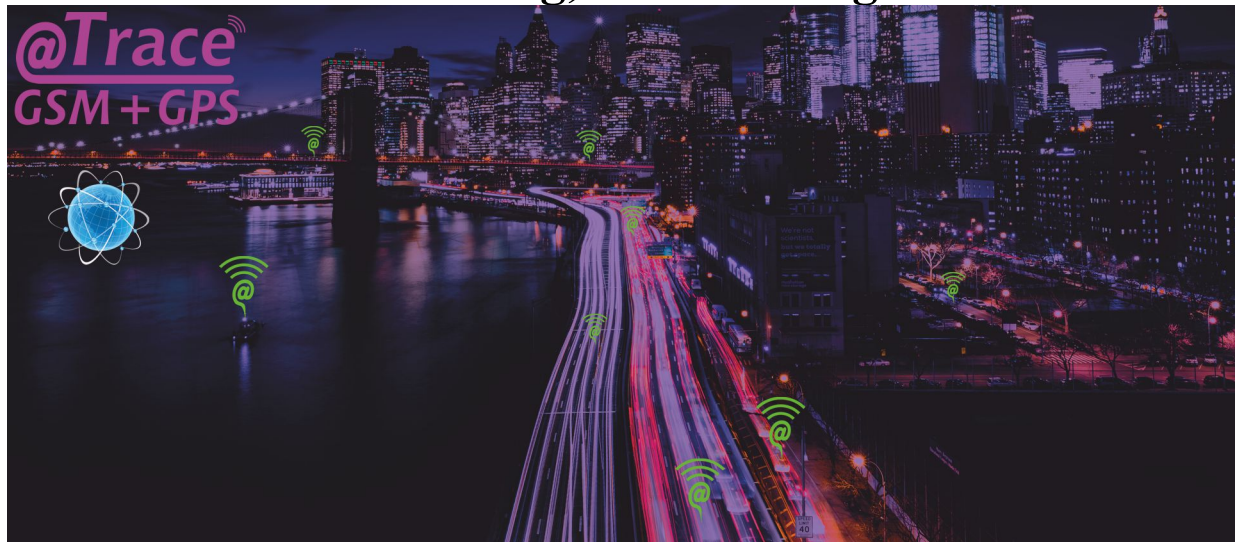**@Trace – Vehicle and goods tracking and monitoring transport/stop conditions**
Asset Tracking, Fleet Management

@Trace

iSys – Intelligent Systems

@City

@AirQ   @Bin
@Light @Metering @Trace

DRAFT

Table of Contents

1. Introduction.

@Trace is an integrated system for tracking, geo-location, geo-positioning and monitoring of transport and stop parameters in real time.

@Trace is part of the Smart City "**@City**" system and works with all its applications.

Measurements are made every 10 seconds to 15 minutes depending on the communication method and range used, updating data in the **@City** cloud.

The **@Trace** system allows autonomous monitoring of GPS position of objects and displaying on maps in the "**@City Cloud**" internet portal for global system or individual partner. Access to the portal can be private (limited to authorized persons) or public (generally available) - depending on the application.

The **@Trace** system allows, to monitor:

- vehicle fleet, urban transport (buses, trams, trains), goods transport

- cars, scooters, bicycles, scooters for rent

- inland water fleet (and sea fleet within GSM/3G/LTE or LoRaWAN network coverage)

- goods, valuable parcels, devices, machines, transhipment containers

- people: couriers, postmen, soldiers

The following GPS / GNSS data is available:

- geographical position (longitude, latitude)

- height above sea level

- current speed

- driving direction

- number of satellites detected (measurement accuracy)
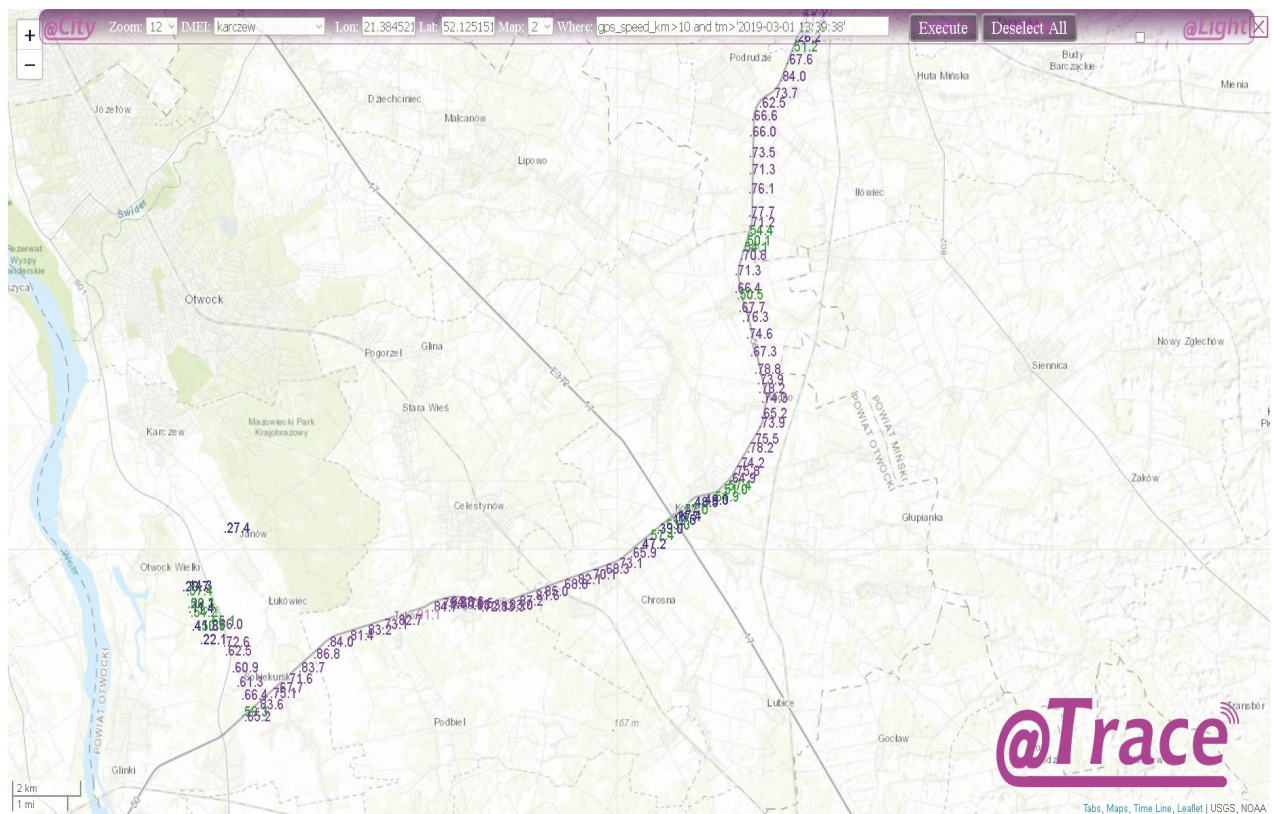
Example of vehicle speed control results (different colors mean exceeding thresholds: 50, 90 km/h)

In addition, the system allows you to measure the parameters of the transport or storage of goods, thanks to several sensors of various types, e.g. temperature, humidity, flooding, vibration , acceleration, gyroscope, dust, VOC, etc.

In the case of large solutions, there is the possibility of a dedicated server or VPS (Virtual Private Server) for the portal/website "@City Cloud" for single partner.

The @Trace system is an IoT/CIoT solution consisting of dedicated intelligent electronic devices for each "object" or vehicle. Devices performing GPS/GNNS position measurement and communication with the "@City Cloud".

@Trace devices can simultaneously carry out measurement, monitoring and alarm functions using optional sensors or detectors:

- measurement of smog (@AirQ) or dust while moving vehicles (PPM 2.5/10um particle sensor) and / or parking

- temperature, humidity, pressure, storm / lightning

- 3 axis (X, Y, Z) acceleration sensors, magnetic, inclinometer, gyroscope (accidents, threats, violent maneuvers, theft, sabotage, etc.)

- proximity (~ 10cm) and long-distance (~ 4m) range

- lighting (exposure to solar radiation, infrared)

- current, voltage (battery status, photovoltaics, electricity consumption, battery charging speed)

- capacities (e.g. touch, or to connect any capacitive measuring sensors)

- resistance (e.g. flooding, moisture)

Data is sent to the server of the @City system - to a mini-cloud, dedicated to the partner (company, city, commune or region).

The system allows data visualization in real time, geo-positioning and display on the map, as well as "modeling information" and using them to perform specific reactions. It is also possible to directly send alarm messages as a result of an anomaly or exceeding the value of measurement of critical parameters (e.g. change in the position of machines, devices, vibrations, tilting, overturning, storms).

Due to the mobile nature of the system and the amount of data transferred, the main type of communication is GSM transmission. In special cases (e.g. Water inland fleet, offshore fleet) where frequent data refreshing is not necessary and a larger range is required, communication can be done using LoRaWAN long range technology. However, this requires coverage of the LoRaWAN range with communication gateways. In ideal cases, it is possible to communicate up to 15 kilometers if there are no obstacles between the gateway antennas and the @Trace device.

2. Capabilities of @Trace system

Main features of the @Trace system:

- Possibility of mobile work - tracking/geo-positioning (assembly on cars, buses, scooters, inland vessels, sailing / motor yachts), valuable shipments

- Possibility of stationary work - security (devices, machines)

- Measurement of PM 2.5/10um particles by intelligent laser sensor with forced air circulation.

- Overall measurement: air quality, pressure, temperature, humidity, harmful gas concentration, thunder/storm

- Possibility of detecting accidents, anomalies, acts of vandalism and informing intervention groups (e.g.

via SMS).

- Possibility of remote locking of vehicles (e.g. cut-off ignition).

- The possibility of measurements every 10s to several hours - in real time 24h/day.

- Basic **GSM** wireless transmission: **2G, 3G, LTE, SMS, USSD (for any operator *), LTE CAT M1 * (Orange), NB-IoT ** (T-Mobile)** - requires the SIM card or MIM of the selected operator and subscription fees for data transmission, telemetry tariffs, M2M or comprehensive contracts.

- Alternative **LoraWAN** wireless transmission - no additional subscription fees required. However, it requires the provision of an appropriate number of LoRaWAN gateways to cover the area. The range of LoRaWAN is much larger than that of GSM technology, around 10-15km kilometers in a little urbanized area. In the absence of obstacles it may be many times larger (e.g. for systems operating on sea/inland vessels). LoRaWAN is, however, much slower than GSM technologies and is not suitable for every application.

- Real-time GPS position measurement (latitude, longitude, altitude, speed, direction)

- Self-positioning on maps with current measurement results

- Self protection and monitoring of measuring devices (against theft and devastation - alarm)

*, ** - depends on the availability of the operator's service in the current location (covering the entire area)

3. Examples of use (real-time systems - online)

3.1. Company car fleet and truck companies (Smart Transport)

- vehicle tracking and location

- remote ignition lock, luggage compartment opening lock

- continuous monitoring of exceeding the speed limits

- monitoring the maintenance of the required route

- monitoring the "quality of work" of drivers (rapid acceleration, braking, turning)

- monitoring stops, traffic jams and road conditions for other fleet vehicles

- failure monitoring

- monitoring of opening, temperature, humidity, pressure of cargo chambers

- monitoring of acceleration/shocks, rotation, movement of goods/load

- monitoring of accidents and events

- measurements of electricity consumption and battery charging

- vehicle and load protection when parked (intelligent alarm and immobilizer)

- intelligent monitoring of the driver's condition (falling asleep, sudden indisposition) - measurement of heartbeat with the ability to immediately cut off the ignition

- Panic button, delayed vehicle lock function

3.2. Passenger transport: Public Transport, Buses, Trams, Metro, Railway

- applications similar to those for the car fleet

- Public Internet portal with online information (WWW application for travelers with the possibility of filtering "selected lines"):

  ○ current vehicle position on the map

  ○ displaying delays in relation to the timetable

  ○ environmental measurements on the route (temperature, humidity, pressure, rainfall / snowfall, smog, storms)

  ○ location of nearest stops

  ○ estimated time of arrival of the vehicle at the nearest stop

3.3. Transport of goods and valuable parcels (Asset Tracking)

- Applications similar to those for a car fleet

- Monitoring of parcel's transport parameters (temperature, humidity, magnetic field, flooding, sunlight, dust, presence of VOC)

- Monitoring of load movement and driving dynamics - acceleration, braking, sudden turns, shocks, tilting of the load, free falls (dropping)

- Continuous monitoring of the shipment's position (alerting if the route changes from the designated one). The GPS locator in a very short time can enable recovery of the load or truck in the event of theft.

4. @Trace Device Operation

The device works 24 hours a day, the minimum measurement and data transfer period is about 10 seconds. This time depends on the total length of all measurements, including the transmission time. The transmission time depends on the transmission medium used as well as the signal level and transfer rate at a given location.

The device can also measure solid particles (2.5 / 10um), pressure, temperature, humidity, general air quality - harmful gas level (option B). This allows you to detect weather anomalies (rapid changes in temperature, pressure (altitude), humidity), fires as well as some attempts to tamper with the device (freezing, flooding, theft, etc.). It also allows measurements of transport or goods parameters by analyzing data from acceleration, magnetic, gyroscopes, and other sensors.

Particulate measurement takes about 10 seconds, so for sensors in motion it gives the average value of the distance traveled during this time (e.g. for a speed of 50km/h - it is about 140m), if it measures the concentration outside the car.

Sending information every few dozen seconds is also an alarm protection for the device in case of:

- attempts to dismantle

- devastation

- sabotage

- location changes

- change of route, vehicle hijacking

- e.t.c.

This allows police or own personnel to intervene.

The device (at the production stage) can be equipped with additional accessories for:

- controlling LED lamp lighting, switching electrical devices on / off.

- Infrared for short distance communication (sending / receiving)

- measuring sensors: current, voltage, capacity, resistance, color, lighting level (ALS)

- proximity sensors - proxymeter (range of about 10cm), and medium range (range of about 4m)

- 3 axis sensors (X, Y, Z - all directions): acceleration / vibration (accelerometer), magnetometer (magnetic field), gyroscope (detection of rotation angle), inclinometer (displacement sensor)

- storm sensor (with distance determination up to max. 40 km)

- Bluetooth connectivity (communication e.g. with a mobile phone)

- NFC (RFID e.g. for authorization of persons) with proximity cards or a telephone.

4.1. Communication

Transmission of measurement data is carried out through one communication interface *:

- **GSM (2G..4G, USSD, SMS, LTE-M1, NB-IoT)** - requires GSM operator subscription fees and full coverage for the selected service. The maximum range is a few kilometers from GSM BTS in the open area.

- **LoRaWAN** (868MHz/EU or 902..915/Others) - long range radio communication in the public band (without GPS positioning). Due to the open and free nature of the frequency band, there is a risk of interference and jamming of the device by other devices. Requires the installation of a minimum of one LoRaWAN/Internet gateway - ensuring coverage of the entire area (e.g. on high chimneys or GSM masts). Maximum range up to 10-15km in open area. It is mainly suitable for the protection of stationary facilities.

- For the protection of stationary machines and devices, it is possible to use a **WiFi** controllers (without GPS positioning).

* - depending on the chosen @Trace controller type and modem options

5. Dedicated @City platform (cloud)

*The **@City** platform, back/front-end is discussed in more detail in the "eCity" document.*

6. Online visualization on maps

GPS geo-positions can be displayed on maps together with sensor measurement values and other parameters, e.g. measurement time (castomization). They are constantly refreshed.
You can view current data for all devices or historical data for one device.
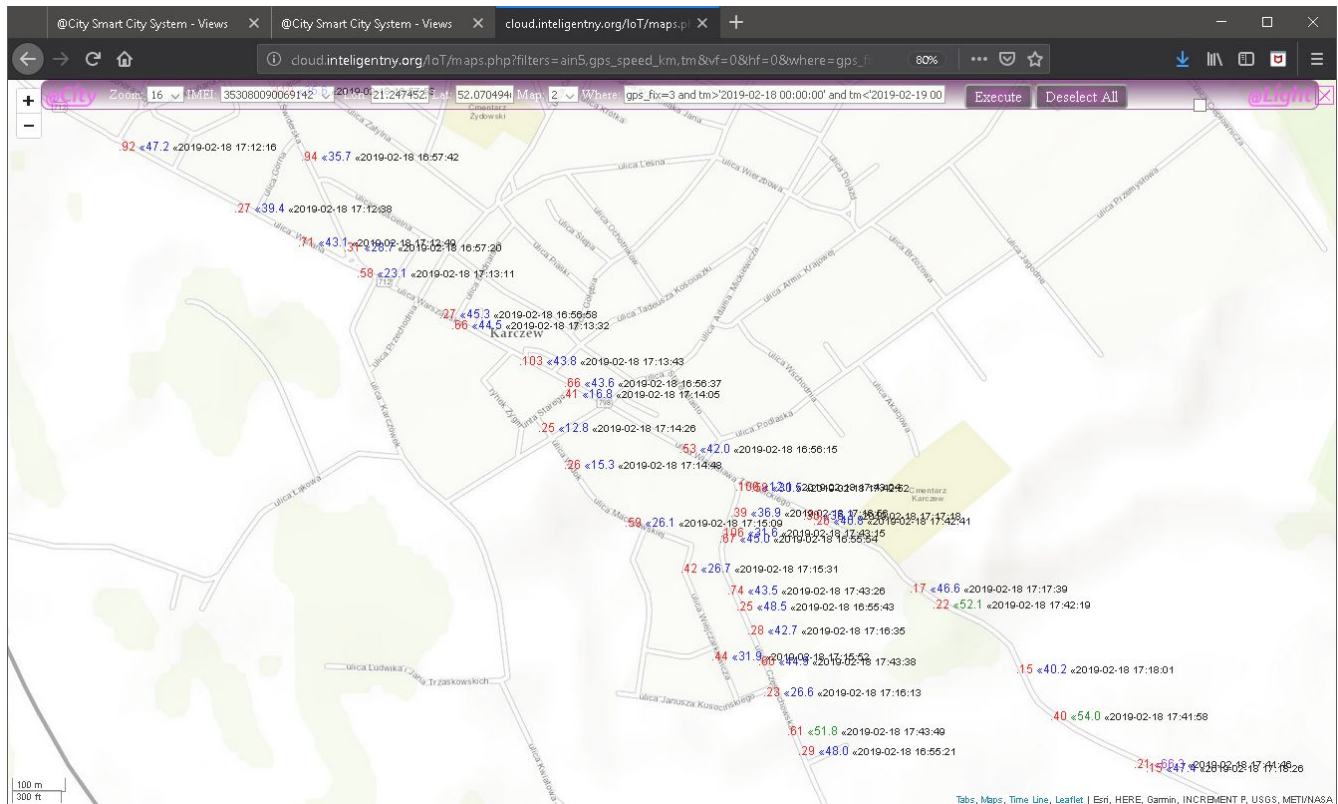
7. Visualization of results in the table

The results can also be displayed in customized tables (searching, sorting, limiting results). The tables also have individually customized graphics (Theme). It is possible to display a table with current data for all @City/@Trace devices or archive tables for a single device. In the case of the @Trace system, this allows, for example, to check other measurements, determine inoperative/damaged devices, etc.

idx	time stamp (tm)	IMEI nr (imei)	rssi	rsrp	adc 5 (ain5)	adc 6 (ain6)	ivalue 1 (int1)	ivalue 2 (int2)	gps_lat	gps_long	gps_alt	gps_fix	gps_speed_km	gps_sat
1	2019-02-10 12:56:23	351580051067110	91	99	0	44	-16776767	450	0000.0000N	00000.0000E		4		
3	2019-03-12 21:10:17	353080090069142	72	1	45	93	19	115	5202.7354N	02115.8172E	86.6	3	0.0	07
6	2019-02-20 09:13:04	356345080018095	88	102	115	73	-16777186	60	5202.9500N	02115.8000E	86.5	3	0.0	10
8	2019-03-08 10:48:03	356345080006819	120	109	4	5	98736	5391744	5202.7364N	02115.8197E	88.2	3	0.0	05
11	2019-03-07 13:08:22	karczew	76	76	103	62	19	77	5203.9312N	02115.4106E	88.2	3	0.0	09
idx	time stamp (tm)	IMEI nr (imei)	rssi	rsrp	adc 5 (ain5)	adc 6 (ain6)	ivalue 1 (int1)	ivalue 2 (int2)	gps_lat	gps_long	gps_alt	gps_fix	gps_speed_km	gps_sat

8. Bar charts.

Bar graphs display sorted and "normalized" bars to the maximum value, from highest to lowest.
They are useful for quickly checking extreme results and taking immediate action.
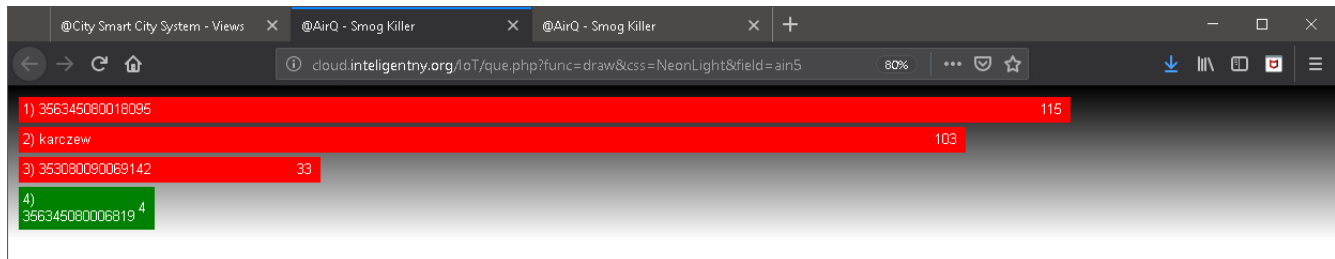
Hovering the mouse over the bar, displays additional information about the device (other measurements and location data)
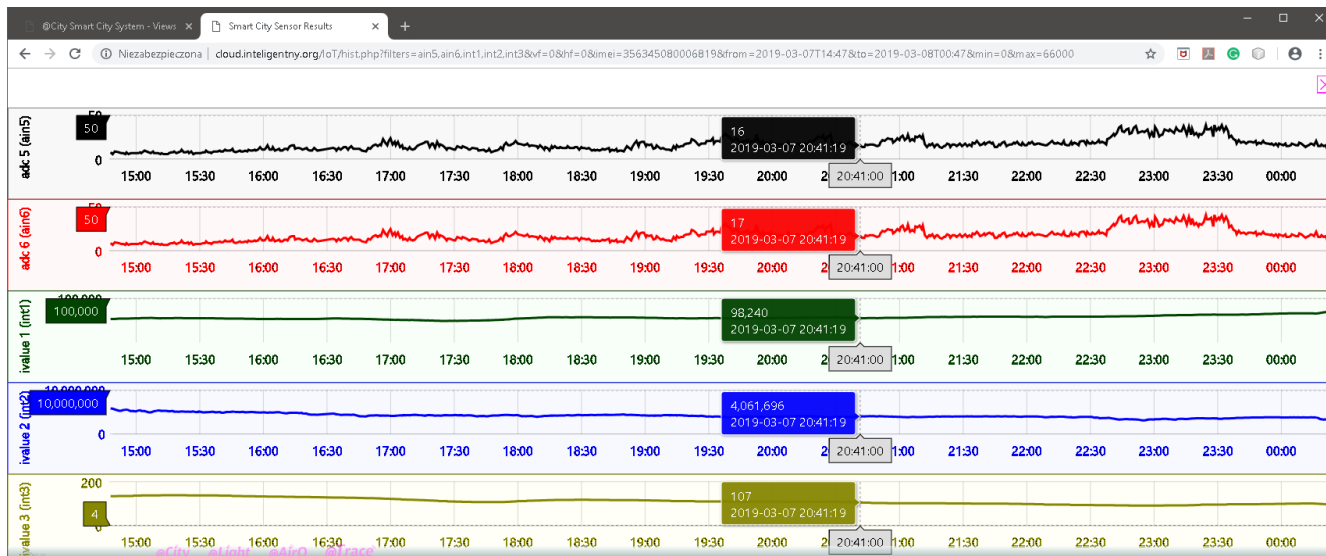
9. Archival Charts.

It is possible to display historical charts for a given period of time for a selected parameter (e.g. PM2.5 solids, temperature, humidity, etc.) for any device.

9.1. Bar Chart: (displays only existing data)

9.2. Continuous chart: (for the same input data)

Moving the mouse pointer displays detailed measurement values and date / time.

10. Equipment Variants

The devices can be in many hardware variants regarding equipment options as well as housings (which gives several combinations). For measurement air quality **@AirQ**, the device must be in contact with the flowing air "external" , which imposes certain requirements on the housing design.
Therefore, the enclosures can be ordered individually depending on the needs.

10.1. *Options for electronics*

- Application of the particulate sensor 2.5/10um
- Use of an environmental sensor (temperature, humidity, pressure, air quality)
- The use of lighting control elements
- The use of any combination of sensors for the selected application (at the production stage of the whole series)
- Different power variants (230V, 230V + UPS, battery, Energy harvesting - photovoltaics, magnetic field, etc.)

10.2. *Montage*

- Stationary devices and machinery
- mobile devices (cars, ships, trucks)

10.3. *Covers*

- dedicated stationary metal cases/ mobile enclosures - selected color, graphic design, printing / stickers, method of attachment
- adapted plastic housings
- dedicated plastic enclosures
- the case depends on the size of the battery

11. Usable information

The laser air pollution sensor used may be damaged if the concentration of dust, tar is too high, and in this case it is excluded from the warranty of the system. It can be purchased separately as a spare part.
The warranty excludes mechanical damage caused directly by lightning, acts of vandalism, sabotage on the device (flooding, freezing, smoking, mechanical damage, etc.).
Some measurement sensors (MEMs) have also critical values which exceeding will cause damage to the device/sensor and it's also excluded from warranty.

The operating time from an external battery depends on: GSM signal strength, temperature, battery size, frequency and number of measurements and data sent.

12. Operating parameters of the @Trace device

Electrical and working parameters are documented at „IoT-CIoT-devs-en" file.