

@Monitoring – monitoring of operating parameters, damages and device failures



@Monitoring

iSys – Intelligent Systems

@City

@AirQ

@Bin

@Light @Metering @Trace

DRAFT

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1. Introduction.

@Monitoring is an integrated (real-time) warning system for devices, vehicles and other facilities.

Possible applications:

- metering of various physical parameters
- security, monitoring, early warning, alarms
- GPS geo-location
- detection of displacement, overturning, turning, vibration
- pressure measurement (changes in height)
- electronic compass (change of position)
- anomalies during work and rest
- micro-damage
- corrosion
- theft, sabotage
- data analysis (BIM - information modeling)
- **"Predictive Maintenance"** - prediction and early detection of damage
- automatic switching off/blocking devices
- integration of devices, machines
- digital transformation

The @Monitoring system allows, to monitor:

- machines, devices, cranes
- antenna masts
- power masts, poles, power lines
- bus / tram stops

@Monitoring Early warning and monitoring system for machines, devices and facilities

- Street lamps (with control function)
- warehouses, storage rooms for goods that require specific storage conditions
- storage and transport parameters of valuable goods
- all kinds of vehicles
- billboards, advertisements

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

The following GPS / GNSS data is available:

- geographical position (longitude, latitude)
- height above sea level
- current speed
- direction of movement
- number of satellites detected (measurement accuracy)

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.

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

The @Monitoring system is an IoT/CIoT/IIoT solution consisting of dedicated intelligent electronic devices for each monitored object/device. Devices can perform GPS/GNNS position measurement and communication

@Monitoring Early warning and monitoring system for machines, devices and facilities

with the "@City Cloud".

The **@Monitoring** devices can simultaneously perform measuring, monitoring and alarm functions by means of optional sensors or detectors:

- smog / dust / particulate measurement (@AirQ) - PPM particle sensor 2.5/10um
- temperature, humidity, pressure, general air quality
- storm / lightning
- 3 axis (X, Y, Z) sensors (e.g. anti-theft / tamper protection, etc.):
 - acceleration (vibrations),
 - magnetic (magnetic field),
 - inclinometer (displacement),
 - gyroscope (rotation)
 - electronic compass
- proximity (~ 10cm) and long-distance (~ 4m) range
- lighting (exposure to solar radiation, infrared)
- color (R, G, B, IR)
- noise
- 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 real-time visualization, geo-positioning and display on the map, as well as "information modeling" (BIM) 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).

For highly dispersed devices and the amount of data transmitted, the main type of communication is **GSM +**

GPS transmission. Alternatively, in situations where frequent data refreshing is not necessary and greater coverage is required, communication can be accomplished 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 10-15km.

For devices working in industrial plants or companies (low dispersion), it is possible to use a variant of the system based on **WiFi** wireless communication. This significantly reduces costs and simplifies the network infrastructure in relation to LoRaWAN and GSM.

@Monitoring controllers can also be equipped with industrial wired communication interfaces if needed (**CAN, RS-485 / RS-422, Ethernet**) by sending information via the appropriate communication gateway to the @City cloud.

This allows hybrid operation and any combination of communication interfaces required by the system or cost optimization.

In addition to the automatic shutdown / blocking capabilities, the system generates alarms in the event of anomalies, which allows immediate manual action to be taken to prevent damage to devices.

2. Capabilities of @Monitoring System

Main features of the @Monitoring system:

- Possibility of mobile work - with the option of tracking and geo-positioning
- Possibility of stationary work - security (devices, machines and any objects)
- Possibility to measure PPM 2.5/10um particles
- Overall measurement: air quality, pressure, temperature, humidity, harmful gas concentration, thunder/storm
- Possibility of detecting damage, anomalies, vandalism and informing intervention groups (e.g. via SMS).
- The ability to remotely control or turn off devices.
- The possibility of measurements from about 10s to several hours - in the real time 24h/day.
- Basic GSM wireless transmission: **2G, 3G, LTE, SMS, USSD** (for any operator *), **LTE-M1** * (Orange), **NB-IoT** ** (T-Mobile) - requires the SIM card or MIM of the selected operator and subscription fees for data transmission or telemetry tariffs, M2M or long-term contracts.
- Alternative **LoraWAN** wireless transmission - no additional subscription fees required. It requires

providing the right amount of LoRaWAN gateways (connected to the internet) 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. LoRaWAN at long distances, however, is much slower than GSM technologies and is not suitable for every application.

- Optional transmissions in industrial facilities, warehouses (**WiFi, RS-485/422, CAN, RF, Ethernet**)
- Optional real-time GPS position measurement (latitude, longitude, altitude, speed, direction)
- Optional 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).
However, devices can work in hybrid mode (many communication variants in single system).

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

3.1. Monitoring of devices and machines (especially maintenance-free)

- optimal working conditions (temperature, pressure, humidity, noise)
- 3-axis (X, Y, Z) measurement and monitoring of acceleration, rotation, displacement, shock, vibration, vibration, tilt, free fall
- remote shutdown of the device when the permissible parameters are exceeded in order to prevent complete destruction or major failure.
- measurements of electricity consumption and battery charging
- protection of electrical devices against unauthorized switching on (intelligent alarm and “immobilizer”)
- Emergency Button (Panic)

3.2. Masts / poles and power lines

- vibration, acceleration measurement (3 axis accelerometer)
- measurement of deviation changes (3 axis inclinometer)
- torsion measurement (3 axis gyroscope)
- corrosion measurement (resistance sensor)
- detection of approach / attempt to climb the pole (proxymeter)
- self-positioning on maps (GPS / GNSS)
- measurement of temperature, pressure (altitude), humidity, noise, rainfall, storms, smog, air pollution etc.
- measurement of the intensity of magnetic radiation (proportional to the current flowing in the wire and the deflection of the wire)
- energy harvesting (photovoltaics and/or the magnetic field of high voltage cables)
- measurement of currents in the cable through converters
- detection of power failure

3.3. Poles / Antenna masts, antennas, banners, advertisements

- vibration, acceleration measurement (3 axis accelerometer)
- measurement of deviation changes (3 axis inclinometer)
- torsion/rotation measurement (3 axis gyro)
- positioning (position/direction) angle of inclination/elevation of antennas (3 axis electronic compass)
- corrosion measurement (resistance sensor)
- detection of approach/attempt to climb the pole (proxymeter) up to 4m
- self-positioning on maps (GPS / GNSS)
- measurement of temperature, pressure (altitude), humidity, noise, rainfall, storms, smog, air pollution etc.
- energy harvesting (obtaining electricity from solar and / or antenna field)
- securing BTS equipment

4. @Monitoring Device Work

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, 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.

With frequent transmissions from the device to the cloud (every several dozen seconds), it is also an alarm protection for the device in the case of:

- attempts to dismantle
- devastation
- sabotage
- location changes
- e.t.c.

This allows immediate intervention by the police or own staff upon detection of any anomalies.

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 / lightning sensor (with distance up to 40km)
- 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, 902..915MHz/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. **@City LoRaWAN** requires the installation of a minimum of one LoRaWAN+Internet gateway - ensuring coverage of the entire area (e.g. on tall chimneys or GSM masts or external antennas on tall buildings). Maximum range up to 10-15km in low-urban areas.
- For the protection of stationary machines and devices, it is possible to use a **WiFi** controllers (without checking GPS position).
- For stationary facilities, it is also possible to use wired interfaces available in the **eHouse system (RS-422/485, CAN, Ethernet)**

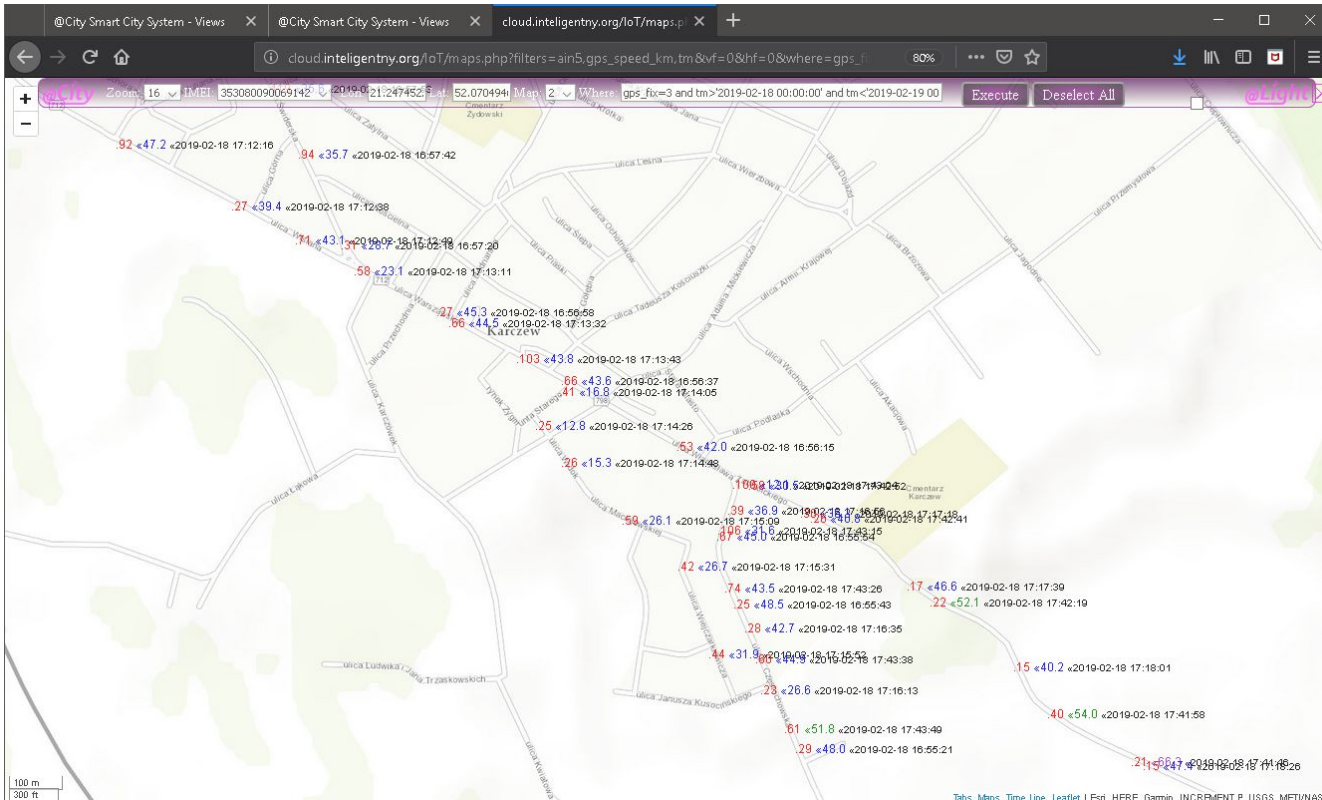
* - depending on the selected @Monitoring driver type and modem options

5. Dedicated @City platform (cloud)

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

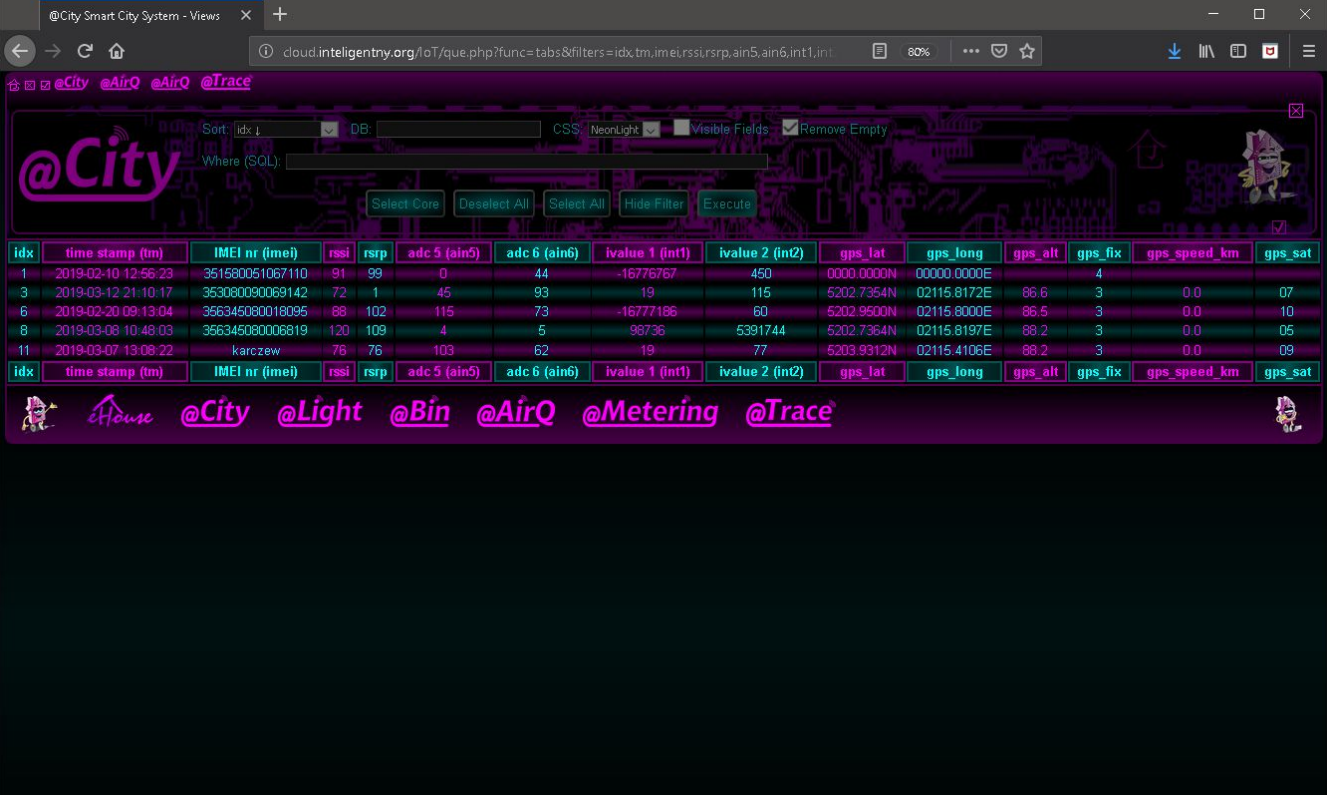
6. Online visualization on maps

GPS geo-positions can be displayed on maps together with sensor measurement values and other parameters, e.g. measurement time (customization). 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/@Monitoring devices or archive tables for a single device. In the case of the @Monitoring system, this allows, for example, to check other measurements, determine inoperative/damaged devices, etc.

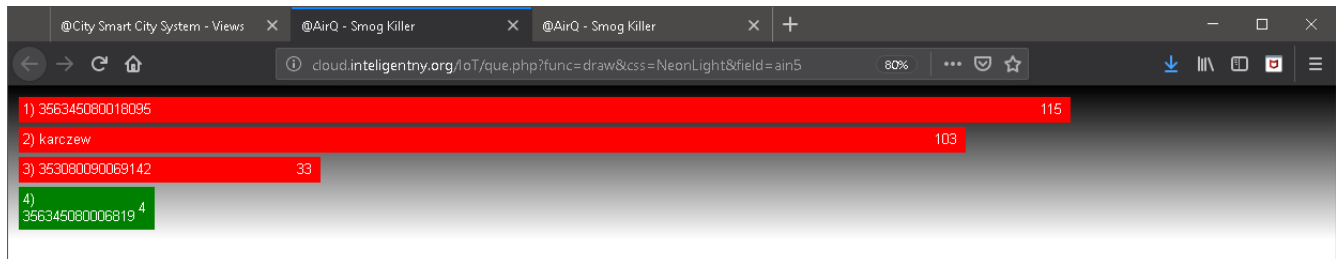


The screenshot displays the @City Smart City System web interface. At the top, there's a navigation bar with tabs for @City, @AirQ, and @Trace. Below this, a search and filter section includes a 'Sort' dropdown set to 'idx', a 'DB' dropdown, a 'CSS' dropdown set to 'NeonLight', and checkboxes for 'Visible Fields' and 'Remove Empty'. A 'Where (SQL)' input field is also present. Below the search section, there are buttons for 'Select Core', 'Deselect All', 'Select All', 'Hide Filter', and 'Execute'. The main content area shows a table with 15 columns: 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, and gps_sat. The table contains 11 rows of data. At the bottom, there's a navigation bar with icons and tabs for Home, @City, @Light, @Bin, @AirQ, @Metering, and @Trace.

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	2019-03-10 12:56:23	351580051067110	91	99	0	44	-16776767	450	0000.0000N	00000.0000E	4	3	0.0	07
3	2019-03-12 21:10:17	353080090069142	72	1	45	93	19	115	5202.7354N	02115.8172E	86.6	3	0.0	10
6	2019-02-20 09:13:04	356345080018095	88	102	115	73	-16777186	60	5202.9500N	02115.8000E	86.5	3	0.0	05
8	2019-03-08 10:48:03	356345080006819	120	109	4	5	98736	5391744	5202.7364N	02115.8197E	88.2	3	0.0	09
11	2019-03-07 13:08:22	karczew	76	76	103	62	19	77	5203.9312N	02115.4106E	88.2	3	0.0	09

8. Bar charts.

Bar graphs display sorted "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)

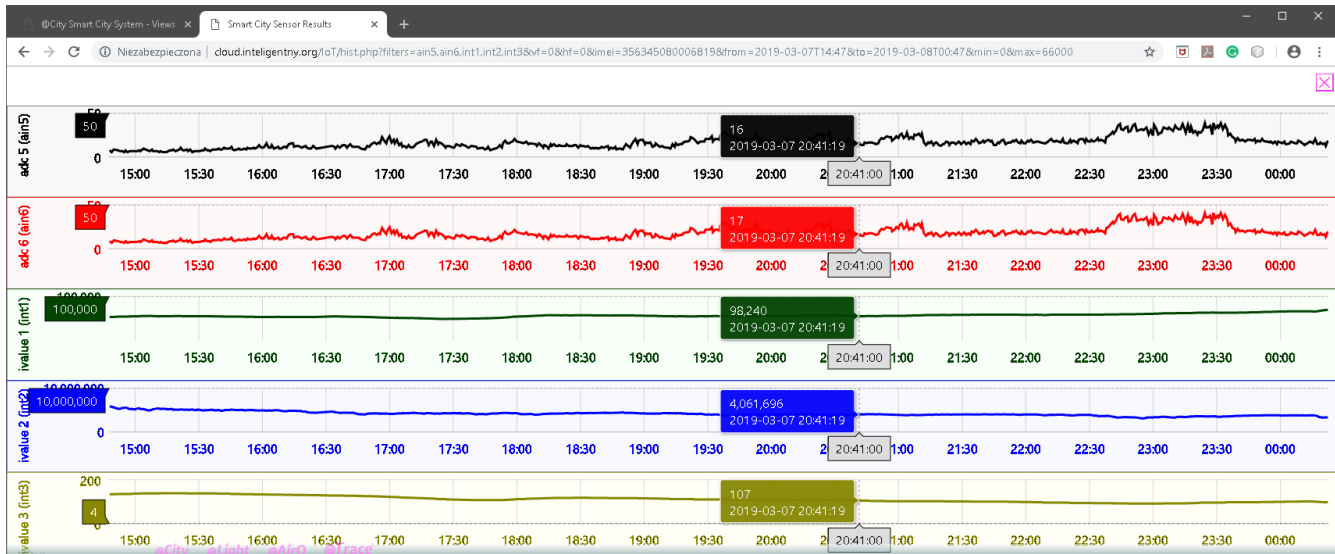
9. Archival Charts.

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 @Monitoring device

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