

SAF€RA final report template for projects

Please send your final report to the SAF€RA Call Secretariat, call-secretariat@safera.eu.

Background information

Date of reporting:	28/02/2023
Person reporting: (project coordinator)	Dr. Patrick P. Neumann BAM/Germany
Project title:	Robot-Assisted Environmental Monitoring for Air Quality Assessment in Industrial Scenarios (RASEM)
Project period (start-end):	01/04/2019 – 31/12/2022
Project website URL:	https://www.bam.de/Content/EN/Projects/RASEM/rasem.html
Project coordinator and country:	BAM/Germany
Project partners and countries:	Finnish Institute of Occupational Health (FIOH)/Finland Örebro University (ORU)/Sweden Separate industrial partners: Outokumpu/Finland Tallink-Silja/Finland
SAF€RA funding: Project funding organization/s (national) and funding amount/s:	SAF€RA EUR: 240 k€ (BAM) + 110.2 k€ (FIOH) = 350.2 k€ Percentage of total budget: 73%
Other outside funding (outside SAF€RA and project partners' own organizations):	Finnish Work Environment Fund EUR: 129 k€ Percentage of total budget: 27%
Project total budget (all outside funding and own input together; i.e. final realized spending):	EUR: 479.2 k€

Project progress and results

1. Summary of the project progress

1.1a What was intended to be achieved during the project (list briefly with bullet points)? How well these milestones have been met? Were there any significant changes to the project work plan or objectives? Note if changes, why and did these have impact on the planned final objectives?	
<p>Intended achievements:</p> <ul style="list-style-type: none"> Fully heterogeneous monitoring system consisting of mobile robots and stationary sensors, carrying high-quality and low-cost technology Long-term measurements in industrial environments Algorithms for distribution mapping Eventually better exposure protecting procedures, gained through the new algorithms and data <p>Most milestones were met. COVID-19 and its related travel bans delayed the project's schedule by over one year. The prolongation of the project, however, ensured successful project results. Three stationary sensor networks were installed in 2021 at three industrial sites in Finland. A measurement campaign with mobile robots demonstrated the heterogeneous RASEM approach in June 2022.</p> <p>The forced reschedule by COVID-19 led to the development of an AI-based algorithm for distribution mapping. Its application to the RASEM data is part of a future research.</p>	
1.1b Did the project progress as planned and are the outcomes as expected, evaluate on 1-5 scale (1= poor– 5 = excellent)	4 = Very Good
1.2a How will the outcomes of the project be used? Who will benefit from the project outcomes?	
<ul style="list-style-type: none"> The industrial partners will benefit from deeper insights into occupational exposure levels based on combination of traditional occupational measurement campaigns and long-term air quality maps (sensor network). One PhD thesis and multiple student theses will directly benefit from the data and generate new insights, even after the end of the project. Academic research fields, e.g., mobile robot olfaction, sensors, and environmental monitoring will continue to gain from new research and data. Occupational exposure experts gained insights on the application of low-cost measurement methodologies in worker exposure assessment 	
1.2b Were there changes in project partners or key personnel? How well did the project partners co-operate towards the project implementation? Could this partnership work successfully together in future projects as well? Will the co-operation of the partners continue after this project?	
<ul style="list-style-type: none"> All direct partners co-operated successfully together. Partnership between BAM and FIOH is still ongoing. Both partners make efforts to continue joint research and publications in the future. The partnership with Outokumpu is considered successful. Outokumpu is willing to contribute to a possible follow-up research project. 	

- A follow-on project has been discussed and agreed upon. All partners are willing to support a new project, once a good opportunity for funding is identified.
- FIOH's project coordinator left the project, but this had no impact on the project as new personnel joined the project.

2. What is the added value and impact of your project?

2.1 What were the practical outcomes of your project? Are the outcomes of the project ready for use, or do they still need further development?	
2.1a Did the project result in a pre-product, commercial product, method/process, etc.? What was the concrete outcome of your project?	
<ul style="list-style-type: none"> • A low-cost sensing node, using commercially available environmental sensors, was developed. It was used as a stationary and mobile platform. This is not a commercial product, but the development has been published and will be re-used and adapted in future research projects. • The current sensor network suits for relative measures of workplace air quality and provides unique information on the long-term spatiotemporal variation. The sensor network can be used as indicative for areas of higher exposure potential. Further development is needed to calibrate the sensor network to reference-like measurement devices. • The insights from the sensor network are useful for directing technical mitigation measures and planning the work in a way to avoid concentration hot spots. These results were disseminated to the industrial partners (management, workers, safety department). • A new method for gas distribution mapping was developed and its basic capabilities were demonstrated. Future research is needed to apply this to complex, industrial scenarios. 	
2.1b Were standards (e.g. ISO, CEN) impacted by the project? If yes, specifically how and when? Or if not directly now, do you estimate that the results of your project could influence standardization later - how?	
0 = no impact on standards	
No standards were directly impacted by the project.	
2.1c Number of patents obtained, applied for or being planned?	0 = no patents foreseen
2.2 Project's impact for industrial safety in EU?	
2.2a Describe briefly how the project outcomes can be applicable to other organizations/countries/ regions in EU, or to scientific disciplines or areas of industry.	
<p>The data obtained in RASEM is a valuable and unique dataset, from which scientific research in the field of occupational health and environmental monitoring will benefit.</p> <p>Occupational hygienists will benefit from the insights on the individual exposure levels of workers.</p> <p>The RASEM approach will be further developed and applied to other industrial scenarios, specifically planned for a wastewater treatment plant and hydrogen filling station. It can be used as indicator for areas of higher exposure potential. This information is useful for directing technical mitigation measures and planning the work in a way to avoid concentration hot spots (based on the air quality maps). It also makes it possible for the workers to avoid peak concentration times.</p> <p>FIOH organized three webinars disseminating the occupational exposure and sensor network results to the two partner companies included in RASEM. Based on the RASEM results and</p>	

<p>suggestions, the company management and safety officers can improve the industrial safety by applying appropriate exposure mitigation methods at the studied work environments.</p>	
<p>2.2b Did the project provide new information on the topic to the intended target group? What was the new information discovered?</p>	<p>1 = yes Yes, new information was gained. For example, on sensor drift/cleaning, calibration, data handling/interpretation, comparability to known exposure measurement methodologies.</p>
<p>2.1c Number of patents obtained, applied for or being planned?</p>	<p>0 = no patents foreseen</p>
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<p>2.2b Did the project provide new information on the topic to the intended target group? What was the new information discovered?</p>	<p>1 = yes/ 0 = no What was the new information?</p>
<p>2.3 Has the project improved co-operation with actors in the industrial safety field (companies, researchers, decision makers, etc.)? Describe briefly how the project partners have networked with actors in the industrial safety field during the project – through what type of activities. Estimate if the project made it easier to contact actors and if there has been more contacts compared, if the project had not been implemented. Has the project brought about new opportunities to make contacts with actors in the industrial safety field?</p>	
<p>The project improved cooperation between actors in the industrial safety field. BAM and FIOH have networked with two industry partners through multiple measurement campaigns. These were new contacts for BAM, that may be relevant for future projects. Through SAF€RA, valuable contacts with other European institutions were made, specifically during the 22nd SAF€RA symposium.</p>	
<p>2.4 What was the visibility of the project and its results?</p>	
<p>2.4a Briefly describe the project activities in different media, e.g., websites and social media (Twitter, LinkedIn, Facebook, YouTube, etc.), newsletters, magazines, conferences, fairs, tv/radio etc. What type of activities and how often in general? What activities you consider have been most effective for your project?</p>	

Project sites were set up to communicate to the general audience:

- <https://www.bam.de/Content/EN/Projects/RASEM/rasem.html>
- <https://www.ttl.fi/en/research/projects/robot-assisted-environmental-monitoring-for-air-quality-assessment-in-industrial-scenarios-rasem>

Additionally, the report to the Finnish Work Environment Fund will be made public.

Updates on the project were posted on social media (Twitter, LinkedIn).

To address an expert audience, the project was visible in the SAFERA context (2022 SAFERA symposium, newsletter) and at multiple international conferences during 2019 and 2022.

In-person conferences direct contact were considered to have been most effective, e.g., SAFERA symposium for scientific exchange. The project site was very valuable as it served as a first starting point for a broad audience.

2.4b Scientific articles (based on the project work) published or being submitted or planned?

Name of scientific journal: *Materials Today: Proceedings*

Article title: *High-quality meets low-cost: Approaches for hybrid-mobility sensor networks*

Authors and their affiliations: *Nicolas P Winkler (BAM), Patrick P Neumann (BAM), Arto Säämänen (FIOH), Erik Schaffernicht (ORU), Achim J Lilienthal (ORU)*

State: *Published*

Name of scientific journal: *MDPI Sensors*

Article title: *Super-Resolution for Gas Distribution Mapping*

Authors and their affiliations: *Nicolas P Winkler (BAM), Oleksandr Kotlyar (ORU), Erik Schaffernicht (ORU), Haruka Matsukura (University of Electro-Communications), Hiroshi Ishida (Tokyo University of Agriculture and Technology), Patrick P Neumann (BAM), Achim J Lilienthal (ORU)*

State: *being prepared*

