iFLINK – Innovativ forvaltning av luftkvalitet og miljø i norske kommuner

Project description

iFLINK will utilize low-cost sensor solutions to develop a geographically distributed network of environmental sensors for Norwegian municipalities. We will develop the R&D to support practical uptake of the technologies by municipalities, and enable upscaling and exploitation of the sensor network systems.

PART 1: The planned innovation

1. Underlying idea

Municipalities have a need to provide air quality data with high temporal and spatial resolution, to improve air quality mitigation and to answer to citizen's demand, but currently deployed technologies do not allow this. The underlying idea of iFLINK is to establish a scalable low-cost sensor network infrastructure for integration and quality control of data from different sources, for delivery of high-resolution outputs. The primary innovation of iFLINK is in enabling a seamless use of sensing and ICT technologies to provide locally specific open environmental data for the municipalities and for citizens. iFLINK will also allow public and private actors to develop real time environmental services related to e.g., air quality, climate change, or noise, with a seamless interface to any local smart city development.

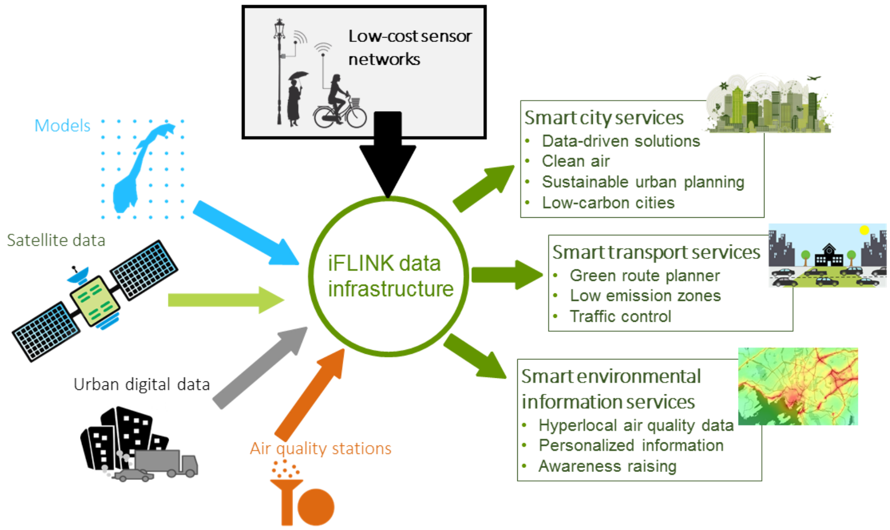

Figure 1. Schematic overview of the iFLINK idea

Low-cost sensor technologies have significantly lower investment costs than traditional instrumentation. They are compact and easy to use, allowing deployment of many units, but the generated data are often of questionable quality. In order to benefit from the sensor monitoring technologies, their deployment requires new ICT infrastructures, including sophisticated algorithm-based methods for calibration and quality assurance and data fusion methods for merging sensor data with other already existing data. iFLINK will develop an open scalable infrastructure allowing municipalities and other actors to develop data-driven and visualization solutions. **iFLINK will develop infrastructures to fill-in the existing gap on providing real-time accurate air quality information with high spatial and temporal resolution at an affordable cost**. The project will have pilot studies in five municipalities (Bergen, Bærum, Drammen, Kristiansand and Oslo).

2. Level of innovation

Municipalities are seeking new cost effective ways to generate and deliver information relevant to individuals. Low-cost sensor technologies for monitoring air quality bring the opportunity for ubiquitous monitoring, potentially at a fraction of current costs. However, **the quality of the sensor data prior to significant processing does not meet the requirements of the municipalities**. iFLINK will implement novel calibration and visualisation approaches using machine learning and data fusion techniques to perform **real time intelligent corrections of measurements, improving data accuracy, and provide comprehensive data coverage in real time**. Municipalities also experience that the total **cost of the sensor network solutions is much higher than expected** due to communication and database needs. In order to address this, iFLINK will be efficient, **scalable, fast and open, potentially serving Norwegian municipalities as well as international clients** based on modern capabilities of Big Data integration (Table 1).

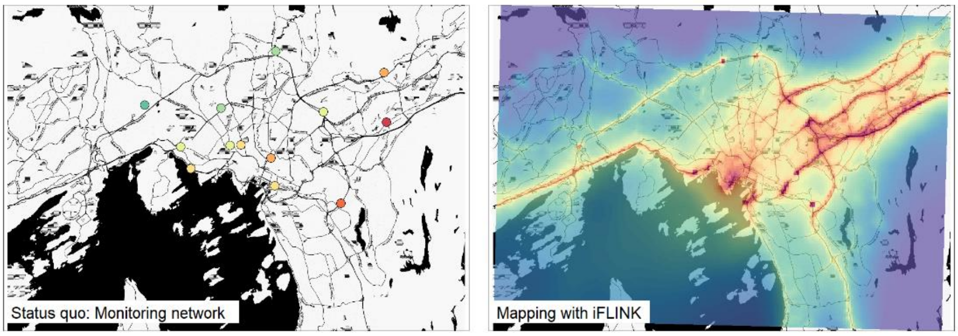

Figure 2. Left panel: Current status quo of air quality monitoring information (e.g. from www.luftkvalitet.info). Right panel: Potential information service derived from a dense sensor network for air quality with the help of machine learning and data fusion techniques.

Table 1. Main innovations involved in iFLINK

New/ improved solutions/ services	Increase the data and information quality from low-cost sensor networks
	Get more information about the spatial variability by increasing the representativeness of the monitoring network. Pinpoint pollution at source
	Strengthen the possibility to implement (real-time) measures to mitigate air pollution
	Enable the evaluation of the success of implemented mitigation measures
	Scalable and portable monitoring systems. Monitoring at sensitive locations (schools)
	Connect already existing sensor networks to the iFLINK infrastructure
	As much as possible, open access to different process levels of data ranging from raw sensor observations to value-added data products, to address the needs of different actors and to support commercial services while respecting ownership
	Provide comprehensive data coverage for air quality facilitating policy decisions.
New/updated methods of production/ delivery of goods/services	Provide a verification procedure to assess the data quality level of various sensor platforms, preventing municipalities from investing money in low-quality platforms.
	Develop smart calibration methods for air quality sensor networks, possibly transferable to other fields of environmental monitoring
	Integrate the data from low-cost sensors with other existing data, demonstrating the value of connected data
	Machine learning solutions that can operate in real time allowing the incorporation of low-cost sensors into traditional air quality systems.
New/updated structures for management/ organisation	Common approach to innovative public procurement and development of business model for municipal sensor network implementation
	Solutions designed in collaboration with the main actors ensuring the usefulness of the results.
	Enable citizen participation and citizen science projects
	Engage with citizens and decision-makers to act on the obtained results
New or updated administrative and funding models	New public-private ownership schemes, combination of public and private ownership of sensor platforms as part of a large sensor network (shared costs and benefits)
	Scalable infrastructure capable to serve Norwegian municipalities as well as international clients
	Open infrastructure to enable innovation by third parties

3. Potential for value creation

Table 2. Potential for value creation.

Increased efficiency	Real-time information on air quality and potentially other environmental variables (e.g., climate change gases, noise)
Improved quality	Improved air quality information from the municipalities to the public
Reduced costs	Potentially reduced public costs to establish sensor network through innovative funding schemes
	Reduced operational costs using IoT, Big data and Smart Cities infrastructure
	Reduction of sickness related costs (medical treatment, hospital admissions, ultimately number of premature deaths). In Norway, premature deaths attributable to air pollution in 2014 posed a socio-economic cost of 75.590 million NOK.
More useful and relevant services	Larger geographical coverage. Currently only 26 municipalities in Norway have a monitoring station, and most municipalities/cities only have three or fewer

	Higher spatial resolution than current services (meters instead of kilometres)
	Personal exposure estimates, early warning systems, automated control systems
	Facilitate political action for improvement by empowering the population
Improved services	Possibility to provide citizens with more detailed/personalised data about air quality; not generally for the whole municipality, but specifically where people work and live
	Municipalities will be enabled to deploy even more target-oriented measures to address air quality/environmental problems in their city
	Automated traffic control according to the air quality situation. E.g., green zones, lower-emission zones, toll prices or traffic lights.
	iFLINK data can be used for Smart City activities
Other aspects of value creation	Improved quality of life for citizens, feeling safe: more detailed information on e.g., places with high air pollution
	The iFLINK data infrastructure will be offered by NILU to Norwegian municipalities beyond this project. We foresee that about 25 cities larger than 25.000 inhabitants will be interested in establishing a sensor network to be connected to iFLINK.
	Local opportunities for technological firms related to maintenance of the sensor networks and provision of information services
	Better achievement for municipalities of providing relevant and actionable information on air quality. Ultimately, popular acceptance of antipollution measures. Possibility to use the monitoring infrastructure towards additional environmental goals (heat stress, climate measures, indoor environment).
	Common approach to innovative public procurement and development of business model for sensor networks implementation in the municipalities

4. Need for research

Sensor networks for air quality are a matter of interest to many municipalities, some of which are already having activities leading to their creation (including Drammen and Oslo). The shared experiences are that:
(1) the (poor) quality of data from low-cost sensors severely limits the usefulness of a network,
(2) the infrastructure and connectivity needs related to low-cost sensor solutions are substantial, and
(3) the costs of the operation of the low-cost system as a whole can be significant.

Previous research done internationally and by NILU allows us to identify research gaps that limit the development and implementation of a functional low-cost sensor network. To achieve the project goals, and solve the problems that the municipalities face, research is needed in the following four areas:

- Metrology (smart calibration of sensor networks)
- ICT (standardized infrastructure development for sensor data collection and processing, connecting to Smart City Infrastructure)
- Assimilation techniques for utilization of heterogeneous information sources in real time
- Identification of information solutions and increased literacy needs to ensure that the public and other stakeholders can use the information on air quality as a basis for decision-making.

iFLINK will address the following key research issues and bring Norway to the scientific front internationally:

- Build a scalable approach to handle large amounts of heterogeneous data using Data-as-a-Service and Linked Data approaches allowing to handle increasing computational requirements in a cost-effective way
- Develop methods for smart physical calibration of sensor networks combining big data algorithms with field procedures
- Develop machine learning algorithms to enable the use of low-cost air quality sensors in applications that require a high degree of accuracy
- Integrate relevant data for air quality from a variety of sources to determine air quality at a particular location and time with high accuracy using sophisticated data fusion techniques.
- Enable development of effective and efficient information solutions.

5. Project organisation and cooperation

The consortium consists of five municipalities, one research institute, one university, two telecom companies, and one technological SME. By joining forces of five municipalities, we will ensure that societal actors who face specific problems and who deliberately choose to exploit new opportunities to design novel and creative solutions drive the innovation. NILU's core expertise is air pollution, lately complemented by extensive research on the use of low-cost sensor platforms for air quality monitoring. Oslo Met does research and development of design elements of sensor networks and information provision. Telia and Telenor work to enable the use of novel ICT infrastructures to operate dense sensor networks and big data structures aligned with smart city concepts. Vicotee is an SME providing sensor network infrastructure. Figures 3 and 4 give an overview of project organization and partner roles.

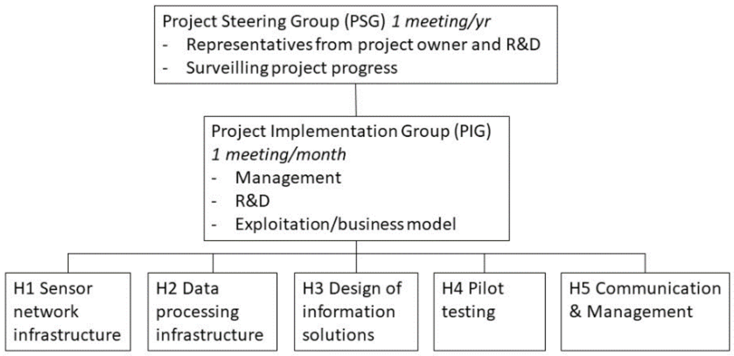

Figure 3. iFLINK organization chart

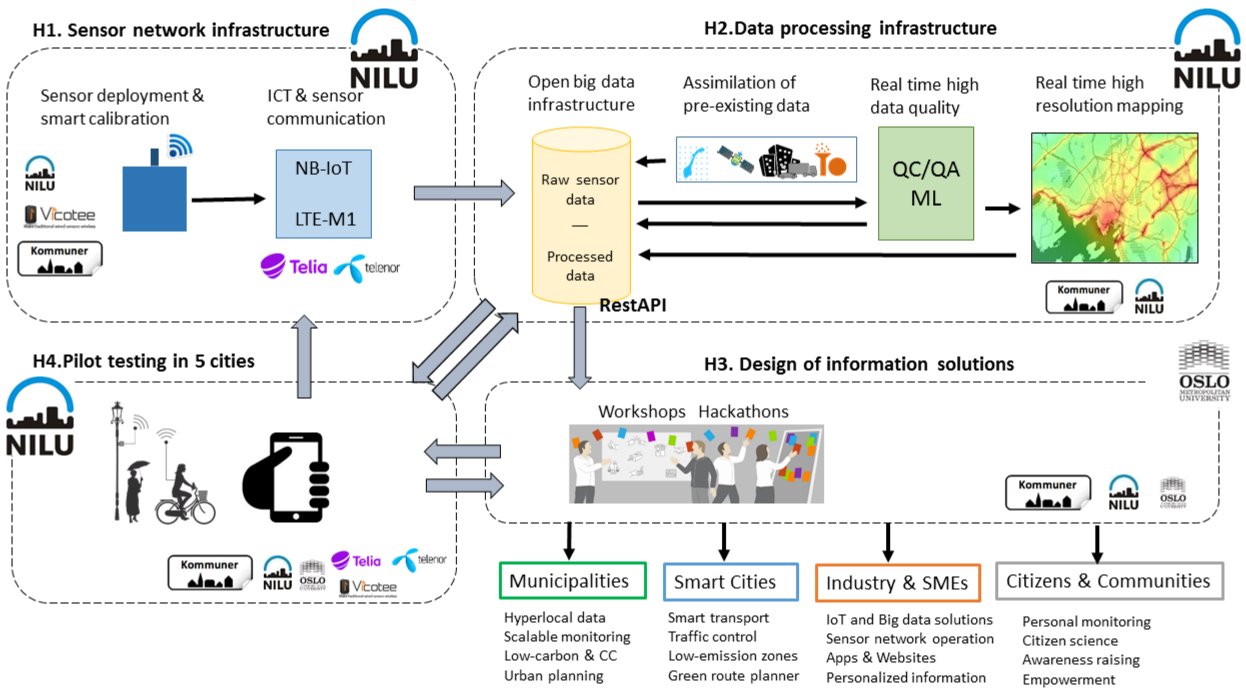

Figure 4. Project data flows, partner roles and main application areas.

PART 2: The R&D activities

6. Objectives

The main objective of iFLINK is to develop a cost effective open IoT infrastructure to manage high quality real-time hyperlocal environmental data from low-cost sensors. The secondary objectives are:

- Developing **smart calibration methods** combining in-situ field calibration with **machine learning** and big data procedures (outcome: standard operating procedures and computational algorithms)
- Developing a REST API **interface** to the iFLINK database and provide **standards** allowing to connect additional types of environmental sensors, regardless of their data format or location (outcome: standards, APIs, functional descriptions, embedded algorithms)
- Implementing the most suitable machine learning algorithms to **increase data quality** (outcome: algorithms implemented as part of the infrastructures)
- Integrating **low-cost sensor data** with a variety of existing data sources using optimized data assimilation algorithms to provide high-resolution environmental digitalized maps (outcome: embedded procedures for real time air pollution maps)

- Developing **improved information solutions** towards providing actionable information on air quality for at the minimum, the municipalities as the main stakeholder in the project (outcomes: data related to acceptability of different information solutions)

The anticipated result of our project is **the successful connection of a variety of low-cost environmental sensors to an open technological platform** that adds value to the low-cost sensor data by increasing their accuracy through applying machine learning and data assimilation algorithms. The platform will allow municipalities and other parties to access different data processing levels (i.e. from unprocessed sensor data to high-resolution maps) according to their specific needs. Open data and open access will be standard. User documentation will allow for new actors to connect.

7. R&D challenges and scientific methods

Based on the analysis of research gaps, iFLINK addresses three main research challenges:

(i) The accuracy of environmental low-cost sensors; i.e. how to ensure that sensor data quality is sufficient for the anticipated use of the data,

(ii) The design of a scalable open data infrastructure that allows the connection of different types of sensors independent of the data format and location, and

(iii) Information solutions aiming at engaging people, industries and communities in addressing complex environmental issues, such as air pollution, climate change and noise.

In order to take full advantage of the potential of this advanced monitoring technology, the individual sensors need to be connected to an IoT data structure. This would allow to reduce the influence of interferences with temperature, relative humidity and pollution levels[1 2], and to use statistics to combine sensor data with a variety of other relevant data for air quality by applying sophisticated data algorithms including machine learning[3 4 5], data assimilation[6 7] and big data analysis[8 9].

Planned approach and choice of methodology

The iFLINK infrastructure and information solutions will be tested in a pilot involving the 5 participant cities. The results will be published in open access as user guides to facilitate the uptake by other municipalities. The data will be accessible through standard APIs to ensure innovation by third parties. The platform of Oslo - European Green Capital 2019 will be used to disseminate the results and foster cooperation with municipalities in Norway and abroad. We will follow RRI principles.

Level of ambition and risks

iFLINK has the ambition to develop **optimal methods that will support the application of low-cost sensor networks** for information about air quality, and thus save significant resources to the participants and to all wishing to do the same. The monitoring and data processing technologies employed in our project **will allow to identify and address environmental problems more efficiently and sooner** than current employed monitoring and modelling techniques.

The iFLINK data structure will contribute to the development of **smart cities**. Potential applications include implementing real-time measures to mitigate air pollution as for instance automated control of toll's fees and emission zones, or providing citizens with information about air quality in their individual neighbourhood or

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[1] Castell, N. et al, 2017. Can commercial low-cost sensor platforms contribute to air quality monitoring and exposure estimates? Environ. Int. 9.

[2] Borrego, C., et al., 2016. Assessment of air quality microsensors versus reference methods: the eunetair joint exercise. Atmos. Environ. 147 (2).

[3] Roman, D et al, 2017. ALaDIn: Shining a Light on Air Quality through Data Integration and Machine Learning. EnviroInfo 2017

[4] Spinelle, L. et al. 2015 Field calibration of a cluster of low-cost available sensors for air quality monitoring. Sensors Actuators, B Chem., 215.

[5] Zimmerman, N. et al., 2017 Closing the gap on lower cost air quality monitoring: machine learning calibration models to improve low-cost sensor performance, Atmos. Meas. Tech. Discuss (in revision)

[6] Lahoz, W.A., Schneider, P., 2014. Data assimilation: making sense of earth observation. Front. Environ. Sci. 2, 16.

[7] Schneider, P., 2017. Mapping urban air quality in near real-time using observations from low-cost sensors and model information. Environ. Int. 106.

[8] Ram, S. et al. 2015. Predicting asthma-related emergency department visits using big data. IEEE journal of biom. and health informatics, 19(4).

[9] Huang, T., et al. 2015. Promises and challenges of big data computing in health sciences. Big Data Research, 2, 1, 2-11.

street. These developments may **change** not only **how environmental programs operate**, but may also modify the **roles played by citizens**, researchers, the public sector, industry and other actors.

There are **risks** associated with all steps of the value chain of the project. We feel confident to be able to address most of the **technical and scientific** questions related to performance of environmental sensors, structure and performance of the IoT data infrastructure, machine learning, data assimilation and GIS mapping. However, the process of ensuring good quality can be extensive and may require more **resources** than those available. This includes both **manpower** and **hardware costs.** The air pollution sensors we are currently working with show high correlation when compared with high-cost reference instrumentation, and theoretical methods are available to utilize dense sensor network properties to improve the outputs.
Further risks are related to the **interplay of technology and users**: experience shows that when involving different types of users we may encounter significant barriers (time availability, interest, technological and scientific literacy, competing interests and others). This may require significant additional investments in **planning** and coordination, and **operative mitigating** solutions.

8. Project plan

a) Main activities ("work packages") under the project

To support the iFLINK innovation through R&D activities, we will structure the main activities as follows:

H1. Sensor network infrastructure to support environmental sensor networks in Norway

Scientific content: The calibration of low-cost sensor remains a challenge. We will develop a verification protocol to analyse the performance of commercial platforms under laboratory and field conditions. The results will be made available as feedback to the manufacturers. We will assess the performance of different calibration models by comparing them against reference data. We will use different statistical indicators including the measurement uncertainty defined in the European Air Quality Directive. Telia and Telenor will provide the connectivity for the sensor platforms using dedicated IoT technology (NB-IoT or LTE-M1) and secure the data acquisition from the sensor platform to the iFLINK platform (input for H2).

R&D category: Experimental development
Deliverables: (i) Protocol for performance evaluation of sensor platforms; (ii) Recommended optimal calibration algorithm: (iii) User document on sensor connectivity infrastructure
Responsible: NILU – Nuria Castell, Franck R. Dauge
Cost: Approximately 22% of RCN funding and 26% of the total cost.

H2. Data processing infrastructure for high accurate real-time air quality information

Scientific content: NILU will develop the iFLINK data infrastructure based on existing scalable, fast, open and large-scale processing and database technologies, like Spark and HBase. The iFLINK data infrastructure will enable machine learning, automated intelligent corrections other sophisticated prediction algorithms to deliver high accuracy data. The iFLINK on-the-fly machine learning module will be superior to other existing modules because it will integrate, combine and process a broader spectrum of external environmental variables together with sensor data. Ingesting and combining data from different sources (JSON, CSV, NetCDF4 formats) require common data models that are currently not available; data is of varying quality and require different data preparation approaches. We will test various machine learning algorithms (Hierarchical clustering, Gradient Boosting Machine, Random Forest, Multi-Layer Perceptron). We will also use our air quality knowledge to improve and simplify the machine learning algorithms. Uniform and device-independent access to the data will be ensured through REST APIs. The iFLINK platform will comply with data safety standards. The infrastructure will be open to enable innovation by third parties. We will implement data fusion methods based on geostatistics and other methods that allow for merging observations from a network of low-cost sensors with other existing sources of spatial information, e.g. from a dispersion model, from satellite data or data from traditional monitoring stations. This is a very robust method to exploit the swarm knowledge of the entire sensor network and to extract realistic signals, resulting in the possibility of high-resolution spatio-temporal mapping of air pollution as well as other environmental parameters.

R&D category: Industrial research
Deliverables: (i) Data Infrastructure prototype, (ii) Rest APIs for data access, (iii) High-resolution maps
Responsible: NILU – Jean-Marie Lepioufle, Philipp Schneider
Cost: Approximately 20% of RCN funding and 13% of the total cost.

H3. Design of information solutions

Scientific content: The municipalities want to ensure that the citizens benefit from the provided information. We will identify the current ICT barriers in order to remove them. We will investigate how different designs influence understanding and uptake of information on air quality, and will provide feedback that would allow specific ICT development to make information attractive to the municipalities target groups. We will employ procurement regulations, anti-discrimination legislation and rewards for universally usable web design, together with technical programming and design competence to ensure the solutions are in agreement with the universal design of ICT. OsloMet will integrate iFLINK into its Design Office course, where 8 master students each year focus on a particular project. In 2018, the Department of Product Design plans to invest in eye-tracking equipment, which will become available for the project. It will help to design information solutions that are usable and desirable and deliver actionable information to the target groups. The municipalities will organize Hackathons involving citizens and companies in for instance the design of data-driven solutions, new uses of data and new ways of data visualization. In addition, we will organize meetings to address business and funding models to ensure the continuity of the infrastructure after the project.

R&D category: Experimental development
Deliverables: (i) Prototypes
Responsible: OsloMet – Johannes Daae
Cost: Approximately 5% of RCN funding and 15% of the total cost.

H4. Pilot testing in Oslo, Bergen, Bærum, Drammen, Kristiansand

Scientific content: We will test the iFLINK data platform in the five municipalities, allowing further technical improvements based on the results of real-life condition testing, and data collection for work in all work packages. **Phase I** will start the first year with the deployment of a limited number of sensors platforms (approx. 10 units per municipality) in the five cities. Once the iFLINK infrastructure is operational, we will test its scalability by increasing the number of sensors in the five municipalities (from 20 to 100 units per municipality, budget/external funding permitting) (**Phase II**). We envision that different types of platforms with varying quality will be deployed, from high-end low-cost sensors (price from 5000 €) to cheap low-cost sensors (price from 100 €). This is desirable in order to achieve a very dense sensor network while keeping the costs reasonable. The sensor procurement for the five cities will be done in consultation with advisers in innovation procurement. The municipalities advised by NILU will select the locations for the sensor platforms. NILU will also train personnel from each municipality to deploy and maintain the sensor network. After Phase II is successfully completed, we will invite other municipalities to connect their sensor networks.

R&D category: Experimental development
Deliverables: (i) Validation of the iFLINK data platform; (ii) Usable prototype
Responsible: NILU – Nuria Castell, Alena Bartonova
Cost: Approximately 24% of RCN funding and 24% of, the total cost.

H5. Communication and management

Scientific content: Efficient communication and management are important to successfully carry out R&D activities. In addition to a scientific coordinator, an administrative project manager will support iFLINK. Internal communication will be ensured through regular consortium meetings and a purposeful information flow. External communication will be established with NFR, national/regional innovation support and municipalities that want to use iFLINK. Established arenas such as "Bedre Byluft forum" will also be used. All project dissemination activities will be planned and carried out in this main activity. The administrative management will organize meetings of project steering group (PSG, min. 1x per year) and project implementation group (PIG, min. 1x per month), as well as project meetings and dissemination activities. Coordination of a PPP business model for sensor network deployment and of a business model for the iFLINK service sustainability will also be carried out.

R&D category: Support to R&D activities and realization of the innovation
Deliverables: (i) consortium agreement; (ii) communication and dissemination plan; (iii) PPP business plan model for sensor network establishment (iv) business model for iFLINK service continuation
Responsible: NILU – Sonja Grossberndt, Alena Bartonova
Cost: Approximately 30% of RCN funding and 22% of the total cost.

b) Key milestones for the R&D activities: MS1 – Infrastructure and database operational (M7); MS2 – Meet ups with users started (M12); MS3 –Production of good data using ML (M15); MS4 – Implementation of data fusion methods (M18); MS5 – Finalisation pilot phase 1 (M22); MS6 – Finalisation pilot phase 2 (M34)

9. Responsibilities and roles in performing the R&D activities & 10. Costs and funding for each research-performing and financing partner (NOK 1 000)

Table 3. Responsibilities for activities and costs and funding (NOK1000) for each partner.

P	Name of partner	Respon-sible	Participa-ting in	Costs (from NFR)	Funding (own contribution)
P1	Municipality of Oslo (Project owner)	-	H1 - H5		
P2	NILU-Norwegian Institute for Air Research (Project manager)	H1, H2, H4, H5	H3		
P3	Oslo Met, Department of product design	H3	H4, H5		
P4	Municipality of Bærum	-	H1 - H5		
P5	Municipality of Drammen	-	H1 - H5		
P6	Municipality of Kristiansand	-	H1 - H5		
P7	Municipality of Bergen	-	H1 - H5		
P8	Telia AS	-	H1, H4, H5		
P9	Telenor AS	-	H1, H4, H5		
P10	Vicotee AS	-	H1, H4, H5		

11. Other forms of collaboration on R&D activities

iFLINK will benefit from the following partnerships and activities:

H1, H2, H4: NILU is partner in the ongoing CEN standardisation work of sensors platforms under the leadership of JRC (EC's Joint Research Center in Ispra, Italy). NILU is leading/participating in ongoing national projects that include testing of sensor platforms, such as the CleanAir project collaboration between the municipality of Oslo, NILU and Telia, and the InnoSense project collaboration between NILU and Oslo municipality. Further, NILU is partner in several ongoing international activities, such as COST actions CA15212 "Citizen Science to promote creativity, scientific literacy, and innovation throughout Europe", the H2020 projects hackAIR and ClairCity. The ICT platform will utilize NILU's expertise in air quality databases (National air quality database, European databases for international conventions and international collaboration on satellite data validation and calibration). Calibration and quality control of air quality data will be also based on NILU's experience as National Reference Laboratory for Air Quality and on participation in international standardization networks such as NORMAN, and in work in the CEN TC/264 air quality.

H3: Through its department of Product Design, OsloMet has R&D projects where user involvement and user interface is in focus. Also the department of ICT has a research group in Universal Design. These activities will be incorporated in H3 as part of the activity called Design Office, which has been heralded by the Minister of Education and Research as the future education practise. NILU will link to projects with citizen science (Cost action CA15212, EU H2020 projects hackair and ClairCity).

PART 3: Realisation of the innovation and utilisation of results

12. Plan for realisation of the innovation

The high-resolution network of affordable sensor platforms will improve the existing infrastructure for air quality measurement in all participating municipalities. The municipalities wish to extend the air quality sensor network with e.g., measurements of noise and aim to integrate the acquired data with other public open data streams. The link of iFLINK IoT infrastructure to ongoing smart city initiatives aims to provide inhabitants with better quality and more updated air quality information.

In the framework of iFLINK, the SmartOslo will engage with Oslo's innovation and start-up communities to use the data created in the project for the creation of new services. SmartOslo will arrange a dialogue meeting for the start-up community before the data will be published to create engagement amongst the start-ups. Once the data are available, SmartOslo will arrange a competition where the most promising ideas can be tested. The data will be published at https://oslokommune-bym.opendata.arcgis.com/. The Norwegian Smart Cities network will be a relevant channel for coordination and dissemination of both the project data and findings.

The most important activities towards a successful realization of the innovation (in relation with Table 1 in section 2) are given in Table 4.

Table 4. Timetable of activities to realize innovation.

		2019	2020	2021
New/Updated services	Procurement of sensor platforms	x		
	Pilot testing of iFLINK data infrastructure	x	x	x
New methods	Laboratory and field smart calibration	x		
	Integration of heterogeneus data sets	x		
	Machine learning algorithms	x		
	Operational iFLIK data infrastructure	x		
New or improved organisational structures	Bussiness model		x	x
	Information solutions		x	x
	Dissemination	x	x	x
	Private-public financial mechanisms			x

Key milestones: VCMS1 – Platform procurement (M6); VCMS2 – Oslo Green Capital Urban conference (M8); VCMS3 – Business model (M24); VCMS4 – Integration of data in municipalities (M30)

13. Risk factors

Table 5. Risk factors for realisation of the innovation.

Category	**Description**	**Consequence**	**Action**
Implemen-tation	Problems in the sensor performance or connectivity	No data	Follow up incoming data, implement alert system based on machine learning for swift action; consult with Telenor/Telia for alternative connectivity solutions.
	Procurement of sensors slow– not sufficient numbers of sensors of acceptable quality available	No data	Reducing number of sensors, contacting new providers.
Financing	Sensors and maintenance are more expensive than planned; more work is required	Delay in network implementation	Reduction in number of sensors, finding other financial sources.
Organizatio-nal; statutory framework	Procurement of innovation does not allow for the necessary volume of sensor platforms to be procured	Fragmentation, delays	This is the highest priority risk of the project. Work with the national/regional support system for innovation to fully utilize the available possibilities for innovative public procurement and PPP.
Political	Change in political priorities	Project will lose support	Develop other applications of the infrastructure. Communicate within the partner organizations with weight on national and international political priorities (SDGs or Paris Agreement).
	Unwillingness to share data, privacy concerns	Delays in access to data	Identify causes and concerns, develop measures, procedures for anonymization

14. Other socio-economic benefits

iFLINK will have technological, scientific, societal and economic impacts. **Scientists** will obtain higher geographical resolution data at a lower cost thanks to trustworthy ubiquitous sensor networks facilitating for instance public health research. **Policy makers** will be able to take data-driven actions to improve air quality and consequently public health. This will have economic impacts as lost productivity through illness and extensive health care will be mitigated. For the **general public**, direct benefits will include better and more useful potentially actionable information; indirect benefits will include improved public health and urban development. The project outcomes will have also a positive impact on the quality of life of **citizens that are very sensitive to air pollution** such as children, elderly, pregnant and people suffering from respiratory and heart diseases providing information that can increase security and feeling safe. The iFLINK infrastructure and machine learning algorithms will have impact on a global scale in the form of **methods transferrable to other challenges** that require a data-driven approach, as for instance Climate Change mitigation. Further, the research process will be open to the general public **in compliance with** the RCN's **RRI guidelines and goals**. This will help to **bridge the gap** between **science** (including modern technologies) and **citizens**, and support the efforts towards a more environmentally friendly society.

15. Dissemination and communication of results

Communication and dissemination of project activities and results will be twofold: for academic and non-academic audience. We aim at publishing a minimum of three scientific papers in high impact scientific peer-reviewed journals, with open access. We will also present the results at scientific conferences. For popular science communication, all project partners will make use of their own communication channels, including newsletter, websites, annual reports or social media. Connections to the local and national press, as well as e.g., Forskning.no will also be used for dissemination, especially to reach citizens that are not involved in any activities related to air quality.

In addition, we aim for close cooperation with the project management of **Oslo Green Capital** to foster synergies. Several municipalities will support and carry out **hackathons** and other innovative **open data initiatives**, both through the national *Norwegian Smart Cities* network and individually, for which the generated knowledge and data will be valuable input.

Existing platforms where partners are represented will be utilised, including the "Kommunenes sentralforbund", "Bedre byluft" forum, the "Nettverk Sunne Kommuner", "Smart by" network, and "Smartere transport i Osloregionen (STOR)" where we will inform about the project activities and establish contact to interested municipalities for mutual learning.

We will also strengthen **international cooperation.** Vicotee has a large international network with municipalities in Israel, Germany, and other European countries that are very interested in setting up a sensor network and would be eager to learn more from our experiences in Norway. Through the Smart City initiatives in the participating iFLINK municipalities, dissemination to **international partner municipalities** is ensured. In addition, international visitors of **the Oslo Green Capital in 2019** will also be made aware of our project activities. Further, NILUs international activities such as participation in the **UERA** network, partnership in the **European Environment Agency** ETC Air and Climate change will be utilized.

PART 4: Other information

16. Environmental impact

The activities shall contribute to improve the municipalities' ability to carry out measures to combat air pollution and other environmental problems.

The project will use extensively electronic communication means for meetings, and will optimize travel arrangements to minimize environmental impact. In addition, NILU is ISO-14001 certified and implements an environmental management plan, which is the case also for most of the other project participants.

17. Ethical perspectives

We do not anticipate any ethical issues in relation to the implementation of our project. The data communication will be done using secure networks from Telia and Telenor. The iFLINK database will not store any private or personal information. We will follow RRI principles.

18. Recruitment of women, gender balance and gender perspectives

Both project managers are women, and all project partners contribute with high percentage of "womenpower" to make this project a success. We will pay attention to gender balance in the project.

19. Additional information specifically requested in the call for proposals

None.