March 2020

Author:
Kinga Korniejenko
UIA Expert

URBAN INNOVATIVE ACTIONS

The Urban Lab of Europe !

The Urban infra revolution project Journal N° 4

*Project led by the **City of Lappeenranta***

CIRCULAR ECONOMY

European Union
European Regional Development Fund

Région Hauts-de-France

The Urban infra revolution project

Urban infra revolution will test new solutions to reduce CO_2-emissions in urban construction development. Sidestreams from industry (ashes, green liquor dregs, tailings, construction waste) will be utilized in urban construction by combining them into a high-value material to replace concrete. Novel material formulas will be created containing suitable side streams to be used as geopolymer binder (replacing cement) and as inorganic aggregates in geocomposites. An innovative bio-fibre reinforced geo-composites will be developed to achieve the high standards of construction industry. Automated, on-site, fast and versatile additive manufacturing construction system, without molds, will be tested in comprehensive urban scale. The material and the piloted technology will be multifunctional and enable aesthetic design with revolutionary shapes with very low CO_2 emissions. Selected pilot structures will be manufactured within the urban infra and their properties are tested in real climate conditions. To implement and finally benefit locally the project results, a viable sustainable business ecosystem will be designed and environmental and socioeconomic impacts assessed.

Partnership

- City of Lappeenranta
- Apila Group Ltd - SME
- Fimatec Finnish Intelligent Module Appartment Oy - SME
- Total Design Ltd - SME
- Design Reform Ltd - SME
- UPM Kymmene - private company
- Outotec Ltd - private company
- Nordkalk Corporation - private company
- Metsä Group - private company
- Stora Enso Oyj - Private company
- Lappeenranta University of Technology - higer education and research institute
- Imatra Region Development Company Ltd - regional development company
- Saimaan ammattikorkeakoulu - higer education and research institute

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1. EXECUTIVE SUMMARY

The fourth edition of the Journal describes and analyses the progress of the Urban infra revolution project in the last six months, from October 2019 to end of March 2020. During this period the progress of the main tasks was significant, but the situation in last month dramatically changed because of crises caused by the pandemic of COVID-19. Overall summary of this situation and how it influences the project is presented in the second section.

The third section introduces up-dates about the project status, especially in the area of products' designing and development of technical solutions. The main challenges in this innovative area, such as: material, process and products are presented. The difficulties, barriers and challenges linked to the innovative nature of the project are analysed. Significant progress in comparison with previous period has been achieved, but still some major issues need to be resolved. Currently, the project is facing new challenges connected with technology scaling-up as well as effective managing during pandemic of COVID-19.

The fourth part of the article presents different area of the project implementation. The project has been started in November 2017. Its implementation was planned till October 2020, but it could be impossible to finish it in planned deadline, because of the constraints connected with COVID-19 epidemic, like restrictions in the consortium's partners activity. This section presents the activities that have been applied to ensure the right conditions for the project implementation and lowering the barriers in the following areas: leadership for implementation, public procurement, integrated cross-departmental working, adopting a participative approach, monitoring and evaluation, communicating with target beneficiaries, upscaling and others.

The last section presents the future scenario for the project. It will be very hard to achieve planed steps according to the schedule. To ensure the possibility of an effective project implementation, it should be prolonged. Contemporary situation can be regarded as force majeure that is independent of consortium efforts.

2. INTRODUCTION

During the last 6 months, there was a significant progress in the Urban infra revolution project. The consortium, after negotiations with the railway company received all necessary formal documents for planned prototype realization. The project of noise barrier had been finished and groundworks were successfully finalized. The process of scaling-up has been started. Additionally, the tasks connected with the analysis are continuing, especially of economic point of view and possibilities of wide implementation of the innovative idea. Despite of significant progress, the proper implementation of the project according to required deadline, is still in question. The situation in Europe changed radically, because of the COVID-19 epidemic.

Currently, COVID-19 epidemic has affected whole Europe, including organisations involved in EU programmes. The situation is affecting in particular engineering and project contracts[1]. Most of the international organizations point the pandemic as the force majeure. The main problems in the projects' implementation are connected with unavailability of key staff, the impossibility of carrying on work in a zone affected by the virus, delays in procurement procedures or lack of possible effective supervision of the planned activities[2].

The situation in Finland is as serious as in whole Europe. On 16 March, the Finnish Government, declared a state of emergency due to COVID-19[3]. The Emergency Powers Act has been implemented and it caused restrictions such as: closing of schools and limitation of public meetings. The activities of the organizations from the private and public sector are also limited. This situation probably will implicate delays in the project realization.

[1] http://www.globalconstructionreview.com/news/covid-19-force-majeure-event-european-construction/
[2] https://eacea.ec.europa.eu/about-eacea/news/coronavirus-implications-for-implementation-programmes-managed-eacea_en
[3] https://thl.fi/en/web/infectious-diseases/what-s-new/coronavirus-covid-19-latest-updates

3. PROJECT UPDATE

3.1 Material development - acoustic isolation

The first step for material development[4] has been successfully finished . The five material's recipes were designed by Apila Group. Especially important was application of local raw materials and a close material loop, in order to diminish the CO_2 emissions of urban building and enhance zero waste economy in arctic cities. The following raw materials were taken into consideration: flotation sand, green liquor sludge, ashes and waste fibres (side-streams of the forest industry). The project emphasizes on new products by functionalized approach that will have strong societal and environmental impact, including energy efficiency, reduction of carbon foot-print, waste reduction and development of idea of circular economy.

The second step was connected with ensuring that the material is suitable for additive manufacturing technology. The materials have been tested on small printer in Apila's laboratory. At this stage, a lot of new knowledge about materials for 3D printing was created and upside down scaling has acquired some small adjustments. More information can be found here: https://www.greenreality.fi/en/lprnyt/blog-post-revolution-circular-economy.

In the next steps, the properties of the materials made by 3D printing technology were compared with samples made by traditional casting (to the moulds, Figure 1). The mechanical properties such as compressions and flexural strength were the same or even better than for traditional technology and for traditional concrete.

Figure 1. The casted sample

[4] https://www.greenreality.fi/en/lprnyt/blog-post-revolution-circular-economy

Nowadays, main challenges are related with large scale implementation. The first part of the material for testing is prepared (Figure 2). The research connected with behaviour of material in the large scale elements are also required. Their results could be other than the ones in small scale and the recipes should be optimized for this process.

Despite the success in laboratory environment, the works on the material are not finished. It still requires further investigation in matters of durability.

Figure 2. Raw materials prepared for scaling-up step

3.2 Process development – first trials

The most important innovative element of the project is effective 3D printing process for new material - geopolymer composite based on wastes or by-products. This is innovative combination of eco-friendly materials and the modern technology – additive manufacturing. The first trials in laboratory were place in autumn 2019. For the test, a robotic arm, that hold a tube with material for 3D printing, has been used (Figure 3). The material was extruded in controlled condition. Through the possibility of robotic arm programming different shapes have been created. This trials allowed to confirm usefulness of the material for 3D printing.

Meanwhile, the legislative activities are continued. The new material must be certificated before it could be launched on the market. For the prototype application is not necessary to have all required certificates, but it will be crucial for future implementation. The other complication is connected with the fact that the raw materials came from side-streams and by-products. For this type of raw materials additional tests are required before its application in construction industry. The legislation in this area requires confirmation of environmental safety, including lack of hazardous and toxic elements.

Figure 3. Robotic arm used for first test of the innovative material

3.3 Process development – scaling-up

Currently, the main challenge is the process of scaling-up technology. The material for prototype manufacturing has been prepared and the consortium is building a large scale 3D printer device (Figure 4 and Figure 5).

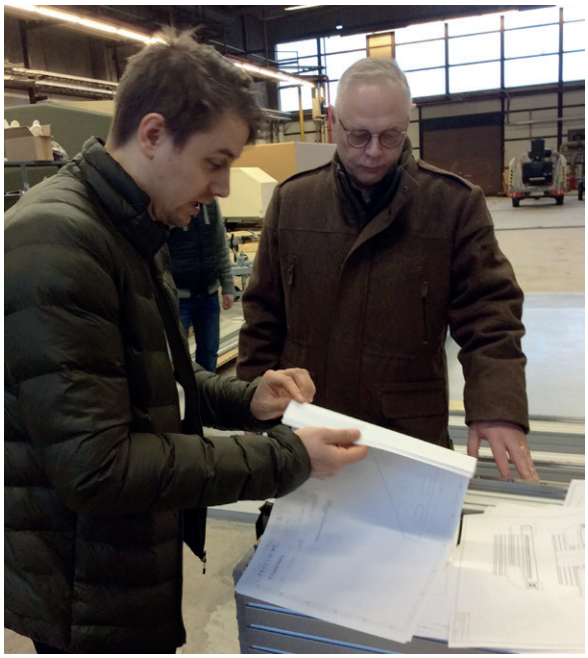

Figure 4. Analysing the documentation for full scale prototype – 3D printer

TThe optimization of the material for 3D printing technology is a complex problem. The same material composition could have some properties in small (laboratory) scale and other in the large scale, especially: reactivity and stability. These particular properties could be depended on the layer thickness in 3D printing technology. The thin layers in small scale joint faster than thick ones in large (industrial) scale.

The other important factor is the speed of the printing. In 3D printing process the material has limited time to achieve required properties. The particular layer must have a proper strength to be applied to another one in short time, but it must be also enough reactive and 'liquid' to be properly joined with previous layer. Numerous factors influence on this process, such as [5]: type of raw materials, chemical and psychical composition of material, type and concentration of alkalis, alkaline liquid-to-raw material ratio, water ratio, pre-curing conditions, curing

[5] Singh N.B., 2018, *Fly Ash-Based Geopolymer Binder: A Future Construction Material*, Minerals 8 (7), 299-320.

Figure 5. Fundaments for 3D printer in the company FIMATEC

temperature, pressure, temperature and others. Moreover, the additive manufacturing caused some limitations in curing process. The challenge is also the process stabilization, including replicability for the manufactured elements to ensure process control for increasing the quality of the final products.

The finalization of the production and starting of construction works were previously planned in April 2020, but because of the weather limitation, the first construction works should start in summer 2020. Unfortunately, because of COVID-19 epidemic situation it will be delayed.

An additional challenge is low temperature. This kind of environmental conditions reduces influences on curing process for geopolymers and on material properties. These conditions are typical for Finland's climate - arctic weather. It caused that the process required numerous trials before receiving the final products.

3.4 Product development – investment costs

On this stage of the project an economic feasibility is also analysed. The investment costs and revenue rate are estimated. The main point of estimation is future implementation. The first results were presented on the project meeting in January 2020 (Figure 6), but calculations are still continued. Additionally, the works of the estimation of environmental impacts are continued. The environmental analysis are related with economic studies to receive full information.

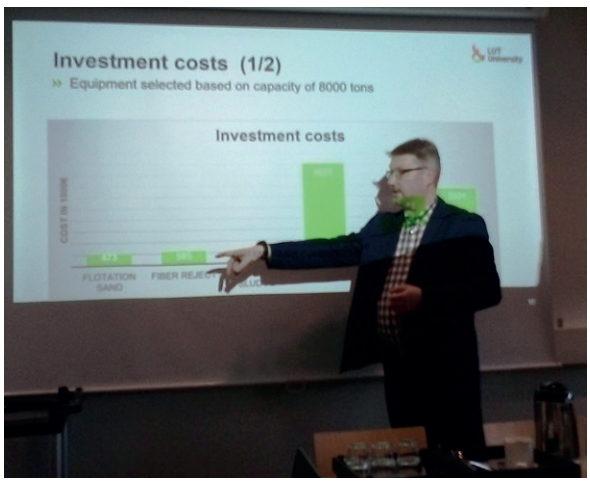

Figure 6. Presentation – fist estimation for the investment cost (full scale technology)

3.5 Product development – prototype

The project's main prototype will be sound-absorbing screens produced by 3D printing technology in conjunction with using secondary raw materials. The solution will be exemplary for a circular economy application.

Nowadays, the full project of the noise barrier (over 100 m length) has been presented and accepted. The prototype allows to compare optimal shape, technology and material for future work. The wall will include four different elements made in two different technologies – casting and additive manufacturing (Figure 7). The different composites will be applied - 5 different recipes. All recipes use by-products from industry. Among the planed recipes, three are dedicated for traditional casting technology and two for modern additive manufacturing technology.

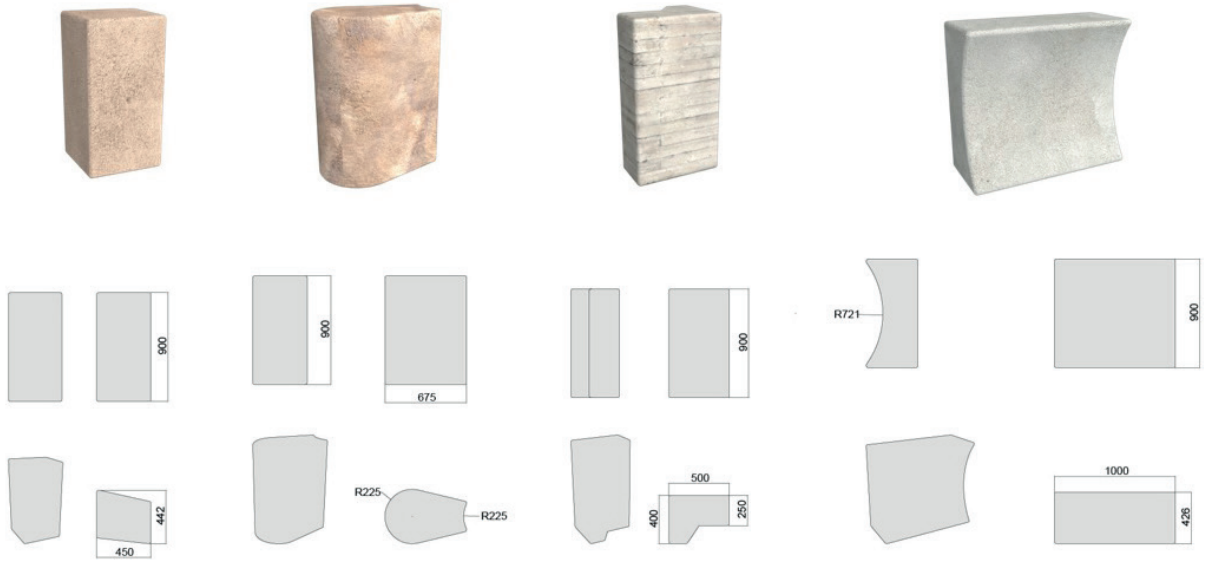

Figure 7. Visualisation on the elements of the noise barrier made by Design Reform's plans of piloting products, Source: Design Reform

After the consultation with other departments, three possible places for the localization have been chosen. Next, the project analysed the advantages and disadvantages of each place. Eventually, the consortium decided on the place near to the school. The sound-absorbing screen will be located behind a kinder garden and a school and will be blocking the noise from the railway (Figure 8). The analysis supported by computer modelling show that the level of noise reduction, which came from railways, will be larger than in alternative places.

Figure 8. The building of the school – nearby the noise barrier will be located

Then, the ground works started. They have been finished in fall 2019 (Figure 9). The fundaments were performed with traditional attested materials and in conventional technology. The end of the ground works was connected with a dissemination event dedicated to citizens, especially for kids from school located nearby and their parents. The main topic of this event was the promotion of ecological friendly solutions using activities prepared for kids, such as mini competitions - playing on piano using banana, or competition in electro-stability hair by balloons. The information about event was published on yle.fi webpage.

Figure 9. Ground works

Now, the works on scaling-up 3D printing technology for geopolymers are in progress and the planned construction works should started shortly, but the situation is a little bit more complicated because of epidemic.

4. IMPLEMENTATION STATUS

4.1 Leadership for implementation

The management is provided by the project leader - the city of Lappeenranta - and supported by Steering Committee. It includes the representatives of the key partners. The leadership of the project is well implemented, on the level of the project, as well as on work package level, including operational management.

Despite the regular meetings, the problem connected with lack of proper feedback between the partners, occurred in the last period. The communication between some of them was far from optimal, because of Individual Property Rights (IPR) reasons. The leader introduced some additional activities to clarify and improved communication, in particular it organized some additional meetings between the partners and ensured that the consortium agreement protected their IPR. The in-depth analysis shown that the partners had "fear of presenting unfinished products". The partners try to be too perfect and would not present unfinished products. Because of that, they were against the schedule. Due to the fact that partners were behind the schedule the leader organized individual meetings where they created together the "corrective action plan". Nowadays, the partners are implementing this plan.

4.2 Public procurement

The public procurements have been finished in the first stage of the project. There were fully in line with procedures presented in grant application. The procedures were made by traditional way. The public procurement procedures for the project have been successfully finished without any problems.

4.3 Integrated cross-departmental working

The cooperation between the departments is very effective. The common activities, such as designing of the prototype solution (noise barrier) are in progress. In this case, the cross-departmental cooperation included not only the decision process, but also common activities connected with finding the optimal location and receiving proper formal decisions. Additionally, the negotiations with the railway company were necessary. The process required inter-department collaboration. The chosen localization required additional administrative agreements between the railway company and the city, because the noise barrier will be only 60 meter far from the national railway. As a result of negotiations, the City of Lappeenranta signed the contact with the railway company, in which the City of Lappeenranta is obliged to rebuild the noise barrier using standard materials and in traditional technology in case of collapse. This agreement was necessary for approved the investment by the railway company.

4.4 Adopting a participative approach

The participative approach is a strong side of the consortium. The project has a large number of the participating organizations form different sectors, which play different roles in the project. Cooperation between the companies and public organizations is well developed. The key players have an influence on the consortium's decisions. The most important factor that creates participating approach are regular meetings between the partners. The city well organizes this activity, including formal meetings with all consortium members as well as informal meetings between the partners, where particular challenges are discussed. At the present time, the communication is mainly provided by the Internet with using dedicated platform for the project. Additionally the supporting tools for virtual communications, such as Skype are used.

4.5 Monitoring and evaluation

The monitoring in the Urban infra revolution project is challenging, because of the size of the consortium. The city of Lappeenranta has implemented the indicators-based system to monitor and measure project's progress and task compliance. It is coherent with the indicators in the grant application. The project status is monitored periodically and the necessary data are up-dated. The last period confirms that this system works properly. Absence of proper indicators warns of the potential problems and the project's delays. Additionally, indicators are consolidated and benchmarked against best practice standards. The common database is very helpful in this area. The partners have on-line access to the up-to-date data. The reports are firstly send to WP leader (organization responsible for management in particular WP), and next main findings, problems and progress are reported to the leader of consortium by the WP leader. In case of problems in-depth analysis is implemented.

4.6 Communicating with target beneficiaries

The planned goals for communicating with target beneficiaries are achieved. The communication campaign is well coordinated and it is successfully implemented. It is a strong point of the project. However, in the situation connected with COVID-19 epidemic it became very risky area.

The project implemented complex information about undertaken activities. In this purpose there are used different media dedicated for different audience. The communication is supported by some websites. It is not only the official UIA project's website that is accessible in English and French, but also the website provided by Lappeenranta city connected with eco-friendly solution applied in the city - that is accessible in English and Finnish - as well as the information distributed through the websites of all project partners. The second point of the communication are social media. Nowadays, this source of information is particularly important for young generation. The blog with information about the project activities is provided. There are published up-to-date information and the most important fact, for example the interview with consortium members, where they show the work progress Moreover, the consortium has created 8 videos or info-graphs during the project. The supporting

material are published on official UIA website and some of them on YouTube, for example the presentation on different events for wider public. Most of materials about the project and related events have been also published in Finnish info-portals.

Besides the activities on Internet, also the traditional events for the citizens were organized, including the promotional event ending the ground works (described in chapter 3.5.). The project is actively promoted on international events, for example on the European Climate Meeting in December 2019. The Finnish parliament member - Ilkka Räsänen, who joined Holopainen in the climate summit, mentioned the project on the seminar dedicated for the scalability of research and innovation in climate change mitigation (more information: https://www.greenreality.fi/en/lprnyt/city-lappeenranta-presented-climate-summit-madrid-912)

The involved universities also promote the project in scientific society. This promotion is focused mainly on educational activities, for example through: streamed lectures, presentations on the conferences, scientific articles and even by the master thesis that were based on the first project results.

The next period could significantly influence on the activities in the area of the promotion. The epidemic situation caused the lack of possibility of organizing traditional events. The whole activity will be provided through the Internet.

4.7 Upscaling

Currently, the upscaling is the main challenge in the project. The finalization of the production and starting of construction works were previously planned in April 2020, because of the weather limitation, the first construction works should start in summer 2020. Unfortunately, because of COVID-19 epidemic situation it will be delayed. Lack of prototype solution could have a significant influence on upscaling the project idea and transfer the knowledge to a wider scale – on other regions of the country or further.

The consortium has identified the legislative barriers and started to implement the proper steps for the implementation of the new solution. The standard rules connected with product standardization and regulations cannot be directly applied for the new material.

The application the local waste or by-products, in the technology, brings large benefits for the environment, but also caused some challenges in scaling-up the solution on the international level. The effectiveness of the used technology is dependent on chemical and mineralogical composition of the raw materials (local waste or by-products resources). Because of that the scaling-up of the solution could be limited by availability of local raw materials with proper composition. They could be unavailable in other countries that have different industrials sectors. In this case, the technology will require some changes because of the new composition of raw materials (depending on the local streams of waste and by-products).

TABLE 1: MAPPING URBAN INFRA REVOLUTION AGAINST THE ESTABLISHED UIA CHALLENGES

Challenge	Level	Observations
1.Leadership for implementation	**Low**	The leadership and coordination is provided by the city of Lappeenranta. The leadership is clear, consistent and accepted by all partners. The city takes into consideration communication with all partners and regularly organizes meetings in which the progress is reported. In the last period, because of delays in the project's realization additional communication activities were implemented. The next period requires changes in the area of communication, because of the restrictions connected with COVID-19 epidemic, which caused limitation of direct contact between peoples. The project is well prepared for that. The consortium use modern ways of communication (via the Internet and files on common server). These tools enable active participation of partners in the project as well as decision making process irrespective of distance.
2.Public procurement	**Low**	The public procurement procedures predicted for the project have been successfully finished. The procurement procedure was organized in a traditional way; no innovative types of procurements were applied in this case.
3.Integrated cross-departmental working	**Low**	The cross-departmental communication in the city goes smoothly. The departments cooperate in the framework of the common initiatives, such as the prototype development. The city has established good working relationships between involved departments. The results are delivered by particular units on time.
4.Adopting a participative approach	**Low**	The consortium is characterized by effective coordination mechanisms. The consortium members know their role and support each other. Contemporary, the communication inside the consortium is applied mainly through the Internet because of governmental regulation against the COVID-19.
5. Monitoring and evaluation	**Medium**	The monitoring and evaluation procedures work properly. The problems and delays in the project are reported and the proper activities are provided. Nowadays, the works planned in this period are continuing. The progress is significant. The unexpected risk connected with virus pandemic occurred. The information about situation are properly distributed, nevertheless the situation will cause significant delays in the project activities.

Challenge	Level	Observations
6. Communicating with target beneficiaries	Medium	The communication with target beneficiaries is a very important element for successful introduction of the outcomes for the Urban infra revolution project. The Finnish society has high level of awareness and want to participate in the decision of local government. The communication with target beneficiaries is a great challenge, because each urban investment must be accepted by all inhabitants (local legislation). The planned goals for communicating with target beneficiaries have been achieved on time till this moment. The communication campaign was well coordinated and it was provided successfully. It is a strong point of the project. However during COVID-19 epidemic it became very risky area. The communication is implemented by various media. The detailed description is presented in point 4.6. The communication with the target users will be one of the most important challenges in the next period of the project implementation. Further informative activities are required to be focused online and other virtual media. It is necessary because of the epidemic situation.
7. Upscaling	High	The most important challenges are connected with upscaling the technology during the pandemic. The preparation of the prototype and research could be very hard because of the limitation connected with virus epidemic. It could be impossible to reach deadlines. Another challenge is connected with law regulations for new construction materials and new technology for manufacturing the final product. The existing product standardization and regulations cannot be applied directly. The steps necessary for legalization of the material and technology have been identified and are under the implementation. The required tests for the material and product will be carried out in the next periods. It will be the background for the product acceptance procedure.

5. CONCLUSIONS AND NEXT STEPS

The article reviews the key activities that took place in the last months in the Urban infra revolution project. The article stress overall positive consensus for all project activities. Nowadays, the significant progress in the project, since October 2019 has been reached. Contemporary, the project will expected some problems with the project implementation according to schedule because of introducing limitations by the Finnish government caused by pandemic situation.

Firstly, the project delay will be linked to the COVID-19 situation. The regulation connected with controlling the epidemic situation also influences the project implementation. The main task connected with building prototype in the next period could be impossible to finalize. Secondly, the implementation of other planned products, such as elements of small architecture dedicated for rest places for citizens, especially pots and benches, as well as skate park, will be impossible in that short period. Eventually, the pandemic situation requires also changing the management procedures connected with consortium activities. The next period will require a lot of efforts and close cooperation from all consortium members.

Urban Innovative Actions (UIA) is an Initiative of the European Union that provides urban areas throughout Europe with resources to test new and unproven solutions to address urban challenges. Based on article 8 of ERDF, the Initiative has a total ERDF budget of EUR 372 million for 2014-2020.

UIA projects will produce a wealth of knowledge stemming from the implementation of the innovative solutions for sustainable urban development that are of interest for city practitioners and stakeholders across the EU. This journal is a paper written by a UIA Expert that captures and disseminates the lessons learnt from the project implementation and the good practices identified. The journals will be structured around the main challenges of implementation identified and faced at local level by UIA projects. They will be published on a regular basis on the UIA website.

Urban Innovative Actions

Les Arcuriales
45D rue de Tournai
F- 59000 Lille

+33 (0)3 61 76 59 34
info@uia-initiative.eu
www.uia-initiative.eu

Follow us on **twitter**
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and on **Facebook**.