aAirQ – Antysmog System Real-time measurements with the possibility of execution





Smart City Products

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@AirQ – Anti-smog real-time system

1. Introduction.

@AirQ is an integrated air quality control system and anti-smog system. It works in real time (measurements every ~ 30sec) and provides continuous measurement of air quality 24 hour a day. It is part of the Smart City
 "@City" system from iSys - Intelligent Systems.

The @AirQ system allows autonomous monitoring of the level of impurities (PM2.5 / PM10 particles). It gives the possibility to catch the perpetrators "in the act" and to execute them (imposing fines by intervention groups, e.g. the Municipal Police, police, fire brigade).

The system measures spot pollutants (in a large number of detectors and measurements) thanks to which it shows real results close to the epicenter of pollutants. Pollutions are purely local and can exceed the average measurements by one air quality sensor hundreds of times.



Data is collected from distributed sensors of general air quality and solid particles 2.5um, 10um.

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@AirQ devices can be:

- stationary (mains powered) for a large number of sensors
- stationary installed temporarily (battery powered) for an medium number of sensors
- mobile installed on cars (battery powered) for a very small number of sensors
- mobile installed on drones

The devices are installed in the area of public property (e.g. street lamps) or with the consent of the residents on their plots.

In the case of public sharing of measurement data, it is also part of the education of residents and "anti-smog", pro-health and pro-ecological prevention.

The @Air system is much less "controversial" and more effective than drones that:

- they fly in private spaces
- they have built-in Full HD cameras and their use can be treated as spyware and voyeurism
- can be considered as a violation of privacy and the GDPR.
- they pose a risk of accidents, may cause damage to property and health
- require an additional operator and have a very small range
- they work for a very short period of the day, max 1..2 hours of battery life (they do not fly in the dark when in winter most often burns in furnaces)
- are very dependent on the weather

Plot owners can effectively enforce their rights regarding drones flying around the houses.

In the case of accidents as well as complaints, there are also costs of litigation, damages, compensation and settlements.

The @AirQ system can simultaneously perform remote and autonomous control of street lighting, city lighting, etc. (Smart Lighting System "@Light").

The data is sent to @City system's server - to the mini-cloud, dedicated to the commune or region.

The main type of communication is GSM transmission (Alternatively WiFi or LoRaWAN in the open band)

The system allows visualization in real time on a map, bar charts as well as direct sending of alarm messages to

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intervention groups.

2. Main Features of @AirQ System.

Main features of the @AirQ system:

- possibility of mobile (mounting on cars or drones) or stationary work
- spot measurement of PM 2.5 and 10um particles by intelligent laser sensor (option A) with forced air circulation.
- general measurement: air quality, pressure, temperature, harmful gas concentration (option B)
- the ability to measure in intervals from about 30s to several hours in real time 24 hours a 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 or telemetry tariffs.

- alternative wireless WiFi, RF (LoraWAN) transmission no additional subscription fees required
- real-time GPS position measurement (longitude and latitude, altitude, speed, direction)
- self-positioning on maps with current measurement results
- independent protection and monitoring of measuring devices (against theft and devastation alarm)
- remote and intelligent lighting control (on / off) and dimming LED lamps (option C)

*, ** - depends on the availability of the operator's service in the current location

3. @AirQ Device work.

The device measures the amount of solid particles 2.5um/10um with forced air circulation (option A).

The device works 24 hours a day, and the minimum measurement and transmission period is about 30 seconds.

Only multi-point measurement of air pollution makes sense, because air pollution is strictly local and the epicenter can have several hundreds times greater pollution than the average values measured at other points. It depends on many factors such as weather, wind direction and strength, pressure, cloud height, humidity, precipitation, temperature, terrain, afforestation, etc.

For example, 50-100 meters from the source of smog, the measurement may indicate up to 10 times less (which is shown on the map above with real measurements taken from the car).

The device can also measure pressure, temperature, humidity, general air quality - harmful gas levels (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.).

The measurement takes about 10 seconds, so in the case of mobile sensors, it gives the average value of the distance traveled during this time (e.g. for a speed of 50 km / h - about 140m)

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

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

This allows the intervention team to be sent to the place of the incident and caught the offender "in the act".

The device can be equipped with accessories to control the lighting of LED lamps (Option C). It is possible to dim the street lamp power supplies, or turn on/off the LED lamps without interfering with the lighting parameters of the lamps. Due to 3 dimmers, the controller can also control decorative lighting, occasional lighting (by adjusting the RGB color set). It can also be used to control the white (lighting) temperature.

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This allows you to remotely control city, street lighting or any electrical equipment.

4. Communication.

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

- GSM (2G..4G, USSD, SMS, LTEM1 (CATM1), NB-IoT) requires GSM operator subscription fees and coverage coverage for the selected service. Maximum range a few kilometers from BTSa GSM in the open area.
- WiFi 2.4GHz b/g/n requires access to a WiFi network with internet access. It does not contain GPS and does not have automatic geolocation (only the stationary variant with a predefined GPS position). It can also be used as intervention equipment for measuring pollution on site. Maximum range up to approx. 100m to WiFi Router in the open air.
- LoRaWAN (868MHz/EU and 902..915MHz/Other) long range radio communication in the public band. 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. It requires the installation of a minimum of one LoRaWAN/Internet gate - ensuring coverage of the entire area (e.g. on high chimneys or GSM masts). Maximum range about 10-15km in the open area.

* - depending on the type of @AirQ controller selected

5. Dedicated @City platform (cloud).

The @City platform is a dedicated "mini-cloud" system for individual B2B customers. The platform is not shared among other users and only one client has access to a physical or virtual server (VPS or dedicated servers). The customer can choose one of several dozen data centers in Europe or the world and several dozen tariff plans - related to hardware resources and performance of dedicated hosting.

5.1. @City Cloud Server.

The @City software runs on VPS servers running on Linux (Virtual Private Server) or a dedicated server on the internet-side, depending on the desired server performance (hereinafter referred to as the server). The performance required depends on the following factors:

- private/public access
- total number of devices
- frequency of device status updates
- data refresh rate

There are several possible server variants (virtual / dedicated VPS) depending on:

- Prices
- server type: virtual or dedicated
- data center geo-location
- virtual/physical number of processor cores (1-8 / 8..32)

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- virtual / physical amount of RAM (1-32GB / 32-512GB)
- SSD size (20GB-1TB / 100TB-400TB)

The IoT @City platform is dedicated to a single recipient (hereinafter referred to as the client):

- local authorities, offices, municipalities, poviats
- B2B (business entities)

Because the server is not shared between clients, this simplifies access, security, and performance issues. For this reason, only one customer is responsible for effective security, stability, performance, data throughput, etc.

In the case of insufficient performance, the customer can purchase a higher tariff plan (VPS or dedicated server), more optimal for the required functionality and performance.

In special cases, cloud-to-cloud communication can be implemented to globalize and centralize data to larger areas instead of the cloud of many clients.

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6. Online visualization on maps.

The results can be displayed on maps together with sensor geolocation and other parameters, e.g. measurement time (castomization). They are refreshed every 1 minute



The above example shows the results of the measurements:

- PM2.5 particles (first number)
- vehicle speed (second number)
- date and time of measurement

The first two measurements are colored depending on the value.

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7. Visualization of results in the table.

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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 @AirQ devices or archive tables for a single device.

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	time stamp (tm)	MEInr (imei)	ight	rsrp	adc 5 (ain ^c)	adc 6 (ain6)	<u>ivalue 1 (int)</u>	<u>ivalue 2 (int2)</u>	<u>gps_lat</u>	gps_long	gps_alt	gps_fix	<u>gps_speed_km</u>	gpa_sat

8. Bar charts.

Bar graphs display sorted and "normalized" bars to the maximum value, from highest to lowest. They are useful for quick checking of extreme results and taking immediate enforcement actions (sending a commission to the place of incident to examine the contents of the boiler/fireplace, etc., and possibly fining).

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1) 356345080018095		115	
2) karczew		103	
3) 353080090069142	33		
4) 356345080006819 ⁴			

Hovering the mouse over the bar displays additional information about the device (other measurements and location data)

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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.

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For this example (both drawings):

- PM2.5 (black)
- PM10 (red)
- pressure (green) {Pa}
- general air quality (blue) {the higher the value the better}

The chart is limited to the evening hours 15:00 - 24:00 when most people smoke in the stoves

10. Compatibility with the web browser.

Function / Web Browser	Chrome 72	FireFox 65	Edge
Maps	+	+	+
Historical (archive)	+	+ (*)	+
Bars (bar charts)	+	+	+
Tabs (tables)	+	+	+

* - Firefox does not support date/time selection (the text field must be manually edited using the appropriate date and time format).

Internet Explorer is not supported (use Edge instead)

Other web browsers have not been tested.

11. View/theme customization.

View's themes allow you to customize and adapt to your own needs.

Various @AirQ website themes can be used to create optimized templates for e.g. printing, operation from smartphones, PADs. A local computer scientist with basic knowledge of HTML, JavaScript, CSS is able to self-customize the user interface.

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12. Equipment Variants.

The devices can be in many hardware variants regarding equipment options as well as housings (which gives several combinations). In addition, the device must be in contact with the flowing outside air, which imposes certain requirements on the housing design.

Therefore, the enclosures can be ordered individually depending on the needs.

12.1. Variants of 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
- Different power variants (230V, 230V + UPS, battery, photovoltaic)

12.2. Mounting:

- Stationary equipment
- mobile devices (for cars)
- mobile devices (for drones)

12.3. Covers:

- dedicated metal stationary/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

13. 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 acts of vandalism, sabotage on the device (attempts to pour, freeze, smoke, mechanical damage, lightning, etc.).

14. Business information.

- The system can be owned by municipal, commune, poviat or city guards or police. Fines imposed in some cases reimburse system costs.
- Some devices can be made available to residents for whom the quality of the environment in which they live matters.
- The devices can also be sold to residents who can transfer data to the @AirQ system for free.

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They can be full devices (GSM) - they require a SIM card and subscription fees. Alternatively, they can be WiFi devices (without GPS) sending data via the resident's WiFi network to the @City cloud on the Internet (with a predefined GPS position). This method allows the transfer of most equipment costs to residents and much more accurate monitoring of smog in the area.

15. Pro-ecological, educational information.

It is possible (legally) to publish current results on the internet, thanks to which the ecological awareness of inhabitants about the harmfulness of smog increases. The system does not violate the GDPR.

Transparent and public results will force those contributing to smog production in the area to:

- not smoking harmful substances such as (garbage, furniture boards, railway sleepers, tires, fabrics, wood impregnated from demolition of buildings, colored paper, plastic, foil)
- using ecological and high-quality fuel (dry wood/eco-peas, high-quality coal)
- changes in a faulty boiler/fireplace

16. Comparison of Smog measurement methods.

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Measurement type	@AirQ – stationary	@ AirQ – mobile (car)	@ AirQ or other at drone
Continuous	Yes 24h/day	Yes 24h/day	No/instantaneous max 12 hours of flight time on a battery
Max refresh frequency	30 sec	30 sec	30 sec
Operator + vehicle	Does not require	Requires (driver + car)	Requires an operator with + drone + car permissions
Violation of private space	No	No	Yes
Violation of privacy	No	No	YES (camera that can view and record image)
GDPR compliance	Yes	Yes	No
Residents' irritation	No	No	Yes
Risk of damage to property or human health	No	No	YES (if the drone falls)
Dependence on weather conditions	Small (T>-10C)	Medium (no precipitation, T> -10C)	Very high: (no rainfall, wind strength, temperature restrictions)
Number of devices	Large	1 or more	1 or more
Guaranteed detection	YES (near the sensor)	No (only by accident or on call)	No (only by accident or on call)
Mains Supply	Yes	No	No
Mains + UPS (battery)	+	-	-
Battery powered	+	+	+
Battery selection	+ (Any)	+ (Any)	-
Battery working time	LTE CAT1 / NB-IoT - several weeks, LTE - a week *	LTE – A week *	Max 2 hours
Autonomous work	+	-	-

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

17. @AirQ Devices operating parameters.

Temperature range	- 40C +65C
Humidity	080% r.H. No condensation (device)
Power supply GSM	5VDC @ 2A (2G - max) ±0.15 V
Power supply LoRaWAN	5VDC @ 300mA (max) ±0.15 V
@City GSM+GPS Device:	
Antenna Input	50ohm
SIM nano-SIM or MIM (c	hoice at the production stage - MIM imposes a network operator
Modem Approval	Orange (2G+CATM1)/T-Mobile (2G+NBIoT)/Others (2G)

Bands (Europe)	Class	TX Output Power	<u>RX Sensitivity</u>
B3,B8,B20 (CATM1) **	3	+23dB ± 2	< -107.3dB
B3,B8,B20 (NB-IoT) **	3	+23dB ±2	< -113.5dB
GSM850,GSM900 (GPRS) *	4	+33dB ± 2	< -107dB
GSM850,GSM900 (EDGE) *	E2	+27dB ± 2	< -107dB
DCS1800,PCS1900 (GPRS) *	4	+30dB ± 2	< -109.4dB
DCS1800,PCS1900 (EDGÉ) *	E2	+26dB ±2	< -109.4dB
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When using an external narrowband antenna frequency-matched for a given band.

* Only with Combo modem: 2G, CATM1, NB-IoT

Certificates:

- RED (EU)
- GCF (AU)
- PTCRB (NA)
- FCC, IC (NA/NV)
- RoHS / REACH

GPS/GNSS:

Frequency of operations:	15591610MHz
Antenna input	50ohm
sensitivity *	-160dB static, -149dB navigation, -145 cold start
TTFF	1s (hot), 21s (warm), 32s (cold)
A-GPS	yes
Dynamic	2g
refresh rate	1Hz

• matched external narrowband antenna

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@City LoRaWAN 1.0.2 Devices (8ch., Tx power: +14dBm) Europe (863-870MHz)

<u>DR</u>	<u> </u>	modulation BR	bit/s	Rx Sensitivity	<u>Rx Tests</u>
0	3min	SF12/125kHz	250	-136dB	-144dB
1	2min	SF11/125kHz	440	-133.5dB	
2	1 min	SF10/125kHz	980	-131dB	
3	50s	SF9/125kHz	1760	-128.5dB	
4 (*)	50s	SF8/125kHz	3125	-125.5dB	
5 (*)	50s	SF7/125kHz	5470	-122.5dB	
6 (*)	60s	SF7/250kHz	11000	-119dB	
7		FSK 50kbs	50000	-130dB	

(*) Parameters required to update firmware via OTA

(DR) – Data Rate

(**BR**) – Bit Rate

T – Minimal refresh rate [seconds]

Particle sensor PM2.5/PM10:

Temperature min for particle measurement Temperature max for particle measurement Humidity RH Measurement time Measurement range Measurement method Life time in optimal working conditions Accuracy (25C)

Power consumption ESD EMI Immunity inrush immunity (contact) Emission radiation

Emission contact

Environmental sensor:

Measurement Time: Max power consumption: Average power consumption

Temperature:

Measurement range accuracy

Humidity:

- 10C (Automatically disconnected) + 50 (Automatically disconnected) 0%..90% no condensation 10s0ug/m3....1000ug/m3 laser sensor with forced air circulation 10000h ±15ug (0..100ug) ±15% (>100ug) 80mA@5V ±4 kV contact, ±8 kV air per IEC 61000-4 1 V/m (80 MHz .. 1000 MHz) for IEC 61000-4 ±0.5 kV for IEC61000-4-4 3 V for IEC61000-4-6 40 dB 30..230 MHz 47 dB 230..1000 MHz for CISPR14 0.15..30 MHz according to CISPR14

10s 20mA@3.6V

1mA@3.6V

-40..+85C ±0.5C @ 25C, ±1C (0..65C)

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	Measurement range Accuracy Hysteresis		0100% r.H. ±3% @ 2080% r.H. With hysteresis ±1.5% r.H. (10%->90%->0%)
Pressu	ire:		
	Measurement range:		300Pa1100hPa
	Accuracy:		±0.6hPa (0 65C)
			±0.12hPa (2540C) @ Pa>700
	Temperature Coeficient:	±1.3Pa	/C
CAS.			

GAS:

Temperature	-40+85C
Humidity	1095% r.H.
VOC	measured with nitrogen background

Molar Volume	Fraction	Production tolerance	Accuracy
5 ppm	Ethane	20,00%	5,00%
10 ppm	Isoprene /2-methyl-1,3 Butadiene	20,00%	5,00%
10 ppm	Ethanol	20,00%	5,00%
50 ppm	Acetone	20,00%	5,00%
15 ppm	Carbon Monoxide	10,00%	2,00%

LoRaWAN practical coverage tests:

Test Conditions:

Kerlink Femtocell LoRaWAN Internal Gateway

Passive outdoor broadband antenna placed outside at a height of ~ 9m from ground level. Location Wygoda gm. Karczew (~ 110m above sea level).

LoRaWAN device with forced DR0 with an external broadband antenna placed 1.5m above the ground on the car roof.

Rural areas (meadows, fields with low trees and rare buildings)

The furthest result was Czersk ~ 10.5km (~ 200m above sea level) with RSSI equal to -136dB (i.e. at the maximum sensitivity of the LoRaWAN modem provided by the manufacturer)

@AirC

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