



Mixed reality for public participation in urban and public space design

Towards a new way of crowdsourcing more inclusive smart cities

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Introduction

The contemporary world is both urban and digital. More than half the world's population live in cities and more than half of the world's population is connected to the internet. There are nearly as many mobile phones as people in the world and the gap is rapidly narrowing. These two mega trends of urbanisation and digitalisation, if harnessed well, present a great opportunity to contribute to sustainable development.

The Sustainable Development Goals (sometimes called the 2030 Agenda), adopted by UN Member States in 2015, are a comprehensive agenda outlining how the world can achieve a sustainable future through 17 inter-connected goals. Goal 11 on sustainable cities and communities highlights the importance of adequate housing, participatory urban planning and inclusive public space, amongst other targets.

The New Urban Agenda, adopted by UN Member States in 2016, outlines the global principles, policies and standards required to achieve sustainable urban development. In the New Urban Agenda, Member States commit to adopting a 'smart-city approach that makes use of opportunities from digitalisation'. They also call for the promotion of citizen-centric digital governance tools, the use of digital platforms and tools for improved, long-term integrated urban and territorial planning and design and for businesses to apply their creativity and innovation to solving sustainable development challenges.

For frontier technologies and innovations to effectively contribute to urban sustainability, they need to be appropriately applied to ensure that the prosperity they bring is shared amongst people, cities and regions. An inclusive smart city must be realised by a wide array of actors, and UN-Habitat is increasingly playing a role in this process through the integration of new technologies and innovative practices. Ultimately, the deployment of frontier technologies needs to pay special attention to underserved populations, in order to address inequalities and to bridge social and spatial divides.

Mixed reality, the technology explored in this report, holds tremendous potential for real-time digital visualisations, both at the street and neighbourhood level and the overall urban skyline and city grid. This new visually realistic blending of reality with virtual imagination can create a more intuitive space for planners, architects, residents and other stakeholders to viscerally experience and re-imagine future environments. Architectural sketches and designs can be made more legible and accessible, thus pulling users into the process of design and strengthening the long-term viability and buy-in of urban projects.

Mixed reality technology offers the opportunity to bridge the divide between inhabitants and their cities, making change literally appear before their eyes and giving entire neighbourhoods the chance to weigh in on how their future smart city will look, feel and serve their needs. Mixed reality can help to take conversations about urban design to people in the streets and thereby better include their actual needs and desires in the process.

This project shows how innovative and multi-sectoral partnerships can contribute to the global debate on the democratic and inclusive smart city and how frontier technologies can make a positive impact on sustainable development. We encourage those developing new technologies to apply their creativity and innovation capacity to solving sustainable urban development challenges.

About this report

This report was produced by UN-Habitat in partnership with Ericsson. UN-Habitat and Ericsson have been collaborating since 2014 on applied research projects which explore ways that frontier technologies can contribute to the development of inclusive, accessible and sustainable cities and provide valuable insights for city leaders and policymakers. The topics in the applied research projects have been wide-ranging, including the use of sensor networks to manage water infrastructure in informal settlements, how innovation challenges can bring youth groups, technology hubs and decision makers together and the use of technology for monitoring urban air quality. Recently, the focus has been on the role of digital technologies in public participation.

In this project, a group of UN-Habitat urban planning staff worked with designers and researchers from Ericsson to develop and test use cases in which mixed reality was used for stakeholder engagement and public participation in public space and urban design processes. The report follows two years of research and technology tests in two contexts. A first pilot was carried out in Johannesburg, South Africa in September 2017 as part of participatory design process in a 'Block by Block' workshop. Block by Block is a public participation methodology which uses Minecraft as a tool to enable residents to co-design public spaces. A second pilot was carried out in Stockholm, Sweden in September 2018 to further investigate digital interactions linked to placemaking and public spaces. An Expert Group Meeting, bringing together architects, urban planners, technologists, designers, artists and civic engagement specialists to

discuss the potential of mixed reality for, urban planning and design, was held in Stockholm in September 2018.

The views on mixed reality that have come out of this research are wide-ranging, but there is a general sense that although the technology is still in its infancy it holds a lot of promise in many fields. These include urban development, but also areas such as arts and culture - which is often articulated in urban environments. However, whilst many opportunities exist, there are also risks and challenges associated with this kind of technology, including information overload, privacy concerns and increased conformity. We look forward to exploring the potential of mixed reality in the coming years.



Executive summary

“Globally, some 60 percent of the area expected to be urban by 2030 remains to be built... estimated corresponding infrastructure investment needed stands at USD 3.7 trillion per year until 2050.”

- World Economic Forum

With two-thirds of the world's population expected to live in urban areas by 2050, cities and communities are under increasing pressure to address urgent environmental, social and economic challenges. The Sustainable Development Goals and the New Urban Agenda acknowledge that participatory urban planning and inclusive public space are top priorities in cities and human settlements.

Frontier technologies can help bridge the gap between residents and policymakers and improve political outcomes. By focusing the use of new technologies on public participation, stakeholder engagement and inclusive urban planning, it can be possible to approach the smart cities field from a different perspective, one that places people at the centre and uses technology to ensure that our future cities are compact, connected and integrated.

This report is based on more than two years of research by a team of UN-Habitat urban planners and Ericsson researchers and innovators, into a brand-new technology – mixed reality – and how it can be combined with gamification to connect urban residents with each other and their local policymakers. Many people lack a direct connection to their

community's development. Creating inclusive and participatory urban design technologies could lead to building cities that work and that people want to live in.

Future mobile networks, cloud-based services, more powerful mobile devices, sensors, big data and analytics all present a huge opportunity for cities to enable new ways to engage with citizens. This ongoing shift is also a unique opportunity to introduce advanced technologies at the grassroots level, and to help the world's cities that have lagged behind in terms of physical and technological infrastructure to leapfrog and find an alternative way forward.

The speed and scale of urbanisation requires local governments to meet accelerated demands for services, including basic infrastructure, housing and high-quality public space. Developed countries are anticipated to need to double their amount of urban space by 2050 to accommodate the expected inflow of newcomers, whereas developing countries will need to expand their urban space by more than 300 percent. This is equivalent to building a city the size of Greater London every month for the next 40 years. Local governments will have to manage this growth and the severe strain it will put on municipal finances.

UN-Habitat is committed to addressing this key challenge: socially and environmentally sustainable urban planning with an eye to inclusion. This goes beyond traditional urban planning as such to include the interests of citizens more holistically and integrate them into the fabric of urban development. To achieve this, urban planners need to consider

the needs, interests and knowledge of different stakeholders. The World Economic Forum estimates that each year until 2050, \$3.7 trillion needs to be spent to upgrade urban spaces to meet the demands of urbanisation. How these resources are spent will be a critical component to the carbon footprint of our cities and their impact on global climate change.

A well-planned and inclusive smart city is one where people have to move around less, decreasing carbon emissions and pressures on public transport and the formal and informal mobility infrastructure. To achieve the tricky balance between density and overcrowding, cities must provide high-quality public spaces that are human in scale, sustainable, healthy, safe and accessible. Once a city is already designed and built, its land use patterns and physical infrastructure can be locked in for generations.

As a technology and research partner, Ericsson was enthusiastic about exploring potentially innovative and new use cases for their current and future technologies. By engaging with UN-Habitat, cities and other stakeholders in a complex design thinking research process, the research team was able to take the technological research to contexts where people eventually will be using it. This way of engaging with society and exploring and developing use cases together with stakeholders increases the relevance of technology and results in overall better technology outcomes.

The questions Ericsson and UN-Habitat posed in this project will remain relevant in any urban environment: how can next generation

mobile networks be used for the public good and to develop quality public spaces? How to address access and equity issues as well as infrastructure and design challenges? The researchers, after initial explorations, took their ideas to the streets in two very different cities – Johannesburg and Stockholm.

Mixed reality is a new technology that enables visual experiences where physical environments and digital objects coexist and interact with each other in a realistic way. In practice, this means you can look through a mobile phone or other device and see digital objects and models as if they were really there. Existing augmented reality applications like the game Pokémon Go, are only the beginning of what will be possible with this technology. This has the potential to fundamentally change the way that people interact with digital information. Within the context of urban planning and design, could mean experiencing the feel of planned buildings, public spaces or streets that do not yet exist.

The results show that although the technology is still in its infancy it holds a lot of potential, including making architecture and urban design more digitally-enabled. Mixed reality could make it possible to present different design alternatives to various stakeholders in more visual and non-technical ways. It can help give urban designers the right insights by giving stakeholders a way to move from desktop experiences to lived experiences and it could help crowdsource design alternatives in a visual way.

When considering the rollout of these kinds of new technologies, cities need to be prepared in terms of regulations, governance frameworks and technical capacity. Adherence to digital rights, including universal access to digital technologies, privacy and data protection, transparency, abidance by open and ethical data standards and a commitment to democracy, diversity and inclusion are crucial if we want to ensure an inclusive digital future. Many local governments need to strengthen their capacity to effectively govern, procure and deploy frontier technologies.

Underscoring these commitments to using technology to serve the underserved, the United Nations has long recognised the importance of cities and communities to sustainable development. The 2030 Sustainable Development Agenda includes Goal 11, "Make cities and human settlements inclusive, safe, resilient and sustainable." This calls, in Target 11.3, on Member States to enhance capacity for participatory, integrated and sustainable urban planning in all countries. For sustainable development to take hold, urban planning and design needs to take centre stage to proactively meet the coming environmental, social, economic and technological challenges. By using an updated and well-functioning urban planning model, regions and cities can develop in an integrated way. This means that policies, projects and proposals are considered in relation to each other.

The New Urban Agenda highlights integrated urban planning as a way to optimise the positive effects of urbanisation. It encourages effective collaboration amongst all stakeholders,

including local governments, the private sector and civil society and specifically calls on the private sector to apply their creativity and innovation to solving sustainable development challenges in urban areas. It also calls for member states to use information and digital technology to make urban planning more accessible to citizens and to engage them throughout the design process. The nexus where urban planning and design, citizen participation and digital technologies converge requires often very different stakeholders to collaborate to work together to achieve common goals. As there is no one solution to these issues, all partners bring a unique perspective and expertise to tackling urban crises.

Mixed reality technology offers the opportunity to bridge the divide between citizens and their cities, making change literally appear before their eyes and giving entire neighbourhoods the chance to weigh in on how their future smart city will look, feel and serve their needs.





Participatory process as part of the development of the Johannesburg Spatial Development Plan © UN-Habitat



Chapter 1

Making the smart city
more inclusive and
participatory

What will the city of the future look like? This has been the focus of an applied research project between UN-Habitat, the UN programme for sustainable cities and human settlements, and Ericsson, the network technology company.

The partnership between UN-Habitat and Ericsson is an unusual one for both. For UN-Habitat, it has provided a unique opportunity to collaborate with a technology partner to explore how frontier technologies and innovation can contribute to sustainable urban development and how smart cities can be made more integrated and inclusive. For Ericsson it has provided opportunities to improve the quality and increase the relevance of new technologies under development based on a better

understanding of global challenges and through testing use cases in real situations.

The ultimate goal was to develop technology that could be used for inclusion, which is right in line with UN-Habitat's vision of a creating a better quality of life for all in an urbanising world and Ericsson's purpose to empower an intelligent, sustainable and connected world. Ericsson wants to combine its strong technology development approach with an integrated corporate sustainability strategy and the mission to be a responsible and relevant driver of positive change. UN-Habitat wants to understand how innovation and technology can contribute to transformative change in cities and human settlements. Both organisations are committed to achieving the Sustainable Development Goals.



Project — Mobility and air quality:
Placemaking activities to exemplify and discuss alternative use of public spaces.



Project — Mobility and air quality:
Discussing with stakeholders around the use of sensors to monitor the impact on air quality.

In the New Urban Agenda, recognising the potential of digital technologies to contribute to urban sustainability, Member States commit to “adopting a smart-city approach that makes use of opportunities from digitalisation, clean energy and technologies”. But what exactly is meant by a ‘smart city’? A 2017 review of smart city strategies by Future Cities Catapult makes an attempt to provide a history, presenting “three waves” of smart city development. According to this review, the smart city concept was initially developed by a few major technology companies as a way to market technology to city governments. This ‘first wave’ of smart city development often focused on large scale technology systems related to energy, water and transportation, but few of these projects reached scale beyond the pilot phase. In the second wave of smart city development, we saw a move away from the focus on technology systems towards a stronger consideration of the needs of people and how technology can deliver services to them. This attracted more interest from local governments and we saw a growth in open data portals, innovation labs, civic engagement platforms and hackathons. In the current, ‘third wave’

we are seeing digital technology companies focused on consumers increasingly using cities as platforms to deliver a range of consumer services in transportation, housing and food.

However, the rapidly evolving smart cities field is in many cases still driven by top-down application of technologies. This technology focus and lack of interest in urban fundamentals including good governance, planning and design can lead to city visions based on an outdated, modernist and unsustainable approach. In addition, many smart city projects do not sufficiently take into consideration the needs of people and how they experience the city around them. Bringing together smart cities with public participation, stakeholder engagement and a focus on inclusive urban planning and design provides an opportunity to approach the field from a different perspective, one that places people at the centre and considers how cities can be designed to be compact, connected and integrated.

Research, for example by Maria Conroy and Jennifer Evans-Cowley, in an examination of over 500 municipal planning websites, indicates that digital technologies can offer new ways to engage people and improve the quality of political deliberation and decision making. It also shows that digital visualisations may help build shared understanding and facilitate interaction amongst residents and government. There are many examples of participatory data collection, mapping and e-government initiatives. In the publication *From Urban Data Collection to Urban Design*, UN Global Pulse describes 24 participatory urban design initiatives, including UN-Habitat's Block by Block methodology. These kind of initiatives should be mainstreamed in order to add a bottom-up approach to the smart cities field that considers the way that people and institutions are affected by, and relate to, technological disruption and to the urban environment around them.

With this as background, UN-Habitat and Ericsson have the ambition of articulating an alternative to urban technology visions that focus too much on the role of technology in optimising technical infrastructure and systems or enhancing productivity. Instead, the project team wanted to understand how digital technologies can contribute to a broader notion of urban prosperity, including facilitating dialogue between different stakeholders, engaging and informing various actors, showing needs and ownership of urban regeneration and helping identify alternative paths of action. In this vision, technology becomes an enabler to articulate a broader vision of sustainable development.



Project — Equitable water distribution:
Using water sensors and shared data to better understand the effects of rationing schemes.



Project — Equitable water distribution:
Working together with the local community to crowdsource maintenance of connected infrastructure.

Mixed reality - visualising 3D digital content in the real world

The UN-Habitat and Ericsson technology explorations eventually led to a project to test how mixed reality, a new visual technology which enables the blending of virtual and physical worlds. Through this technology, it is possible to view the urban environment not only as it currently is, but with proposed new plans and designs superimposed on top of reality in 3D.

The New Urban Agenda in various paragraphs calls for the effective participation of local communities and vulnerable people in urban and territorial development and asks for citizen-centric digital governance tools and digital platforms and tools that improve long-term integrated urban and territorial planning and design. But how can that be achieved in practice? Mixed reality is one digital technology that has the potential to contribute to this vision.

By blending visualisations of the 'future city' with the 'current city', people can get up close and personal with 3D simulations of future plans. By doing this, new ways of understanding of how the city may change over time open up. Seeing proposed new plans or designs of urban environments as if they were really there, as opposed to as 2D drawings or plans, makes them easier to understand by people who are not trained architects or urban planners. This creates a new channel for professionals to engage with non-professionals, including both residents and stakeholders such as local government policy makers. The use of technology can make the design of the city more open and transparent.

When interacting with 3D urban design models in a new visual way, people may also be able to understand experientially the trade-offs involved in public planning and the way that different institutions and stakeholders may react to them. For instance, should a parking space be turned into a community garden or a bus stop? What are the resources required for each alternative and what is the opportunity cost for not doing something? Residents can start to understand the decision-making and what's behind the options - what they will gain and what they will give up if they make a particular choice. Given that youth in particular aren't reading source material as much and have little experience with a 2D maps, 3D models can bring home the spatial realities of their neighbourhoods in new and visceral ways.

Although architecture firms, the military and other industries have been looking at mixed reality for employees and customers for a whilst, this project takes this innovation to the public domain. It explores the next generation of inclusive city-scale mixed reality technologies that could give non-specialists a visual language with which to communicate with specialists, bridging a gap that has proven difficult to overcome historically.

The mixed reality technologies discussed in this report have been researched and shaped with the real world in mind. In conversations with residents and other stakeholders, a number of intriguing mixed reality concepts for public participation and urban design emerged, which were then prototyped and piloted in a series of technology explorations. Based on these, it became clear that mixed reality is at the cutting edge of technology innovation and will be powered by the capabilities of future mobile networks. Mixed reality has the potential to articulate the role emerging technologies can have to address global grand challenges.

Human-centric and design-driven innovation

The research activities and projects in the partnership between Ericsson and UN-Habitat are based on methods that have much in common with 'design thinking'. Design thinking is a human-centered creative approach to innovation, which draws from the designer's toolkit to integrate the needs and desires of people, the feasibility of technology and the viability of businesses. Design thinking is characterised by a curiosity to understand people, different disciplines and a desire to create something new.

In spite of the name, design thinking is also very much a practice, with the thinking inseparable from the doing. It involves putting innovations into use, testing assumptions through rapid prototypes, verifying feasibility through proof of concepts and taking the technological research to the context where people eventually will be using it.

The innovation projects in the partnership between UN-Habitat and Ericsson have all been guided by the above elements of design thinking. However, these design principles have also been applied to redefine how global challenges are approached and to identify opportunities for action within complex areas, such as sustainable urbanisation. This way of addressing systemic change and broader societal outcomes has much in common with strategic design and the projects have been as much about cultural and organisational innovation as about technical innovation.



Colonia Doctores urban planning and design project, Mexico City © UN-Habitat Urban Lab



CHAPTER 2

Urban planning, design
and public space for
sustainable urbanisation

The importance of urban planning and design

In recent years, the importance of urban planning and design for sustainable development has become increasingly recognised. The Sustainable Development Goals call for participatory and integrated urban planning in all countries as part of Goal 11. In the New Urban Agenda, Member States commit to “implementing integrated planning and promoting planned urban extensions, prioritising renewal, regeneration and retrofitting of urban areas, including the upgrading of slums and informal settlements, providing high-quality buildings and public spaces, promoting integrated and participatory approaches that involve all stakeholders in order to avoid segregation.”

UN-Habitat has developed an integrated approach to urban planning and design that helps city leaders achieve sustainable development by helping to formulate medium- and long-term objectives that reconcile a collective vision and the resources to achieve it. In UN-Habitat’s *A New Strategy for Sustainable Neighbourhood Planning: 5 principles*, urban design and planning are integrated to ensure socially mixed, high-density neighbourhoods with an efficient street network and limited land-use specialisation. The purpose is to use planning and design to create more integrated, mixed and dense cities - in which people from different backgrounds live together, where it is not necessary to travel long distances from home to work and where non-motorised forms of traffic become the norm.

This approach requires an integrated plan based on the insights of multiple stakeholders.

In UN-Habitat’s vision, urban planning is more than a technical tool - it is an integrative and participatory decision-making process that addresses competing interests and is linked to a shared vision, an overall development strategy and national, regional and local urban policies. This can help cities be better prepared and to channel and manage growth proactively. Cities can increase their impact by implementing demand-led plans in which residents and all stakeholders are involved.

Urban planning makes the most of municipal budgets by informing investments in infrastructure and services and balancing demands for growth with the need to protect the environment. It also distributes economic development within a given area to reach social objectives and creates a framework for collaboration between local governments, the private sector and the public. It helps local governments address spatial and economic inequality and make plans to reduce emissions and deal with the effects of climate change.

Urban design considers people’s experience of their environment and how they interact with their block, their neighbourhood and their city as a whole. Urban design looks beyond the construction of a city, towards the framework that orders the holistic design and interdependence of buildings, public spaces, transportation systems, services and amenities. Architecture, landscape architecture and city planning all come together to make cities not just more useful and functional, but liveable and engaging. Residents can have a complicated relationship with their city, but quality urban design bridges the gap between how people feel at home and move about their world. Central to urban design is stewardship of the urban environment, with an eye towards social equality and economic opportunity over the long-term. Having people feel at home in their city helps ensure they engage in its future, and

good urban design can foster this sense of identity and belonging. Good policy is always helpful, but without design and planning, it is harder and takes longer to leverage a city's full potential.

Public space and the inclusive city

It has been widely shown that dense, inclusive and connected cities are more likely to be environmentally sustainable, for example by David Owen in his book *Green Metropolis*. However, in order to support high levels of density without being overcrowded, cities must provide high-quality public spaces that are human in scale, sustainable, healthy, safe and accessible. Well-designed and managed public spaces are a key asset for a city and have a positive impact on its economy. Investment in public spaces contributes to improved health and well-being, reduces the likelihood and impact of climate change, encourages people to walk and cycle, increases safety and reduces fear of crime. Public spaces improve residential neighbourhoods, safeguard property values, make them more attractive to tourists and increase retail activity.

Public space is a vital ingredient of successful cities. Small public spaces are priceless, as they can build a sense of community and create a safe and secure environment for everyone, including men, women, young people and older people. Such public spaces contribute to the building of social capital, encourage economic development and strengthen communities. Having access to public space improves quality of life and is a first step towards civic and economic empowerment and opens opportunities for greater institutional and political engagement. Public spaces can

also contribute to improved environmental conditions by improving air quality, reducing the heat island effect and sequestering carbon.

Urban planning is key to defining the separation between public and private space. This action has a lasting impact and cannot be easily changed. Creating public space in an already developed area requires complex expropriation programmes which can be expensive. Planning for public space ahead of urban growth may achieve at least similar results but at a fraction of the cost. A clear delimitation of public and private space can address encroachment issues and occupation of street spaces.

UN-Habitat's Global Public Space Programme advises national and local governments working on the issues of public space strategy and design. Its mandate is both normative and operational and includes the upgrading of existing public space, public works and neighbourhood regeneration, in collaboration with local governments. The public participation elements of UN-Habitat's design philosophy came about with the realisation that actual upgrading of existing public spaces, as is often the case in major world cities that have already been built up, requires public input to be truly inclusive and sustainable.

Mixed reality for public participation in urban and public space design



City-wide public space assessment in Wuchang, China © UN-Habitat

The five Principles of Sustainable Neighbourhood Planning

A major feature of fast growing cities is urban sprawl, which drives the occupation of large areas of land and is usually accompanied by many serious problems including inefficient land use, high car dependency and a high level of segregation. Coupled with land use speculation, current models of city growth result in fragmented and inefficient urban space where urban advantage and city concept are lost.

To become sustainable, cities need a different urban structure and design, moving from sprawl and segregation towards integration and connection. In UN-Habitat's five principles of sustainable planning, design and planning interact to ensure that urban areas become more inclusive and connected. Designing high-quality streets, public spaces and buildings are crucial in order to achieve comfortable high-density neighbourhoods.

The Five Principles are:

1. *Adequate space for streets and an efficient street network.* The street network should occupy at least 30 per cent of the land and at least 18 km of street length per km².
2. *High density.* At least 15,000 people per km², that is 150 people/ha or 61 people/acre.
3. *Mixed land-use.* At least 40 percent of floor space should be allocated for economic use in any neighbourhood.
4. *Social mix.* The availability of houses in different price ranges and tenures in any given neighbourhood to accommodate different incomes; 20 to 50 per cent of the residential floor area should be for low cost housing; and each tenure type should not be more than 50 per cent of the total.
5. *Limited land-use specialisation.* This is to limit single function blocks or neighbourhoods. Single function blocks should cover less than 10 percent of any neighbourhood.



<https://unhabitat.org/a-new-strategy-of-sustainable-neighbourhood-planning-five-principles/>



Using Minecraft as a participatory tool for public space design in Palestine © UN-Habitat



CHAPTER 3

Stakeholder
engagement and the
potential of digital
technologies

Inclusion and public participation

To create more inclusive and sustainable cities, urban planners need to consider the needs, interests and knowledge of different stakeholders. This requires collaborative design and decision making processes where decision makers work together with residents and other stakeholders to address public problems and find solutions. Collaboration is important to provide decision makers with the collective knowledge, ideas and expertise of the population.

In many cases, however, public policies and plans are not developed through participation and deliberation but through the technical expertise of public officials. Often, when deliberation occurs it is often biased towards more powerful stakeholders with greater resources. To effectively solve urban planning and design challenges, collaborative forms of governance ensuring the exchange of resources, democratic inclusion, joint ownership and synergies between various public, private, and civil society stakeholders can have a positive effect. This means that information should not only flow from government to residents, but also from residents to the government.

Participatory outcomes are often aspired to, but hard to implement in practice. Involving multiple stakeholders is challenging and requires considerable planning and preparation. In economically distressed communities in particular, residents are often challenged by competing pressures to earn a living whilst higher-order needs for engagement in city governance can often take a back seat.

Involving people who are not trained in spatial thinking, reading maps or drawing — likely to be the case in marginalised communities — can also be particularly challenging. Using different communication and engagement methods can be a useful way of lowering barriers to entry, particularly for underrepresented segments of a population.

Urban planning and 'wicked problems'

Many contemporary urban problems, such as social exclusion, marginalization and environmental depletion, are inherently 'wicked' – a concept coined in 1973 by Rittel and Webber, two urban planning and design researchers at Berkeley. Rather than being single problems, wicked problems are best understood as a confusing mess of interrelated problems which are difficult to define, ambiguous in character and often contested.

The following can characterise wicked problems:

- There is no formal definition of a wicked problem.
- With a wicked problem, the search for solutions never stops. It has to be continuously addressed and re-solved.
- Solutions to a wicked problem are not true or false, but good or bad, and largely a matter of judgement. In comparison, solutions to ordinary problems can be objectively evaluated as right or wrong.
- A wicked problem is always a symptom of another problem. Whilst an ordinary problem is self-contained, a wicked problem is entwined with other problems.
- Often there is no one root cause but the issue's roots are complex and tangled.
- Many wicked problems present challenges which have no precedent.

It is widely recognised that wicked urban challenges cannot be effectively tackled with standard policies or monocentric processes. Instead, conventional planning, which often revolves around a predefined option, can create polarisation amongst stakeholders and may even exacerbate social conflict. Traditionally, the quality of urban planning was associated with the extent of expert knowledge embedded in spatial plans and other planning documents.

Experts would model water flows, traffic volumes, wildlife migration or housing demands to produce rational and effective plans. Yet, over the last two decades the credibility of such planning practices have been called into question as models and simulations have often failed to resolve sustainability challenges.

This has led some researchers and planning experts such as Judith Innes and David Booher to adopt a social constructivist planning perspective (as in the journal *Landscape and Planning* in 2016). In this perspective, urban planning is recognised as being as much about process as about content. Following this, there is an urgent need for new approaches and tools that can improve the quality of the processes in which urban visions and plans are created and implemented. Increased public participation is an important means to envision alternative futures and enhance urban sustainability. Yet current public participation methods have seldom achieved genuine participation in planning or other decisions. As emphasised by Innes and Booher in this research: "they do not satisfy members of the public that they are being heard; they seldom can be said to improve the decisions that agencies and public officials make; and they do not incorporate a broad spectrum of the public. Worse yet, these methods often antagonise the members of the public who do try to work with them."

In order to solve wicked urban challenges there is a need for new collaborative forms of interaction between various public, private and civil society stakeholders. Public participation in the planning process is vital to provide government with the collective knowledge, ideas and expertise of the population. New

The potential of digital technologies to strengthen public participation

ways of facilitating this interaction and breaking down barriers, such as using new technologies, may be a useful way of improving the quality of decision making.

The Sustainable Development Goals emphasise the need for inclusive public participation in the design of infrastructure, urban space and services to promote sustainable urbanisation. With the adoption of the Agenda in 2015 there is now a global commitment to not only promote but make sure that participatory planning becomes the norm when upgrading and building the cities of the future. There is also global recognition of the fact that public participation is critical to ensure that cities are inclusive, safe, resilient and sustainable.

The World Development Report 2016, Digital Dividends, argues that digital technologies can “provide new platforms for citizens to engage with the government, lowering the costs to citizens of providing information, and enabling policy makers and service providers to seek information and track the feedback loop.” UN-Habitat’s research, summarised in the report *ICT, Urban Governance and Youth*, shows that ICT use by youth can indeed have a direct impact on increasing civic engagement, giving them new avenues through which to become informed, shape opinions, get organised, collaborate and take action.

Digital technologies can be used to communicate technical information to enhance understanding, provide public access to information that was previously only available to experts and officials, to crowdsource information and feedback directly from the public and make it publicly available. They are also useful for visualising ideas, thus promoting shared understanding and facilitating interaction between residents and government.

However, whilst the potential of digital technologies to improve public participation remains, positive impacts are unevenly distributed. As outlined in the World Bank report, whilst digital technologies have spread rapidly across the world, what they call ‘digital dividends’ - the broader development benefits from these technologies - have often lagged behind. To more broadly share the positive effects of the digital revolution, requires the closing of the remaining digital divides, especially in internet access.

This raises a concern that high-tech approaches to public participation (for example e-government platforms) tends to favour higher income, more technologically savvy residents, whilst inadvertently further marginalising those who lack internet access or technology skills. Whilst it is clear that digital technologies can help increase levels of participation, efficiency and accountability in public urban policies, the tools must be appropriately used, accessible, inclusive and affordable. Particular focus must be placed on digital inclusion, skills development and bridging the digital divide.

One successful example of using digital technologies to strengthen public participation is Block by Block. This is the collaboration between UN-Habitat, Mojang and Microsoft that uses Minecraft, the popular video game, as a co-creation tool as part of a process to engage the public in the design of public spaces. One of the strengths of Minecraft is that it is very easy to learn - even by people with no previous digital skills. Experience from projects in Africa, Asia and Latin America, including in informal settlements, shows that almost anyone - young, old, educated or not educated - can use the tool to start sketching digitally within a few hours.

By using using a simple 3D design tool such as Minecraft, it may be possible to break down the digital divide and the skills gap, thus facilitating a more equal dialogue between experts and non-experts. Evaluations show that it increases understanding of different perspectives, builds social capital and trust and reduces the 'us/them-thinking' and strengthening 'we-thinking'.

It also gives people a visual language with which to communicate to the experts in the field.

Successful urban planning and design projects need to involve multiple stakeholders on many levels. One side is of course public participation, but it is also important to bring together people with different professional experiences. These include technical experts such as architects and planners, but also business owners, decision makers and service providers. This is a complex governance issue that cities need to find good ways of solving. Design and technology have the potential to enable dialogues around the common good, but currently many smart city projects are disconnected from the people that are impacted by the technology and often fail to consider the digital divide. Public space, which everyone has access to, presents an opportunity to engage a wide range of stakeholders and interests and serves as one suitable context for technology enabled dialogues.

Going forward it will be crucial to use digital technologies in ways that enable a diversity of people to imagine new futures for our 21st century cities, and enrich urban planning and governance with up-to-date understanding of the interaction between the lives of residents - especially the most marginalised - and urban challenges.

Block by Block

Block by Block, originally launched in 2012 as a collaboration between UN-Habitat and Mojang, the company that makes Minecraft, is an approach that uses Minecraft as a participatory tool in the design of public spaces. Minecraft is one of the world's most popular video games and is best described as a kind of digital Lego in which players place various coloured blocks in a three-dimensional environment with the purpose of building creative structures such as buildings or cities.

UN-Habitat has used the Block by Block methodology in public space upgrading projects in more than 35 countries and territories, including Nigeria, Kenya, South Africa, Peru, Mexico, Haiti, Nepal, Bangladesh, India, China and Kosovo. In workshops, UN-Habitat and partners bring people together to visualise their own public space design ideas in Minecraft and present these to city officials. The Minecraft designs are then used as part of the process of implementing real public space improvement projects.

Using technology as a participatory tool in urban planning and design in this way is a useful way of including non-traditional stakeholders in bottom-up decision making processes. The lessons and experiences from using Minecraft show that it is a good way of including youth, women and girls in planning processes from the onset. The game promotes creativity, innovation and visual learning, helps encourage dialogue between different groups and contributes to the development of important skills such as collaboration, public speaking and negotiation. In 2016, the Block by Block Foundation was set up by Mojang and Microsoft to support public space implementation and participatory processes.



Brainstorming session at Vukuhambe special school © UN-Habitat



Presentation of group ideas during the Block by Block workshop in Seferihisar, Turkey



Playing on Minecraft: Tunnel lighting to improve visibility, Vietnam © Love Strandell

The long-term impact of technology on cities

Laura Petrella, Leader, City Planning and Design, UN-Habitat



“Cities are grappling with these technologies and how to make good use of them. They want to have the confidence that they are going to deliver something positive that is not just another layer of complication that they have to manage.”

The role of technology in urban development, according to UN-Habitat’s Leader of City Planning, Laura Petrella, needs to be much better understood from a long-term impact perspective. “We need to appreciate the impact that some of these technologies can have on the form of the city. Important innovations from previous eras, for example the elevator and motorised transport, fundamentally changed the cities of the time and have had a long-lasting impact that remains to this day. These new technologies will probably change the nature of today’s cities in ways that are not yet well understood.”

The virtual nature of the current transformation, she says, “open up many possibilities, but also risks that we need to follow very closely to ensure that we get the outcomes we want. No one currently knows how technologies such as mixed reality or drones or autonomous vehicles will change cities, but for sure they will have impacts that need to be considered by policy makers.”

UN-Habitat’s collaboration with Ericsson, therefore, is important for both. “It is a very smart way of conducting a market study. Ericsson worked with us to create opportunities to understand more about these potential frontier technologies and their impact on society. This provides an opportunity for us to understand how new technologies will impact the cities of the future. We can also represent a proxy of certain interests or points of view,

and this gives us an opportunity to influence the direction that the development of the technology takes. There are a lot of synergies we can still develop.”

Participatory design, combined with technology, can be “an entry point to bend the technologies to the problem that we want to solve - not the opposite, when the technology creates its own logic. It’s crucial that we take a big picture perspective in these kinds of partnerships.” Considering how the technology will be used from the outset, says Laura Petrella, “will create more opportunities once the technologies are deployed in urban environments.”

Over the longer term, challenges remain. “These kinds of technologies are already changing the way that cities are governed. Consider, for example, the whole debate about the sharing economy and the effects it’s having on society - mainly in cities. But cities are rarely consulted, particularly in the Global South. What are the consequences of faraway decisions on their situation?”, Laura says.

Smart cities, she feels, is an area which requires a more humanistic approach. “It is a very technology-driven system, smart cities - not people-driven. There isn’t enough discussion. The technology arrives and people and institutions are expected to adjust somehow. It can be quite disruptive, but not participatory. We need a discussion on possible scenarios, which technology to develop and the relevant use of that technology.”

Ultimately, she says, the impact of emerging technologies and how cities relate to them is becoming increasingly important. UN-Habitat will continue to collaborate with different organisations in this area, as “it is really bringing two worlds together that are not very compatible normally, with not many points in common. The partnership with Ericsson took a lot of time to establish, but thanks to our team exploring different options and spending time trying to understand what the possibilities are, it is now clear and well established. This collaboration is very different to the kinds of projects we normally do - it’s a combination of research, development and collaboration all at the same time, with a lot of co-creation thrown in. It is a very interactive process, often surprising, and inspiring”.

“Cities are grappling with these technologies and how to make good use of them. They want to have the confidence that they are going to deliver something positive that is not just another layer of complication that they have to manage. If we can demonstrate that, and make good applications, that can be very important for the technologies, the cities and the people that will use them.”

100 Whitfield Street



Fitzrovia Cycling Group

04

Garden + Bike Hub



Bike Hub



Planting



Seating



Toolshed

"We love the garden idea, and have added bike storage to increase local cycling capacity."



5 C



Viewer

Designer

Future mixed reality: A vision of a future city-scale mixed reality experience on a thin client enabled by 5G and edge computing © ARUP

CHAPTER 4

Mixed reality -
what is it?



New types of digital experiences in the physical world

A widely used definition of mixed reality is that it is about new visual experiences where physical environments and digital objects coexist and interact with each other in a realistic way, blending the real and the virtual. In practice, this could mean looking through a mobile phone, or in a not too far away future when the technology has matured, a pair of thin glasses, and viewing digital objects and models as if they were really part of reality. Existing augmented reality applications like the game Pokémon Go, interior design experiences or art exhibitions are only the beginning of what will be possible with this technology. Mixed reality will enable a much more realistic blend of digital content and physical environments, for example, when it comes to occlusion, shadows, and reflections, thus opening up entirely new types of digital experiences out in the physical world.

These kinds of immersive technologies have the potential to fundamentally change the way that people interact with digital information. Mixed reality will give people a world of physical objects which have digital data or information or visualisations applied onto them or extended from them, as if they were part of the physical world. It will not remove people from the physical space, but move them to a slightly different layer or dimension of it. Within the context of urban planning and design, this could mean seeing future buildings, public spaces or streets that do not yet exist, but still being able to experience what they would be like.



Future mixed reality: A vision of a future city-scale mixed reality experience on a thin client enabled by 5G and edge computing.

Mixed reality - What is it?

One key component and prerequisite for the realistic blend of the real and the virtual is a high definition 3D digital model of the existing physical world. This 3D model is used to render the digital objects in the physical environment and applying new techniques such as occlusion-masking when digital content should appear behind physical objects, or displaying shadows and reflections when physical and digital objects are near each other. Characteristic visual elements in a 3D map are also used to determine the exact position and angle of the viewing device, making it possible to render the digital objects with a much higher position accuracy than what is possible with GPS and other positioning systems.

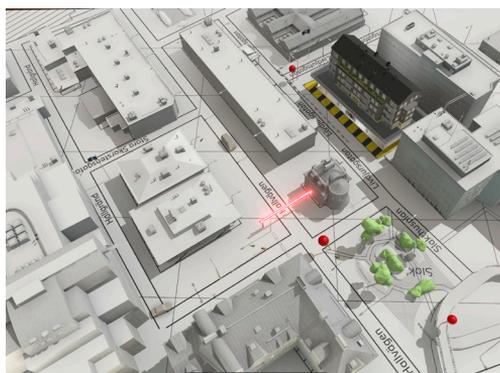
Increasingly, local governments and other organisations are digitalising their inventories and building digital replicas of the built environment. It is likely that in a not too distant future, every place and object in a city will have its 'digital twin' - a digital 3D model that not only looks like the real world but also describes the properties and use of various objects. These digital twins will be key for instant and mobile mixed reality experiences in urban environments.



3D model: One example of a point cloud converted to a basic 3D mesh.

Today's mixed reality solutions depend heavily on software residing on the viewport device, such as an app on a smartphone. Devices have no real understanding of the world around them, apart from what they can distinguish from their own sensors with a very limited range. To enable mobile devices to display mixed reality content far from the viewer, making use cases for urban planning and design possible, there is a need for external representations of the physical environment. Another issue with today's mixed reality solutions is that all computation happens in the device, which means that memory, processing capabilities and battery resources provide serious limitations.

Taken together, all this means that future mixed reality applications that work at the scale of a city will need an outside-in approach. Initially, to achieve scale, shared high-definition 3D models that are up-to-date will need to be dynamically distributed to mixed reality devices in an intelligent way. Then, to develop the viewing technology, for example to make thinner and lighter smart glasses technically feasible and fashionably viable, some of the computer heavy and power hungry visual computing processes will need to be offloaded to a cloud service.



3D model: A refined city digital twin with additional layers of data for mobility flows, wind patterns, time of day, etc.

Empowered by future mobile network technologies

Previous generations of mobile networks have mainly addressed consumer needs in terms of voice, text, web browsing and higher-speed data and video streaming. The transition towards the next generation of mobile networks - called 5G - will need to serve both the data needs of individual consumers and those of a wide variety of different kinds of organisations. The needs of industry, for example within manufacturing, mobility and logistics or the requirements of new technologies such as mixed reality, go beyond simply higher speeds and lower latency. They also require completely new capabilities such as the ability to connect objects digitally or create fully digital environments.

Mobile networks have already become a critical infrastructure for many societal services. Future mobile networks, cloud-based services, more powerful mobile devices, sensors, big data and analytics all present an opportunity for cities to enable new ways to use physical spaces, to deliver services, to use resources more effectively or to connect residents to each other and to their policymakers. Hence, the global technology shift that is in front of us goes across the entire society and the grand challenges we are facing.

Ericsson is currently undertaking intensive research into a range of use cases for 5G, in order to understand which technology enablers are needed for mixed reality and other applications. One thing that is clear is that the prerequisite outside-in approach needed for future mixed reality in combination with requirements on high bandwidth and low

latency makes it a very interesting case for 5G and future mobile networks, distributed cloud services and edge computing capabilities near the location of use.

The only way to understand how mixed reality technologies could and should work, and to explore what the third transformational horizon could look like, is to iteratively build and pilot mixed reality in different contexts. Urban design and public participation is one of many use cases for a mixed reality platform, but as a first pilot area it has been very relevant. Through this use case, it has been possible to test mixed reality on a large scale in urban environments where new technologies such as 5G are likely to be deployed first. As part of the project, it has also been possible to show Ericsson's vision to empower a sustainable world and the company's commitment to SDG 11 on sustainable cities and communities.

Mixed reality in mining

In 2016, Ericsson engaged in a joint research project with the Swedish mining company Boliden to explore the near future opportunities with 5G and ICT within the mining industry. The goal was to develop tangible concepts showcasing how Ericsson's current or future technologies could create benefits in terms of safety, productivity, employee well-being and other relevant aspects. In the end, the outcome turned out to not only be relevant for mining, but also interesting for a range of other contexts.

The focus of the project was on semi-manual, skill-based work and how this could be improved by means of technology and considering the interplay between automation and humans. A prototype illustrated a range of mixed reality applications for improving operations down in the mine as well as remotely from above ground. The applications showed how mixed reality, for example presented on the visors of the helmets, or added to a camera feed from remotely controlled equipment, could guide mine workers in various tasks through digital information blended with physical objects and material. This could help them to have precise information about safe blasting procedures overlaid on the rock surface, to get recommendations for the exact spots where more concrete is needed for reinforcements, to analyse rock and mineral characteristics from sensors and scanning equipment in near real time, to be visually guided to safe meeting spots when other vehicles are approaching behind a bend or to see the path to the nearest rescue chamber when the mine is filled with smoke and completely dark.

The project showed that technologies like mixed reality enabled by 5G, fine-grained positioning, a detailed 3D model of the mine and real time data has the potential to transform operations, traffic control, productivity aids and safety measures. However, during the project, Ericsson quickly realised that the scope extended far beyond the mining context. One example is that a similar digital replica of a city could be the base for a wide range of mixed reality applications in urban contexts, including processes and tasks like simulations, prototyping, visualisations, evaluations and inspections. Or for participatory urban design and new ways to present plans and processes in legible formats to various stakeholders.



Mixed reality mining: Operators of mining vehicles are guided to safe meeting spots. The green light suggest the best place to wait.



Mixed reality mining: Operators of mining equipment are guided in the reinforcement of tunnels. The red parts indicate that a thicker layer of concrete is needed.

The coming technology revolution in urban spaces

Damian Dugdale, Innovation Consultant, WDO



“This will change everything from an urban planning perspective.”

Damian Dugdale is an innovation consultant at WDO Innovation, a digital design agency in Sweden. He was invited by Ericsson and UN-Habitat to take part in an Expert Group Meeting in Stockholm, Sweden in September 2018. Although his involvement only extended to this meeting, Damian’s view is that the UN-Habitat and Ericsson mixed reality project is a taste for the technological revolution to come. Mixed reality, in his view, will play a large part in this new world. Overall he felt mixed reality pilots in places like Johannesburg can help shape the future rollout and use cases of new technologies such as 5G, for the good of urban residents around the world.

“We were trying to look at how this mixed reality technology will change how citizens and individuals interact with government and with society as a whole,” he said. The workshop focused on looking at what would happen when mixed reality is rolled out globally. “It is radically going to change the city, even though it is ten years away.” The technology will be embedded in everyday items, such as glasses or spectacles. “This level of interaction is going to change everything - how we live, communicate, and get from point A to point B.”

“This will change everything from an urban planning perspective. The UN-Habitat Block by Block project with the mixed reality add-on in Johannesburg demonstrates how you are engaging with citizens, and how they want their cities to look like.” The results, Damian

feels, show that people want their cities to be “radically different to how they look today. What touched us the most with this project was that people wanted to build actual cities with it.” For instance, the first thing many people said they wanted was grass. “In 90 percent of cities built today, where do we plant grass?”

The mixed reality public participation aspect of the project, he said, “was different from how city planners have created stuff in the past. What people are asking for is different. We can now engage with residents and bring people into the story of developing their homes and environments. The voice of the individual will be much different.” Cities and societies, Damian feels, will need to rethink how they respond to resident desires for things like public spaces and green lungs. “For a lot of what people are asking for, we have to rethink and step back.”

Damian cites the innately disruptive nature of the project, which takes two pieces of tech and mashes them together. “Looking at all these pilot projects, we need more of them. We need to document our successes and highlight our failures, when we play with new technologies and new ways to communicate. If you try something at home and it fails and put it aside, no one ever knows about it. When we talk about projects, it ignites something else somewhere else. The convergence of failure and success is what’s going to drive the adoption of that change.” The unique nature of the partnership, he says, is key to its ultimate

success. From project design to execution, the various stakeholder perspectives are incorporated. The technical aspects are in many ways the easiest to overcome, he says.

“From an engagement perspective, it will look very different. We have to find something that sticks. The biggest challenge, [is working with] local councils and governments trying these new ways of working.”

The gaming industry is showing us that this does stick - this isn’t a fad. It’s not going away. It’s something we have to embrace. We have to be conscious of how this is going to impact. We are trying to look at the best possible outcomes for this technology. From a societal perspective, this isn’t something you can stop now.”



Mixed reality prototype demo, Stockholm, Sweden © Ericsson



CHAPTER 5

Prototyping and
piloting city-scale
mixed reality

As discussed in Chapter 3, the case for a more inclusive and participatory urban design and planning process is clear. Digital technologies, if used appropriately, have the potential to contribute to this. Given that an estimated 60 percent of the world's urban spaces required between now and 2050 remain to be built - there is a great opportunity for innovation. According to the World Urban Forum, USD \$3.7 trillion of investments will be required in urban infrastructure per year until 2050. The smart city concept has become synonymous with technology advancements, but big data and high bandwidth networks cannot alone tackle the most pressing challenges. Smart cities also need to ensure that technology is used effectively.

As this report shows, mixed reality opens up a number of interesting opportunities for public dialogues. It could allow planners, architects, residents and other stakeholders to experience digital content, such as architectural 3D models, by walking around in them in existing streets and public spaces. It can, if deployed with care, make plans and processes more engaging and relevant by being able to view alternative developments from locations and perspectives and times that matter to people. It could lower the barriers to entry for public participation by being able to experience plans and processes in a familiar context: their lived city. It could help to demystify the planning process, increase transparency and help build understanding amongst residents.

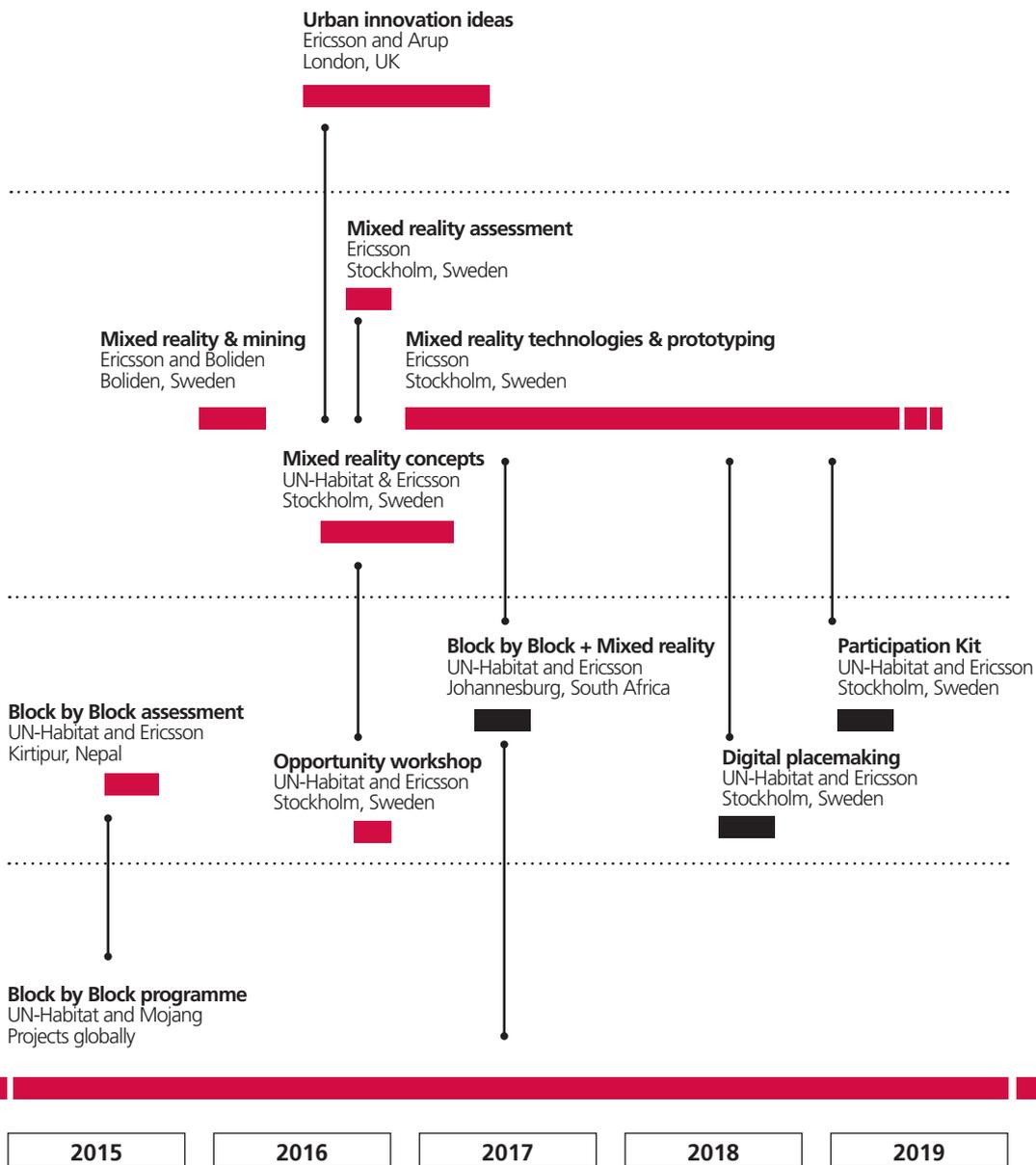
This chapter outlines the research process that was followed - over several years - to arrive at the mixed reality prototypes that were tested in Johannesburg and Stockholm.

The human-centric and design-driven innovation process

All creative processes include a combination of divergent thinking to produce a variety of possible options and ideas and convergent thinking to refine and narrow down to the best idea. These two phases are often represented by a diamond shape to visually map the divergent and converging mindsets. In most design-driven innovation this happens twice, once to gather insights before formulating relevant problems, and once to generate solutions to those problems before developing prototypes or products. One of the most important things is to not move too quickly through the first two phases in the first diamond to ensure that the developed solutions really address problems that matter.

The first of the four phases is commonly known as *Discover* and is about looking at the world in new ways and to gather insights. The second phase, *Define*, includes making sense of the possibilities, deciding which one of them is most important and framing the design challenge. The third phase, *Develop*, is the iterative creation and testing of concepts to gradually improve ideas. The fourth phase, *Deliver*, is where the resulting prototype or service is piloted or produced. However, it is important to remember that a creative process is seldom linear and rather highly iterative with ideas continuously being developed, refined or dropped.

Timeline showing all the activities in the project



Setting the strategic direction

This applied research project has included many overlapping activities and interactions with various actors and stakeholders – each one almost like a separate design-driven innovation process in itself. In general, the early activities emphasised the *Discover* and *Define* phases in order to understand the opportunities for mixed reality within urban design. The later pilot activities, on the other hand, focussed more on the *Develop* and *Define* phases to test technologies and build mixed reality applications.

The key design principles of empathy, creativity and diversity cut across all the four phases, and all of the project activities have drawn upon these principles in order to explore and identify mixed reality innovations.

The partnership between UN-Habitat and Ericsson was central to developing the strategic direction of sustainable urbanisation and the ambition to investigate the role of ICT as an enabler for social change. From that, a theme gradually emerged around how urban technologies can engage and inform a range of actors and enable constructive dialogues about alternative paths of action.

In a separate but linked project, in mid-2016, Ericsson and Arup Digital Studio engaged in a series of conversations to explore how new forms of urban governance can involve more stakeholders in an ongoing urban design process. One identified area of interest was a kind of public digital commons which could facilitate dialogues and interactions between various stakeholders. In this vision, a digital urban space or layer – connected to the physical one – could drive collaborations and innovations around potential future urban developments. When these lines of thinking were cross-pollinated with a mixed reality mining project, an intriguing idea for how mixed reality might contribute to a more engaging and legible urban design process began to materialise .

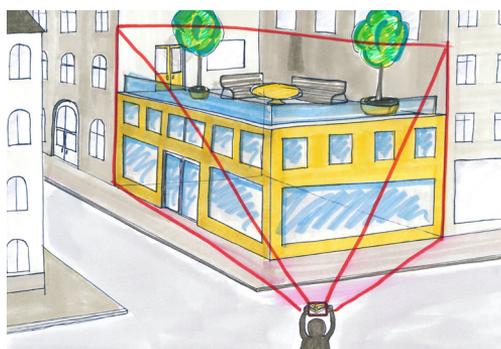
Mixed reality and public participation concepts

Inspired by the Arup conversations and the partnership with UN-Habitat, the Ericsson team explored and concretised a broader range of city-scale mixed reality concepts in a series of ideations during the second half of 2016. Although the team looked at a variety of tasks and applications, the main focus was on ways to create dialogue about urban planning and design a more integrated part of people's everyday activities. The imagined touch points ranged from low-fi to hi-fi, including personal devices like a mobile application or Google Cardboard style goggles, to shared mixed reality goggles available at the library and public digital binoculars near bus stops or pop-up locations.

As part of these ideations, Ericsson engaged in continuous conversations with the urban planning department of Stockholm to exchange knowledge and perspectives. In these interactions, the sketches and concept visualisations served as valuable stimulus material. The research team also participated in various analogue and digital forums for public participation to experience different examples of current processes first-hand.

As another parallel and integrated activity, a comprehensive literature review of urban planning and public participation was carried out to build knowledge about the issues at hand. Part of this research has formed Chapter 2 of this report, particularly the discussion on urban planning and 'wicked problems'.

To support the analysis, a small field study was done by Ericsson Sustainability Research in Stockholm. The set of concepts that illustrated how visualisations of future plans and strategies could be experienced in-situ were presented to get feedback from people of various ages. This was done to develop an understanding of the barriers that hinder people from participating in the urban design process as well as what could trigger their engagement.



Early sketches: Two examples of the idea sketches that were used to stimulate conversations around different mixed reality applications and touch points related to urban design.

At the end of 2016, a workshop with UN-Habitat was held to further explore and develop the thinking behind how the concepts could be applied in a real-world context. The workshop had a particular focus on cities in the global south to transfer knowledge to Ericsson about planning practices and urban challenges in emerging markets where most of the world's urban growth is taking place. The outcome was a better understanding of how technology must interplay with social, cultural, organisational, and political dimensions, and the need to create the right circumstances for participation, to build municipal capacities to respond to ideas and suggestions and to offer complementary physical interactions.

From these discussions an idea emerged to combine the mixed reality concept tests with the UN-Habitat Block by Block methodology, in which Minecraft is used as a participation and co-creation tool in public space design and regeneration projects. Testing a 3D gaming experience such as Minecraft in combination with mixed reality held a lot of promise and it soon became the obvious next step for the research.



Concept visualisation: An early concept visualisation created to explore the complexity of blending digital building models and urban data with reality.



Vision: A refined concept showing a mixed reality-enabled public participation tool for understanding proposals and sharing ideas.

Mixed reality and Block by Block pilot

Some technology exploration and research had started already during the concept stage, but after agreeing to pilot a way of viewing Minecraft designs in reality, an intense prototyping period begun. This pushed the team to move from theory to practice and find out if the mixed reality concepts actually were possible to realise.

The first prototype, developed in early 2017, was a small-scale version for indoor use, which used simultaneous localisation and mapping (SLAM) technologies. This basically means that the camera and the sensors on the phone are used to create a digital 3D model of the room, including all objects. When moving around, the 3D model is continuously updated and refined, but at the same time used to determine the exact location and orientation of the viewport. In this way, the digital 3D model and the physical environment can be perfectly aligned. This in turn makes it possible to view digital objects that blend in with reality, through occlusion-masking and environmental reflections.



Early block builder prototype: Creating a 3D map of the physical environment, which is not normally visible to the user.

After this first prototype, the team was fairly confident that this also would work on a larger scale. UN-Habitat was already planning a public space regeneration project in Johannesburg, South Africa, with the Johannesburg Development Agency and this project was selected as a suitable location and context for the first city-scale prototype. In May 2017, a team from UN-Habitat, Ericsson, the City of Johannesburg and local partner organisations Sticky Situations and Bantu Design visited a number of locations in the city that were prioritised for regeneration and eventually choose a small public space in Braamfontein in downtown Johannesburg.

Since the project was targeting a larger outdoor area, it was not realistic to rely on walking around with a phone to create a digital 3D model of the whole space. A company specialising in 3D modelling was engaged to scan the space and create a digital model that could be pre-loaded in the mixed reality prototype. This detailed 3D model was then

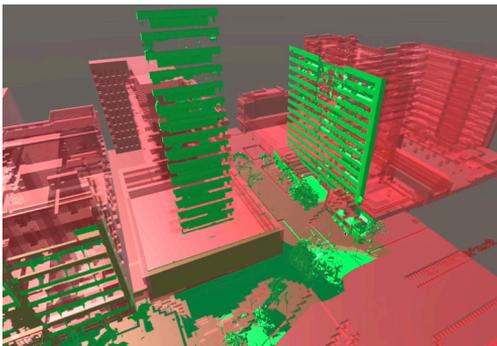


Early block builder prototype: Building digital blocks that use a 3D model to blend with the physical environment.

aligned with the Minecraft real-world replica UN-Habitat prepares for Block by Block workshops, meaning that there was now two digital versions of the public space in question - one detailed 3D model and one Minecraft model.



Johannesburg pilot: A view from Minecraft showing the Minecraft replica of the public space to be redesigned.



Johannesburg pilot: The Minecraft replica was aligned with the high definition 3D model of the public space.

During the Fakugesi digital innovation festival in September 2017, a series of Block by Block-inspired pop-up workshops were organised, attracting festival goers and passersby as well as invited students from neighbouring Wits University and Rosebank College. Each workshop session started with a brief introduction to Minecraft and the purpose to design something to improve the adjacent public place, after which the participants created proposals in Minecraft using computers. After finishing, the urban design proposals that the participants had created were copied to the mixed reality prototype, meaning that they now were able to go outside and view their creations in the public space itself using a mobile phone.

The alignment of the Minecraft replica with the detailed digital 3D model, and the alignment of the 3D model with the phone's position and orientation, made it possible to blend the Minecraft objects with the real world in terms of occlusion, shadows and reflections. Real objects like buildings, signs, trees, and streetlights appeared either behind or in front of the Minecraft designs, as it should if the digital objects were physically there. The reactions of the participants to seeing their creations in mixed reality were very positive and inspiring to the research team.

Following the open workshops, an urban design postgraduate student from Wits University developed some of the proposals into a slightly more refined plan for remodelling the whole space using Sketchup. Using the same principles of aligning the Sketchup models with the detailed digital 3D model, these refined draft proposals could also be explored on-site, in mixed reality.

Mixed reality and digital placemaking



Johannesburg pilot: *The mobile phone view when walking around and looking at one of the Minecraft designs as if it was there in reality.*



Johannesburg pilot: *The mobile phone view when walking around and looking at a refined Sketchup design that had incorporated the ideas from the Block by Block workshop.*

Inspired by the first promising pilot in Johannesburg, the end of 2017 and beginning of 2018 is a period defined by more technical prototyping activities. One purpose was to refine the prototype functionality and to test mixed reality content other than Minecraft designs. Another one was to use the learnings from the first pilot to better formulate the requirements of a platform that would enable a range of city-scale, near-photorealistic and shared mixed reality applications.

In parallel, the dialogues with municipalities' urban planning departments, architect firms, engineering companies, game developers, residents and many other organisations continued. A valuable tool here was a vision video that Arup had put together to illustrate how mixed reality could be used to visualise proposals for the city, whether planned developments or small interventions, and to describe the value of projects in order to stimulate meaningful participation or engagement. This design probe helped the team discuss questions about appropriate interfaces and network technologies and how to best convey proposed interventions.

One of the many conversations led to an opportunity to be part of the second Gather festival in Stockholm, Sweden. In collaboration with the festival organisers and one of the main festival partners, one of Sweden's largest property developers, UN-Habitat and Ericsson decided to explore the combination of mixed reality and digital placemaking. The purpose of this activity was to go beyond the design of future places and also consider how the experience of existing places can be enhanced and combined with different digital experiences

to make them more attractive destinations. The team wanted to exemplify mixed reality's potential at different urban scales, for different types of digital content and create more playful digital interactions linked to placemaking.

The prototype environment was built on the same principles as in Johannesburg. A high-definition 3D model created from drone photogrammetry was preloaded on tablets, and then aligned with the tablet's position and orientation for the positioning of the digital content, and for the occlusion-masking and environmental reflections. As in Johannesburg, a physical marker in the form of a QR code was used for the initial alignment of the physical and digital worlds.

Three different parts of the prototype were designed in order to explore different perspectives of mixed reality and placemaking. The first part included various ways to present future building alternatives; one with realistic but hypothetical building models that really blended with the physical environment, one with a set of building volumes that represented the actual plans for the festival location and one for free exploration through placing high-rise buildings at any location.

The second part included a few examples of digital placemaking experiences. One in the form of an interactive game that used both the built environment and digital objects extending from it as props. For example, making virtual balls shot from the device bounce on buildings and streets. Another example came in the form of digital objects that interplayed with their physical counterparts, for example, virtual

jellyfish flying in the air, through the door into the conference, eventually joining their physical friends that were hanging on the ceiling as decorations.



Digital placemaking prototype part one:
The tablet views when walking around and looking at detailed digital models in a current parking lot.

Mixed reality participation pop-up kit

The third part included visualisations of urban data in order to explore how mixed reality might be used to describe access and linkages between places. Some of the examples included locations of festival activities taking place in the proximity, different transportation alternatives in the neighbourhood and suggested places of serenity with low noise levels and better air quality.



Digital placemaking prototype part two:
The tablet view showing a bit more playful mixed reality experience with a combination of digital and physical public space elements.

The third iteration of the mixed reality prototype evolved from the prototype developed for the Gather Festival, and combined a miniaturised 3D model for an overview with the street-level mixed reality perspective. The main purpose was to illustrate a possible format for a mobile participation pop-up kit.

The setup was a table with a printed map of a part of Slakthusområdet, which is a neighbourhood in Stockholm that will be redeveloped in the coming years. When aiming a tablet at the map, a miniature digital 3D model of the area appears, including animations for mobility flows, wind patterns, time of day, etc. The model also includes the possibility to browse through a number of alternatives for future buildings that are mixed in amongst the existing cityscape.

At any time, it is possible to immerse yourself in a mixed reality street level experience and experience the very same building alternatives at the actual location in Slakthusområdet, as if they were part of reality. For dialogues or demos that take place in a different location outside Slakthusområdet, the street level experience is simulated using a pair of VR goggles, allowing a flexibility for participation on-site as well as off-site.

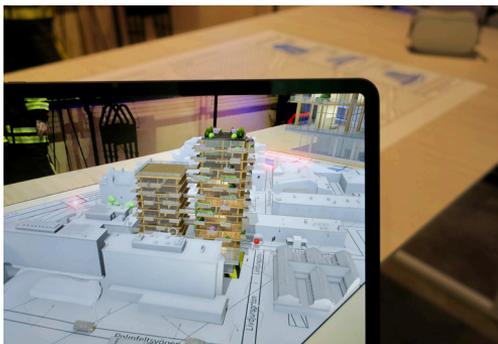
The two prototype perspectives enable complementary conversations around the different building alternatives. The miniature 3D model provides a more analytical overview to discuss the wider impacts on the neighbourhood and the broader urban systems. The mixed reality experience is more about

seeing and believing, and to grasp what the different alternatives actually would feel like when being there on the street.

Another purpose with this prototype is to describe the type of technology platform that would enable this and many other types of large scale and photorealistic mixed reality experiences. This is primarily about offloading parts of the visual computing to a cloud service, and how 5G in combination with edge computing are key components. However, the prototype also serves as an entry point to discuss topics such as the intelligent processing and distribution of high definition 3D data of the existing cityscape. This includes discussion of the opportunities for what could shape the emerging multi industry ecosystem that, amongst other things, includes city infrastructures, autonomous vehicles, Internet of Things and mobile devices.



Participation pop-up kit: The mixed reality view when looking at one of the building alternatives.



Participation pop-up kit: The demo setup with a printed map of a development area, a miniature digital city twin and building alternatives.

Participation pop-up kit: The mixed reality view when moving between different locations and experiencing different building alternatives.

Stockholm Expert Group Meeting

In September 2018, UN-Habitat and Ericsson organised an expert group meeting and a workshop in Stockholm, Sweden to discuss the opportunities and challenges of using mixed reality for participation in urban planning and design. The two meetings brought together around 45 architects, urban planners, technologists, designers, artists and civic engagement specialists. The participants first tested two of the mixed reality prototypes developed by Ericsson, and then spent time in a structured discussion session exploring the potential of the technology.

The views on mixed reality were wide-ranging, but there was a general sense that although the technology is still in its infancy it holds a lot of potential in many fields.

There was a broad discussion about the needs of making the architecture and urban design fields more digitally-enabled. Mixed reality could make it possible to present different design alternatives to various stakeholders in more visual and non-technical ways. Some concerns were raised about the professional roles of architects and urban planners when design is opened up to co-creation by non-professionals. Participants highlighted the important role of the professional designer to analyse and interpret what is being said and translate it into something useful. However, urban designers also need the right kinds of insights in order to be able to plan and design properly. Mixed reality can support this by helping stakeholders to move from desktop experiences to something that is close to lived experiences.

One common challenge with existing participatory processes is how to get people to participate, attend meetings and make their

opinions known. Technologies such as mixed reality and video games such as Minecraft have the potential to attract people - for example youth - who otherwise would not want to participate. Mixed reality can be useful as a way of sharing information and data with residents in a more direct way and enable them to experience, and be involved in better ways, thus breaking down some power imbalances between professionals and non-professionals. But there is sometimes the risk of participation overload, where it becomes difficult to make necessary choices between different alternatives.

Mixed reality can also be a useful way of experiencing both future and past realities. This could include future urban developments or plans, but also past neighbourhoods, buildings or events. It may, for example, be able to experience a city as it was 50 or 100 years ago. Another interesting area to explore is shared realities and how to create better shared experiences. It is important that this technology does not worsen existing 'filter bubbles' by creating fragmentation in physical public spaces.

Many participants raised human rights concerns to do with privacy, freedom of information and exclusion. It is crucial to consider the way that data is collected, how it is stored and used. People need to be made aware in clear ways that data is being collected and clear legal frameworks around the ownership of, for example urban 3D models, need to be developed. What happens if mixed reality become a necessary technology to fully experience public spaces, but only some people have access to it? It is important to consider how to overcome digital divides and ensure digital inclusion.

External view of technology as democracy accelerator

Dan Hill, Futurist Design Studio, Arup



"Can we unlock the way people understand their city, like an X-ray? Instead of them going to a meeting they have no time for, how can a meeting go to them?"

Arup is a global multidisciplinary architecture and design firm. Dan Hill led their small strategic design team, who use design and design methodology to help boost collaborations at the early stages of a project. Arup became involved in the conceptual phase of the mixed reality project already having implemented dozens of public space projects. Together they explored urban mixed reality interfaces that could take advantage of new network opportunities.

Dan Hill said his team concluded, after decades of major public works projects, that participatory urban design is not just better in principle - it is the only way that truly works if public spaces and buildings are to become and remain useful and relevant. "If participation is done well, the process could also be faster. Criticism can slow down the process. But you'll have to deal with people sooner or later, so bring them in sooner as a creative input rather than an obstacle you bring in later."

Participatory processes is a way of bridging the gap that currently exists between designers and users in much of urban design. "With the built environment, industry builds the building and then people adapt. It's fractured as a process, the property developer doesn't carry cost of the operational side. In a proper product design process, for example when designing the iPhone, you use user feedback continually, generating data and improving design on the back of real user research. With the built environment, we aren't really making great

products as an industry. We often overrun, in cost or time, and the result is not necessarily what the client wanted anyway. Projects are difficult to adapt once built." With this, Dan means that urban designers need to be much better at continuously asking for feedback from users - such as urban residents - in the same way that product and industrial designers constantly test their products on potential customers. Digital technologies make this kind of testing easier, for example through the crowdsourcing of ideas.

According to Hill, a deeper-level question urban planners and designers ask is, 'do people really understand what you can and cannot do?' "The assumption historically was that only the experts can make informed and educated decisions as to what and where to build, and what and where to leave alone or turn into a public space." That model, he says, should and will change as the public increasingly demand a seat at the design table.

To overcome the gap, Dan Hill's team developed a series of use cases based on what was currently known about emerging technologies. The key question, was 'how can these emerging technologies help cities be not only smarter, but more inclusive and sustainable'?

Some answers initially might come from the gaming community, which is at the forefront of developing 3D and virtual reality technologies. Dan Hill and the Ericsson team used augmented

reality and 5G network technologies as a springboard to ask fundamental questions about which questions or problems were they trying to solve. 'What are the real problems cities are having in terms of connecting with their residents?'. Starting with people in mind, as opposed to places or buildings, the teams challenged themselves to start with the end goal and look at how people could use an interface to make suggestions for their own place- and city-making. Initially flushing out the question would eventually turn it into an application, which in turn would be a technology that could be developed. "The old way was, 'here's a new technology, will you please buy it?'

By keeping urban design front and centre in a collaborative virtuous cycle, Hill says Arup is able to "keep it bound together, as a designed process, in that it focuses on the outcomes and making those tangible. Design also has to integrate the question, will this work in reality? This is a level of technical reality, and a future advert for something that doesn't exist yet."



Mixed reality experience in Johannesburg, South Africa © UN-Habitat



CHAPTER 6

Bringing together
urban design, public
participation and
mixed reality in
Johannesburg

Johannesburg is a rapidly changing city, but its socio-spatial structure remains highly fragmented and divided. Public space is scarce and in many neighbourhoods virtually non-existent. UN-Habitat and the Johannesburg Development Agency have a longstanding planning collaboration to undo decades of apartheid-era planning - for example developing the 2040 City of Johannesburg Spatial Development Framework.

In 2017-2018 UN-Habitat and Johannesburg Development Agency worked together on the project 'Building the Public City'. The project considered the creation of quality public space, public participation and improved collaboration and cohesion between city departments as fundamental for a successful city. This included developing a framework for co-management of public spaces and a policy to define, design and deliver various types of public spaces, able to respond to the needs of three very different neighbourhoods across the city. These include Braamfontein, a rapidly gentrifying and centrally located neighbourhood; Hillbrow, an area with huge social and poverty issues in the inner-city; and Diepsloot, a semi-informal township in the northern part of the city.

Over a 12-month period, a variety of participatory design, visioning and mapping approaches were used to engage residents in the three locations. In Braamfontein, the city actively sought input from residents through a unique 'pop-up' public participation project. As part of this project, students from Rosebank College and Wits University worked with residents in a Block by Block process in which they used Minecraft to crowdsource and co-design new ideas for regenerating Eland Park, a public space across the road from Wits University.

This pop-up activity in Braamfontein presented an opportunity to pilot the mixed reality platform. The purpose was not only to test the platform, but also to better understand how mixed reality might be used effectively by the urban planning department of a local government. The diverse set of stakeholders that were part of the project 'Building the Public City' opened up for a range of insights that could guide future technology developments and mixed reality applications.



Johannesburg pilot: Project partners discussing the public space challenges in the Braamfontein district.



Johannesburg pilot: Project partners discussing the the ideas from the Block by Block workshop.



Johannesburg pilot: A participant in the Block by Block workshop using Minecraft to design ideas for the nearby public space.



Johannesburg pilot: Participants in the Block by Block workshop out in the actual public space, viewing their Minecraft designs in mixed reality

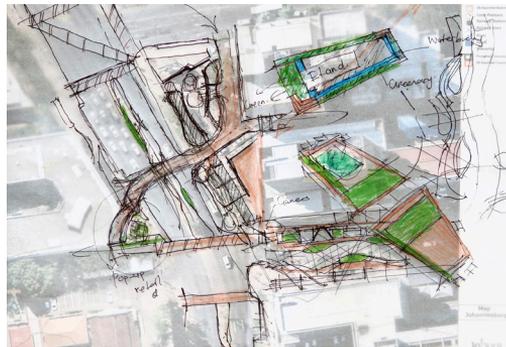
Each pop-up session started with participants using Minecraft on a laptop to make something to improve the public space. Once they finished designing in Minecraft, they could go outside and. Then by looking through a mobile phone, view their Minecraft designs in real life, including walking around the digital objects out on the street as if they were physically present. The integration with the Block by Block methodology emphasised the inclusive and participatory aspects of mixed reality. Instead of presenting highly realistic and detailed building proposals for feedback, the Minecraft designs in combination with mixed reality experiences enabled imaginary and creative conversations about the space that were grounded in real-life conditions.

As seen in many cases before, the Block by Block process was a successful way of eliciting feedback from people - especially from youth. Also in this project, feedback from the city indicates that this was a very interesting way of moving beyond the traditional big town hall meetings - were the speakers are usually male and politically connected - to a process that was more participatory and provided the opportunity for more diverse people to have a voice.

In this case, the mixed reality add-on amplified some of these perspectives. To begin with, it created a significant amount of engagement and excitement for the task at hand. The mixed reality solution also made it possible for people to move away from the two-dimensional computer screen, and the physical disconnect that comes with it, to a three dimensional experience in the actual public space. This ability to see ideas live in the right environment certainly helped participants understand how design proposals might be improved and refined.

The ideas from this process were varied and focused on improving safe access across the busy Bertha Street, pedestrianising Stiemens Street, increasing security and providing seating and activities for the hundreds of students who regularly use the space. An urban designer from Wits University then interpreted the needs and ideas that people expressed through the Minecraft process and designed a first 3D proposal for improving the site in Sketchup. This proposal was then exhibited to people for their feedback at a separate pop-up participation session. This again allows people to be outside and, by looking through a mobile phone, view and walk around the designs in real life.

Based on this iterative form of pop-up participation, the conversations and ideas enabled by Minecraft and mixed reality gave the professionals confidence to approach the decision makers in the city in a more persuasive way. Minecraft and mixed reality should not only be seen as tools for crowdsourcing the actual design, but rather as tools that empower urban designers and architects when applying principles and presenting to public authorities. The proposal becomes much more than personal preferences as they have gone through various forms of exploration, co-creation, and discussion, which is extremely valuable when arguing what the final design should be.



Johannesburg pilot: The first sketch of a public space proposal based on the ideas created and discussed during the Block by Block workshop.



Johannesburg pilot: The final public space proposal to be implemented after feedback from stakeholders, and studies of feasibility and viability.



Johannesburg pilot: The final public space proposal to be implemented

External insight:
Engaging communities using mixed reality
Nikki Pingo, Development Facilitation Manager, JDA



“There’s a real level of gratitude to UN-Habitat and Ericsson to test this technology with us in Johannesburg. We have to choose opportunities where we can implement, to go from Minecraft to mixed reality to reality, to get the impact we’d like it to have.”

Many cities, for all that they recognise the need for urban design and development, are often restricted by a lack of internal resources and capacity. They are looking for innovative ways to address their many challenges within available resources. One case in point is Johannesburg, South Africa and the ‘Building the Public City’ project, funded and implemented in collaboration with UN-Habitat.

According to Nikki Pingo, Development Facilitation Manager at Johannesburg Development Agency, the Minecraft and mixed reality project was an excellent opportunity to generate lessons learned about what works well and what might be complemented by other public participation methodologies. In her own words, here are the key takeaways:

“Tools like Minecraft and mixed reality let people deal with the details, in a way they can’t when we have our big meetings. They are allowed to sit and see how their space can be transformed in an experiential way. It is not just a list, ‘I would like to see more seating and lighting. And I’d like you to address the traffic intersection and how pedestrians use it.’ With this particular UN-Habitat grant, [we are looking at] ‘massive small’, thinking about the small interventions you can do as a city that make place and neighbourhood and economic opportunities, not just state-run big infrastructure projects.

The Minecraft and mixed reality process was interesting. But at the end of the day, as urban designers we have to assess the space and come up with key decisions. In our context, the management of places and facilities is difficult, so when the community is indicating something specific, it is because they know how people will use it after it is developed. If they have no control over that, they have no control over the space post-implementation.

The bigger challenge is about changing all of our mindsets as city officials, to prioritise this type of participation to really make it work within our city constraints and budgetary pressures. It is particularly wonderful tool - Braamfontein demonstrated it can be a way to engage with the youth who are tired of big meetings.

One of the major lessons was to embed tools like Minecraft and mixed reality in a bigger profile city project. The key components that came out of Minecraft had to do with pedestrian access. So the main proposal was mainly about closing a part of a street and claiming that as part of a public space. We are now looking at removing some parking and turning that into green space. It means closing a piece of the road and reclaiming that - with key safety interventions: key seating, lighting, greening, as well as linkages with the pedestrian network in the area.

It is very specific, with the Minecraft examples, 'I like this TYPE of bench to be considered on this location in this site.' If you live in the neighbourhood, those types of details mean so much for how you use public space after it's developed. It is such a great tool to get that level of detail.

We saw in the participatory process, a lot of issues around safety for women. For example, the feedback on seating is quite detailed. The women wanted to change a configuration of seating, which had created a wall of where young men would sit and have good times. It became a negative space for young women to walk through. We saw specific interventions with Minecraft: how else could the seating work, that [the team] took into consideration.

You can use these innovative technologies and people embrace them, particularly young people in our cities. We have a high gini coefficient and crime rate, so we have to improve people's earning capacity and possibilities. As a push towards participatory urban planning and design gains momentum on the African continent, more effective tools of engagement are needed to generate meaningful co-design methods and develop appropriate urban responses. Generating interest and fighting perceived powerlessness – particularly amongst marginalised people – demands careful consideration of engagement methods.”



Mixed reality experience in Johannesburg, South Africa © UN-Habitat



CHAPTER 7

Conclusion:
implications for the
future

What these mixed reality pilots have shown is the potential for frontier technologies to help shape how people can engage with their cities and to help design their future. The implications for urban planning, design and future-proofing our cities are far-reaching. What if residents could form an integral part of design teams and contribute to making the cities of the future? What if technology could help communities get together to decide what their own priorities are for themselves and their children?

To make these kind of scenarios a reality, UN-Habitat and Ericsson have partnered to bridge the gap between public participation and urban design - bearing in mind that multiple stakeholders each have their respective priorities and interests. As none of these actors individually could have the same impact or inspire the same collaborative spirit without the involvement of the other, a new ecosystem involving many stakeholders — including local government officials, urban planners and designers and residents themselves — is needed. In the vision stage of this project, digital technologies such as mixed reality can be a useful way to bridge the communication gaps between various interests and thus provide the catalyst for change. But there has to be the will on all sides to experiment and try new models, embracing alternative points of view.

This means that new technologies must become relevant and accessible to all - no matter the geography. Developing countries in particular are leapfrogging from a non-digital to a digital future as an entire generation of young people embrace technology available on their mobile devices. Gaming technology, like the use of Minecraft, could offer younger people in particular a gateway to civic participation that

previously was blocked off. But the persistent digital divide between those with access to technology and those without, both within and between countries, need to be tackled for this to become a reality.

Mixed reality has demonstrated its capabilities, but used in isolation - without the right collaborations with policymakers, urban designers, architects and developers - the impact will be diffused and less effective. These pilots have illuminated the synergies in designing urban spaces using public input, via technology, but it has also highlighted the issues in implementing the results afterwards. City governments, the private sector and technology companies all require a measure of organisational transformation and openness to accommodate the disruptive impact.

Given the potential of these kinds of technologies, and the speed at which they are being rolled out, the time is right to reconsider their use cases within the prism of social good. An engaged, informed and aware public can serve the interests of all, and contribute to creating more equitable and inclusive communities. Co-creation can be a powerful methodology for urban design, and new technologies provide the potential to enable it on a much larger scale and in new ways.

The pilots described in this report also illustrate the importance of linking the city and municipal-level aspirations and realities to the high level policy and normative documents like New Urban Agenda and the Sustainable Development Goals. Commitments may begin at the global and national level, but are often enacted and operationalised at the local level. Cities and local governments are demonstrating both a willingness and an urgency to adopt

disruptive and experimental technologies to help improve their city services.

A concurrent trend which illustrates the desire for collaboration and co-creation on the part of residents, is the speed with which social movements have turned to social media and other technologies to organise for change. When people have the tools for collaboration with them, they start using them in a variety of unexpected ways. This major societal change is now also reaching the urban development sector and people all over the world are increasingly demanding a say in the way that their cities are planned and designed.

Young people in particular have proven themselves early and willing adopters of new and innovative technologies. Youth see with new eyes what is not working in their communities, and often have the desire and energy to try new ways to try and solve these challenges. Feedback generated across the world indicates that although youth feel their community's problems weren't created by their generation, they want to be part of the solution. Many are looking for a mechanism and an invitation to do so. UN-Habitat and Ericsson's research shows that digital technologies in the hands of youth has the power to create transformative change.

What next?

This collaboration between UN-Habitat and Ericsson has proven itself a way to showcase, in a practical innovation project, how the aspirations of Agenda 2030 and the New Urban Agenda can be put into practice and how people can have significant impact on the way that cities are actually designed and lived. The technology is brand new and has not been used elsewhere for the purpose of public participation and urban design. Although the development goes quickly with many companies looking at the area of city-scale mixed reality, there are as yet no consumer applications and services ready for the market.

Especially for applications that target the public domain, there is a need for more pilots and iterative improvements of both the technology and the way it is used for public participation. These pilots need to link more clearly with the planning process of local governments to make sure that mixed reality is deployed inclusively and effectively. The next phase of this experimental methodology is to roll it out in more cities and to begin to integrate the pilots with public policy initiatives and institutionalise the learnings.

There is also a need to bring more partners on board. The project has shown what is possible, but to turn the potential into reality will require a diversity of different partners. This urban ecosystem will need to include the private sector, cities, technologists, and others with complementary expertise across many sectors.

The need for effective governance

Various futurists and technology subject matter experts have highlighted the potential downsides of a completely unregulated technological roll-out. Many cities already pay for public transport and urban mobility using advertising. But in some dystopian futures, smart glasses, interactive billboards and unregulated product placement will literally follow people around their daily life as well as in their online life.

Cities unprepared in terms of regulations, governance frameworks and technical capacity may be at the mercy of forces outside themselves. Adherence to digital rights, including universal access to digital technologies, privacy and data protection, transparency, abidance by open and ethical data standards and a commitment to democracy, diversity and inclusion are crucial if we want to ensure an inclusive digital future. Many cities need to urgently strengthen their capacity when it comes to effectively governing, procuring and deploying frontier technologies.

This is also true for city-scale mixed reality and the broader ecosystem that enables this technology. A collaborative effort is needed to produce the necessary high definition digital 3D models of the physical environment. A range of urban data, both describing the use of the current infrastructure and spaces as well as alternative future designs and plans, must be shared and publicly available in an open and accessible format for developers and innovators to build mixed reality applications upon. Governance frameworks that ensure public use are especially important for mixed

reality applications that target the public realm as they are, in effect, creating digital public spaces.

UN-Habitat invites cities, technology partners and engaged organisations to take part in this co-creation of cities of the future. Together, we need to ensure that these new technologies are developed with sustainable urban development and inclusion in mind.

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For frontier technologies and innovations to effectively contribute to urban sustainability, they need to be appropriately applied to ensure that the prosperity they bring is shared amongst people, cities and regions. An inclusive smart city must be realised by a wide array of actors, and UN-Habitat is increasingly playing a role in this process through the integration of new technologies and innovative practices. Ultimately, the deployment of frontier technologies needs to pay special attention to underserved populations, in order to address inequalities and to bridge social and spatial divides.

Mixed reality, the technology explored in this report, holds tremendous potential for real-time digital visualisations, both at the street and neighbourhood level and the overall urban skyline and city grid. This new visually realistic blending of reality with a virtual imagined version creates a more intuitive space for planners, architects, residents and other stakeholders to viscerally experience and re-imagine future environments from the city streets of today. Architectural sketches and designs can be

made more legible and accessible, thus pulling users into the process of design and strengthening the long-term viability and buy-in of urban projects.

Mixed reality technology offers the opportunity to bridge the divide between inhabitants and their cities, making change literally appear before their eyes and giving entire neighbourhoods the chance to weigh in on how their future smart city will look, feel and serve their needs. Mixed reality can help to take conversations about urban design to people in the streets and thereby better include their actual needs and desires in the process.

The project shows how innovative and multi-sectoral partnerships can contribute to the global debate on the democratic and inclusive smart city and show how frontier technologies can make a positive impact on sustainable urban development. We encourage those developing new technologies to apply their creativity and innovation capacity to solving sustainable urban development challenges.

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