WHITE PAPER

# IoT Sensor Networks at AIT: **Environmental & Safety Solutions**


**Contact:**
Patrick Zwickl
Mario Drobics



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# IoT Sensor Networks at AIT

## 1 Introduction

Emissions can pose a severe short- or long-term threat to the **environment, the climate or the safety and health** (e.g., of employees, the public). Transparently monitored **emission and/or immission data** can provide viable information on the state of the environment and climate of a region, but ultimately a change is necessary: AIT's Crisis and Disaster Management (CDM) group is dedicated to technologies that can enable policymakers, industries and individuals to use a solid data basis to derive measures with high positive effect on the environment, climate or the safety of individuals.

Today policymakers and industry can be supported by AIT’s information systems to perform related **operative and strategic tasks**: On the operative level, air and water quality can be monitored, contaminations can be recorded and automated triggers can be enabled (e.g., alarms when a certain contamination level is reached or a change of traffic speeds when a traffic-induced pollution reaches a threshold). On a strategic level, city planning can be supported by a clear modelling of the city in terms of emission sources and factors, energetic modelling of the city (e.g., using UAVs and 3D models), and simulation tools to assess the effectivity of potential improvement measures for various scenarios.

While sensor networks have always been sophisticated and distributed technology, the recent trend towards including new technologies, especially around the Internet of Things (IoT) and remote sensing (satellite and UAV data), is creating new capabilities towards more analytical and service-oriented use cases. Fundamental basis is the increased sensing resolution that allows to better model and understand emission or contamination sources and to project model results or estimates on to, e.g., land value results or health-related maps or other use case-specific visualizations.

Many new use cases will further arise for **safety-related applications** that can profit from a digitization and dynamization: IoT-enabled sensor networks can be used to improve the workplace safety in industrial settings as well as the recognition of terror attacks in public places or even in subway stations. Today, such application areas are often only targeted by non-digital solutions that do not provide a real-time integration into the operative picture of first responders, public authorities or responsible persons in industries.

## 2 Monitoring the Environment & Safety-related Parameters

Closely following the legal obligations, esp. created by the European Commission, to track environmental variables and the technical capabilities that have been recently available, point by point environmental monitoring of immission or emission has played an important role in improving the environment over decades. Today these monitoring duties are fulfilled by forming **sensor networks** for **air and water quality** (i.e., a distributed information system) using stationary sensors with low measuring tolerance.

AIT is providing one of the leading sensor network information systems named **UWEDAT (www.uwedat.com)** that is capable of measuring air and water quality, CBRN contamination, noise, dust, weather, electromagnetic load, and traffic-related statistics with almost any sensor equipment on the market and integrating it into a central information system. Like UWEDAT, such central sensor network information systems have to provide a series of key functions for monitoring purposes:

- Automatic detection of limit violations in order to enable mitigating actions (e.g., reduction of traffic speed limits, affecting work on construction site)
- Query languages for dynamic, real-time and custom analysis of environmental variables
- Modular design for the inclusion of further environmental sensor or data sources

Like UWEDAT, these systems should further support the organizational processes ensuring the long-term quality of the monitoring data: 1) Administration support tool, 2) Maintenance support tool, 3) Calibration and self-test tool, 4) Reporting interfaces.


*UWEDAT data validation for sensor network data (sample data)*

Complementary techniques can be used to increase the spatial coverage beyond stationary point by point measurements: **Remote Sensing**, i.e., satellite observing (Earth Observation) technologies, are increasingly being used in all sorts of domains. Main advantages include covering huge spatial areas by one sensing (i.e., image), multi-spectral views provided by different remote sensing devices (e.g., infrared, visible), otherwise hardly available by other technologies. However, for complex analyses like air pollution assessments, satellite imagery requires a combination with established high-precision and high-accuracy ground-level sensor networks (i.e., UWEDAT) for a calibration with professional-grade ground-truth data.

Beyond environmental use cases, combining local, stationary, UAV-based and Remote Sensing is attractive for CDM use cases where a quick assessment of crisis situations on ground is often required, e.g., detecting and identifying flooded areas, or assessing damages after an earthquake. In this context AIT is currently nationally and internationally researching in two directions: Firstly, the combination of Remote and UAV-based Sensing with crowd-tasking and -sourcing can create close to real-time assessments during crisis situations. Secondly, AIT is further combining UAV-based monitoring and observation techniques with local sensors in order to monitor barrages and landslides, facilitate the main-trailing of policy forces, or observe natural disasters as the evolve in real-time (e.g., floods, river jams, mudflows, forest fires).

# 3 IoT-enabled Advanced Environmental Analytics

## 3.1 IoT Interoperability

The last decade saw a tremendous rise of of-the-shelve smart devices with the **Internet of Things (IoT)** trend – integrated with home or office appliances (lighting control, temperature thermostats, household appliances, etc.), as well as embedded with personal devices such as smartwatches or smartphones. While these smart devices are capable of tracking useful parameters regarding the environment and personal health (pulse, blood pressure, sleep etc.), they are typically organized in discrete vertical silos of hardware, platforms and applications. Today, inter-platform collaboration is limited to restricted data exchange offers with specific services, which are driven by the interest of leading IoT solution vendors. For application developers and platform providers, this creates the pressure to create a powerful ecosystem. For consumers, a lock-in to multiple IoT ecosystems is created.

AIT is, thus, strongly engaged in **IoT interoperability** for establishing an IoT landscape that profits from the super-additivity of collaboration on mutual interest, e.g., in order to increase the spatial or temporal coverage of different geolocations or settings, or in order to create enriching and innovative joint or new service offerings by domain specialists. Within a European research project, we are developing an interoperability framework that enables us to create environmental services which are no longer restricted to a specific city, service interface, or specific spatial coverage. Instead, AIT's prototypical realization accesses and utilizes further data sources beyond professional-grade sensor networks as well as further algorithmic service through an interoperability layer in order to realize an **Advanced Environmental Analytics** service, i.e., smart ecological routing for bicyclers, as first service example. This prototype is tested in the cities of Vienna, Porto and Zagreb, in order to provide valuable feedback for the next development phase.

## 3.2 Hybrid Sensing

Technically such services are achieved with AIT's **Hybrid Sensing** approach. In AIT's Hybrid Sensing approach, professional-grade stationary sensor networks based on UWEDAT or similar sensor networks remain the primary ground-truth source of monitoring information. Additionally, AIT will integrate secondary sensors via an IoT interoperability layer, which typically have a substantially higher measuring tolerance (satellite imagery, mobile sensors etc.). These secondary sources are typically IoT-enabled crowd-sensed air quality monitoring solutions via wearable sensors and mobile devices. Wearable sensors offer the means to collect measurements which are dense, both in space and time, so that the personal exposure levels can be traced at a much finer granularity. With the help of a **distribution model** data is harmonized between primary and secondary sensors. Harmonized data from the distribution model can be used to get correction factors for mobile sensors but can also be used as a common data representation, e.g., a map visualization, that enables clearer causality modelling of environmental factors such as pollution and enables the realization of new services like pollution aware routing calculation can be offered.

Beyond environmental analytics, further use cases for hybrid sensing will include city planning (pollution, land value determination, etc.), detection and mitigation of contaminations and threats (e.g., toxic gases) and new services like smart ecological routing for bikers, pedestrians or cars.

The CDM group is a leading player in the transition towards Hybrid Sensing where it facilitates the creation of **services enabling operative control mechanisms (e.g., traffic control) using environmental data (e.g., air pollution):**

- *Algorithmic environmental use cases*, e.g., smart ecological urban routing integrating air quality parameters into classical routing algorithms for cyclists
- *Services with control loops*, e.g., automatic traffic steering based on pollution levels, production and construction site steering using dust, noise or other (emission) data
- *Recognition of terror attacks* with toxic substances at public places (e.g., railway stations) and distribution modelling of the used substances for tailored procedural recommendations
- *City planning and land value determination* by providing services assessing the air pollution and air circulation in certain areas from which also measures can be derived

Hybrid Sensing further enables new (semi-)indoor use cases such as in industrial facilities for monitoring safety-related parameters, safety monitoring in railway stations or air circulation within a quarter.

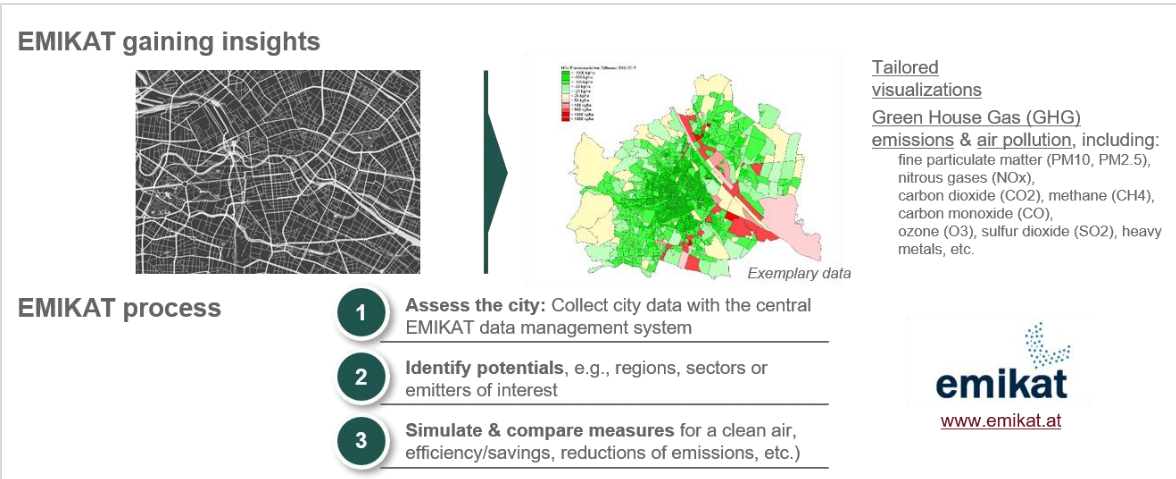
# 4 Emission Analytics & City Planning

By National and European law, emission sources need to be analytically modelled and understood by public authorities. For this purpose, AIT has created the EMIKAT ([www.emikat.at](www.emikat.at)) framework that provides a tool for **emission analytics** that facilitates strategic decisions of policy makers and builds the ground for mid-term and long-term improvement measures.

EMIKAT is an information system that collects emission-related data from multiple sources and follows a scenario-based design that allows policymakers to ask key questions around emission sources (emitters) and potential countermeasures:

- *Who are the largest emitters in the area (sectors, businesses, etc.)?*
- *Which emission reductions are most effective?*
- *What measures improve the city or quarter?*

Emission inventories require the management, documentation and interrelation of large amount of heterogeneous data in a user-controlled logic. EMIKAT is a system that support those who establish emission inventories and work with it. EMIKAT derives emissions for the smallest administrative units, the „census units“. In each census unit, emissions are calculated according to the specific properties of emission sources, organized according to business sectors, emission source categories as well as input materials and fuel types, and transformation processes. Results that have a defined spatial reference (such as census units, communities, counties, raster cells) can also be visualized as maps.




*A typically result - NOx emission in Upper Austria*

Beyond this, AIT is with partners further pushing the technological capabilities for city planning as well as decarbonization and energetic efficiency monitoring by utilizing modern sensing techniques such as UAV-bound infrared and optical camera systems feeding into 3D models of cities or quarters. Together with EMIKAT, the energetic potential of redeveloping quarters or cities can be calculated and associated with corresponding measures by cities or financial incentives for building and infrastructure owners.

## About the AIT

We are Austria's largest Research and Technology Organization (RTO) and belong to the first league worldwide in many of our areas of research. This makes us a powerful development partner for the industry and one of the top employers in the international scientific scene.

AIT is strategically positioned as a key player in the Austrian and European innovation system by performing applied research for and enabling the market exploitation of innovative infrastructure related solutions. The functionality of "bridging the gap" between research and technology commercialisation is a key aspect of developing new technologies and enabling an economic boom. Regarding the Austrian innovation landscape, the AIT fulfils this role by its new orientation, providing a research environment to help key industries facing mid- to long-term challenges. Unlike universities that are focusing on basic research and addressing short-term exploitation, AIT covers the entire spectrum from taking up emerging technologies, first proof of concepts, applied research to transferring these emerging technologies into specific applications up to demonstrators and prototyping.

This allows us to connect basic research and the usage of new technologies for the industry and thereby pave the way for commercialisation.

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**AIT Austrian Institute of Technology**
Center for Digital Safety & Security
Giefinggasse 4, 1220 Vienna
www.ait.ac.at

**Patrick Zwickl**
Business Developer
Cooperative Digital Technologies
+43-0-664-88-39-00-16
patrick.zwickl@ait.ac.at

**Mario Drobics**
Head of Competence Unit
Cooperative Digital Technologies
+43-0-664-82-51-00-7
mario.drobics@ait.ac.at