motorcycles/bicycles in negative direction	30014	vehicles	1
Average speed of motorcycles/bicycles in negative direction	30015	Km/h	0,1
Number of pedestrians in positive direction	30016	pedestrians	1
Average speed of pedestrian in positive direction	30017	km/h	0,1

Number of pedestrians in negative direction	30018	pedestrians	1
Average speed of pedestrian in negative direction	30019	km/h	0,1

- A regular vehicle is any vehicle up to approximately 8 meters in length.
- A medium vehicle is a vehicle between approximately 8 and 15 meters in length.
- A long vehicle is a vehicle over approximately 15 meters in length.
- Motorcycles and bicycles are considered the same type.
- Pedestrians are defined as all those vehicles detected with a speed of less than 10 km/h.

In registers 30100 onwards, the individual information of each detected vehicle is saved. They are encoded as 16-bit signed integers.

- Register 30100 saves the number of total vehicles to know how many consecutive registers must be read with individual information for each vehicle.
- Register 30101 onwards for the individual information of each vehicle. It is saved:

– TIMESTAMP: number of seconds since the last restart of the device (2 registers).

– VELOCITY: average speed in km/h. A positive speed indicates vehicles moving away, while a negative speed indicates vehicles approaching. To calculate the value, scale by 0.1

– DISTANCE X: estimation of the horizontal distance in meters from the vehicle. Useful for lane identification. > 0 to the right of the radar, < 0 to the left of the radar. To calculate the value, scale by 0,1.

– TYPE: identification of the type of vehicle. 1 = regular vehicle, 2 = medium vehicle, 3 = long vehicle, 4 = bicycle/motorcycle, 5 = pedestrian.

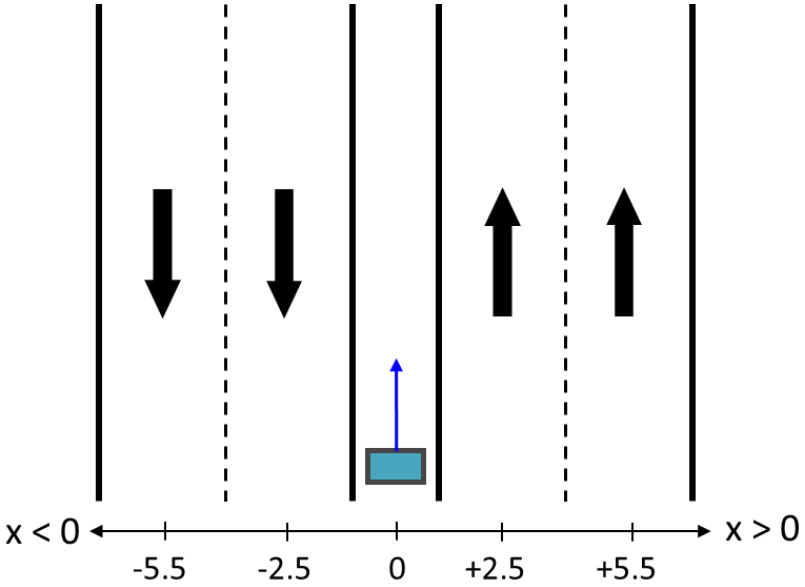
Parameters	Address	Units	Scale Factor
Total number of vehicles measured in this period	30100	vehicles	1
TIMESTAMP vehicle 1	30101 & 30102	seconds	1
VELOCITY vehicle 1	30103	km/h	0,1
DISTANCE X vehicle 1	30104	m	0,1

TYPE vehicle 1	30105	-	1
TIMESTAMP vehicle 2	30106 & 30107	seconds	1
VELOCITY vehicle 2	30108	km/h	0,1
DISTANCE X vehicle 2	30109	m	0,1
TYPE 2	30110	-	1
…	…	…	…
TIMESTAMP vehicle N	30101+5*(N-1) & 30102+5*(N-1)	seconds	1
VELOCITY vehicle N	30103+5*(N-1)	km/h	0,1
DISTANCE X vehicle N	30104+5*(N-1)	m	0,1
Tipo del vehicle N	30105+5*(N-1)	-	1

Each vehicle occupies 5 registers. Therefore, only the individual information for the first 1980 vehicles can be saved. Be sure to read and update these records periodically if you want individual information by vehicle. The total information of records 30001 to 30020 continues to be updated, even if the number of 1980 vehicles is exceeded. Also, remember that only 125 registers can be requested at once, so each call will only be able to read the information for 25 vehicles.

Example

We assume a radar installation in a central reservation with two lanes on each side, as in the following image.



The device is configured and the action START is executed, which sets time 0.

The following information should be sent to the device:

- Device Id: 82
- Function code 6
- Address to modify: 101
- Value to write: 256
- CRC: 9876

Which converted to a Modbus frame in hexadecimal would be the following:

52 6 0 65 1 0 94 26

The frame to be received will be the same as the one requested:

52 6 0 65 1 0 94 26

Between two actions UPDATE_MEASUREMENTS 3 vehicles are detected with the following characteristics.

- Vehicle 1:

  It is detected 1872 seconds after the START action, at a speed of +65.1 km/h (driving away from the radar), with a Distance X of +2.6 meters (one lane to the right of the radar) and Type 1 (normal vehicle).

- Vehicle 2:

It is detected 1915 seconds after the START action, at a speed of -80.6 km/h (approaching to the radar), with a Distance X of -5.3 meters (two lanes to the left of the radar) and Type 2 (long vehicle).

- Vehicle 3:

It is detected 2027 seconds after the START action, at a speed of +115.2 km/h (driving away from the radar), with a Distance X of +5.0 meters (two lanes to the right of the radar) and Type 1 (regular vehicle).

To obtain the value of the measurement reading records, the registers 30001 to 30020 should be requested to obtain the general statistics and from 30100 onwards to obtain the individual vehicle information.

In the case of general statistics, the following information should be requested:

- Device Id: 82
- Function code: 4
- Address of first record requested: 1
- Total number of records requested: 20
- CRC: 44205

Which converted to a Modbus frame in hexadecimal would be as follows:

52 4 0 1 0 C AD AC

And the answer obtained will be:

52 4 18 0 2 03 86 0 0 0 0 0 0 0 0 1 83 26 0 0 0 0 0 0 0 DA F4

Represented in a table, the values of the measurement reading registers of the example would be as follows:

Register	HEX value	Decimal value	Note
30001	0x0002	2	Vehicle 1 and vehicle 3
30002	0x0386	902	Average value of +65,1 and +115,2 = +90,2 km/h
30003	0x0	0	
30004	0x0	0	
30005	0x0	0	
30006	0x0	0	
30007	0x0	0	
30008	0x0	0	
30009	0x0	0	
30010	0x0	0	

30011	0x0001	1	Vehicle 2
30012	0x8326	-806	-80,6 km/h
30013	0x0	0	
30014	0x0	0	
30015	0x0	0	
30016	0x0	0	
30017	0x0	0	
30018	0x0	0	
30019	0x0	0	
30020	0x0	0	
…			
30100	0x0003	3	Total of 3 vehicles detected
30101	0x0000	0	Time stamp vehicle 1 = 1872 seconds
30102	0x0750	1872	
30103	0x028B	651	Velocity vehicle 1 = +65,1 km/h
30104	0x001A	26	Distance X vehicle 1 = +2,6 m
30105	0x0001	1	Type vehicle 1 = 1 (regular)
30106	0x0000	0	Time stamp vehicle 2 = 1915 seconds
30107	0x077B	1915	
30108	0x8326	-806	Velocity vehicle 2 = -80,6 km/h
30109	0x8035	-53	Distance X vehicle 2 = -5,3 m
30110	0x0002	2	Type vehicle 2 = 3 (long)
30111	0x0000	0	Time stamp vehicle 3 = 2027 seconds
30112	0x07EB	2027	
30113	0x0480	1152	Velocity vehicle 3 = +115,2 km/h
30114	0x0032	50	Distance X vehicle 3 = +5,0 m
30115	0x0001	1	Tipy vehicle 3 = 1 (regular)
30116	0xFFFF	NaN	
30117	0xFFFF	NaN	
…			

API Operation 9

Purpose

Through this API, the user can obtain the list of detected vehicles, as well as read or modify the configuration parameters.

Authorization system

For authorizing the client two special headers must be sent for the API authorization.

First, a Bearer Token type authorization system is used on this API. Also, the requests must include a fixed header with an api-key used for controlling the API use of each client.

The names and content of the headers are the following one:

Header name	Header content
Authorization	Bearer <Token>
x-api-key	<api-key>

Where <Token> is obtained on the Login endpoint and <api-key> is a fixed value that will be provided by uRAD.

Endpoints

1. Login

Description: Endpoint used to authenticate the user.

- Request

Endpoint: https://api.urad.es/v1/api/auth/login

Operation: POST

Body:

```
{
      "username": <username>,
      "password": <password>,
}
```

Where <username> and <password> are the username and password provided by uRAD.

- Reply

In case of correct identification, the message body will contain:

```
{
    "success": true,
    "tokens": {
       "idToken": <Token>
    }
}
```

Where <Token> is the value that must be sent in the rest of the tokens for authorization.

In case of incorrect identification, the message body will have the following message:

```
{
    "error": "User or password incorrect"
}
```

2. Logout

Description: Endpoint used to terminate the user's session.

- Request

Endpoint: https://api.urad.es/v1/api/auth/logout

Operation: POST

On the header should be sent the

- Reply

In case of correct identification, the user's session will expire, and the message body will contain:

```
{
    "success": true
}
```

In case of incorrect identification, the message body will have the following message:

```
{
    "error": "User or password incorrect"
}
```

3. Get list of devices

Description: Endpoint used to obtain the listing of all devices managed by the user.

- Request

Endpoint: https://api.urad.es/v1/api/devices

Operation: GET

As previously explained the ‘Authorization’ and ‘x-api-key’ headers must be included on the request.

- Reply

The body of the response will contain a JSON with the device ID’s.

An example of a response would be the following:

```
{
      "Devices": [
            "SN1234",
            "SN4567"
      ]
}
```

4. Obtain detected vehicles

Description: Endpoint used to obtain the information of the vehicles detected by the selected device.

- Request

Endpoint: https://api.urad.es/v1/api/devices/<device-id>/data?from_date=<from_date>&to_date=<to_date>

Where <device-id> is one of the radar identifiers obtained at the /devices endpoint.

<from_date> and <to_date> are the dates between which you want to get the data.

Important: No more than 1 months can elapse between the start and end date.

The date format is:

Year-Month-Day (i.e: “2025-11-21”)

Operation: GET

As previously explained the ‘Authorization’ and ‘x-api-key’ headers must be included on the request

- Reply

The response will be a csv with all the vehicles detected between <from_date> and <to_date>.

This CSV has the following columns delimited by commas:

- seen_at: timestamp in seconds (integer value)
- speed: vehicle speed (floating value)
- x: detected position on the X-axis (floating value)
- type: vehicle type (integer Value)

The timestamp or Unix time is the number of seconds elapsed since January 1, 1970 in GMT.

The possible detected types are:

1 = Regular vehicle

2 = Medium vehicle

3 = Long vehicle

4 = Bike/Motorbike

5 = Pedestrian

The vehicle speed will be positive in case of vehicles moving away from the radar and negative in case of vehicles approaching the radar.

An example of a reply would be the following:

```
seen_at,speed,x,type
1765967371,-18.05,3.38,3
1765967371,79.66,3.15,3
1765967371,13.32,0.5,2
1765967377,-73.46,2.9,2
```

5. Get device configuration

Description: Endpoint used to obtain the configuration of a device.

- Request

Endpoint: https://api.urad.es/v1/api/devices/<device-id>/configuration

Operation: GET

Where <device-id> is the radar identifier obtained from the /devices endpoint.

- Reply

The answer is a JSON with the following information:

```
{
    "state": {
        "config": {
            "mode": 0,
            "x_min_pos": 4,
            "x_max_pos": 8,
            "x_min_neg": 0,
            "x_max_neg": 5,
            "yaw_angle": 0,
            "v_pos": 1,
            "v_neg": 1
        },
        "powerOn": 0
    },
    "sync": false
}
```

The detailed meaning of the parameters is indicated in the configuration section of the general user manual.

`mode` can contain the value 0 indicating the standard mode or 1 indicating the high-speed mode.

`v_pos` can contain the value 0 indicating that vehicles are not measured away from the radar or 1 indicating that vehicles are measured moving away from the radar. For `v_neg` logic is homologous.

`powerOn` indicates if the radar is online or not.

`Sync` indicates if the device has read the last configuration.

6. Modify device configuration

Description: Endpoint used to modify a device's settings.

- Request

Endpoint: https://api.urad.es/v1/api/devices/<device-id>/configuration

Operation: POST

Where <device-id> is the radar identifier obtained from the /devices endpoint.

Body of the request:

```
{
    "config": {
        "mode": 0,
        "x_min_pos": 4,
        "x_max_pos": 8,
        "x_min_neg": 0,
        "x_max_neg": 5,
        "yaw_angle": 0,
        "v_pos": 1,
        "v_neg": 1
    }
}
```

The format of the configuration parameters is the same as those of the configuration request.

- Reply

In case the configuration is correct the operation will return:

```
{
    "success": true
}
```

In case any field in the configuration is missing or does not have the appropriate type, the answer will be:

```
{
    "success": false
}
```

Safety & Handling 10

This chapter includes important safety and handling information for uRAD device

Read all safety and handling information below as well as the operating instructions before using uRAD products in order to avoid any injury or damage.

Keep this user guide on hand for future reference.

Important Safety Information

WARNING: Failure to follow this safety instructions could result in fire, electric shock, or other injury or damage.

Proper handling uRAD contains sensitive electronic components. Do not drop, disassemble, crush, bend, deform, puncture, shred, microwave, incinerate, paint, or insert foreign objects into uRAD.

Water and wet locations Do not expose any sensitive components of uRAD to water or rain, or handled near washbasins or other wet locations without a proper case. Take care not to spill any food or liquid on uRAD. In case uRAD gets wet, allow it to dry thoroughly before turning it on again. Do not attempt to dry uRAD with an external heat source, such as a microwave oven or hair dryer.

uRAD repairs Never attempt to repair or modify uRAD by yourself. Disassembling may cause damage that is not covered under the warranty. If uRAD is damaged, malfunctions, or comes in contact with liquid, contact us at contact@urad.es.

Radio frequency interference Observe signs and notices that prohibit or restrict the use of radio frequency devices. Emissions from uRAD can negatively affect the operation of other radio frequency equipment operating in the same frequency band. Turn off uRAD when use is prohibited, such as traveling in aircraft, or when asked to do so by authorities.

Important Handling Information

WARNING: Failure to follow this handling instructions could result in damage to uRAD or other property.

Carrying uRAD contains sensitive electronic components. Do not bend, drop or crush it.

Cleaning To clean use a soft lint-free tip and isopropyl alcohol. Dust can be removed with compressed air of low power.

Plugging Never force the connectors or apply excessive pressure because this may cause damage that is not covered under the warranty. Check for obstructions.

Operating Temperature Keeping uRAD within acceptable temperatures. uRAD components operate from -40ºC to 85ºC but we recommend operates uRAD in the range from -20ºC to 65ºC.

Disposal and Recycling Information Your uRAD must be disposed of properly according to local laws and regulations. Because this product contains electric components, the product must be disposed of separately from household waste. Contact your local authorities to learn about recycling options.

Product Warranty 11

Manufacturing

All components and solder alloys used in this product comply with the RoHS Directive. The RoHS Directive prevents all new electrical and electronic equipment placed on the market in the European Economic Area from containing more than agreed levels of lead, cadmium, mercury, hexavalent chromium, poly-brominated biphenyls (PBB) and poly-brominated diphenyl ethers (PBDE).

Certification

uRAD Industrial module is CE marked under EU-Type examination certificate n. 803416897303 and fulfills with the corresponding directives:

- RED Article 3.1 (a): Health and Safety of the User
  Test EN 62368-1: 2014 +AC: 2015 Safety
  Test EN 62311:2008 - EMF Human exposure
- RED Article 3.1 (b): Electromagnetic compatibility
  Test EN 301 489-3 V2.1.1 EMC Short-Range Devices SRD
- RED Article 3.2 :Effective use of spectrum allocated
  Test EN 305 550-2 V1.2.1_Radio equip. 40 GHz to 246 GHz
- Notified body
  EU-Type Examination Certificate RED - N.B. 2559 (en)
- RoHS
  Test EN 63000: 2018 RoHS documental assesment

Testing

Each uRAD shield is subject to strict tests to make sure they are not faulty:

- First, it is thoroughly tested for short circuits and open connections.
- Second, it is powered to check there are no over-range voltage.
- Then, the microcontroller is programmed and debugged.
- Finally, the board is plugged in a computer and several test programs are run to check its overall functionality.

Limited Warranty Statement

IMPORTANT: BY USING uRAD PRODUCTS YOU ARE AGREEING TO BE BOUNDED BY THE TERMS OF THIS LIMITED WARRANTY STATEMENT. DO NOT USE YOUR PRODUCTS UNTIL YOU HAVE READ THE TERMS OF THE

WARRANTY. IF YOU DO NOT AGREE TO THE TERMS OF WARRANTY, DO NOT USE THE PRODUCTS AND RETURN THEM. THIS LIMITED WARRANTY IS THE END-USER'S SOLE AND EXCLUSIVE REMEDY AGAINST uRAD, WHERE PERMITTED BY LAW.

1. Warranties

1.1 uRAD warrants that its products will conform the specifications detailed in the corresponding datasheet. Warranty lasts for 1 year from the date of sale if the shield is bought outside the EU and last for 2 years if bought in the EU. uRAD shall not be liable for any defects that are caused by neglect, misuse or mistreatment, including any products that have been altered or modified by any way by the Customer.

1.2 If any uRAD product fails to conform to the warranty set forth above, uRAD's sole liability shall be to replace or repair such products. uRAD's liability shall be limited to products that are determined by uRAD not to conform to such warranty. If uRAD elects to replace or repair such products, uRAD shall be given a reasonable time to provide replacements. Replaced or repaired products shall be warranted for a new full warranty period.

1.3 The Customer agrees no to use uRAD products for any applications or in any components used in life support devices or to operate nuclear facilities or for use in other mission-critical applications or components where human life or property may be at stake. The Customer acknowledges and agrees that any such use is solely at the Customer's risk, and that the Customer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

1.4 uRAD may provide technical, applications or design advice. The Customer acknowledges and agrees that providing these services shall not expand or otherwise alter uRAD's warranties, as set forth above, and that no additional obligations or liabilities shall arise from uRAD providing such services.

1.5 uRAD disclaims all other warranties, expressed or implied, regarding products, including, but not limited to, any implied warranties of merchantability or fitness for a particular purpose.

1.6 The Customer acknowledges and agrees that the Customer is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning the products and any use of uRAD products in the Customer's applications, not with- standing any applications-related information or support that may be provided by uRAD.

1.7 In no event shall uRAD be liable to the Customer or any third parties for any special, collateral, indirect, punitive, incidental, consequential or exemplary damages in connection with or arising out of the products provided hereunder, regardless of whether uRAD has been advised of the possibility of such damages. This section will survive the termination of the warranty period.

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