Cities of the Future – Where Is the Actionable Geospatial Information?

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SUMMARY

Cities need to look to innovative ways to deliver their visions whilst meeting the many challenges of growing urbanization. Technology is a key enabler, particularly digital technologies as cities move increasingly into a world of connected devices and people.

Improved availability of fundamental, actionable, data, the foundation for digitally-enabled cities, leads to improvements in transparency, urban planning, resilience, resource/asset and environmental management, and new business opportunities. Geospatial data is one key element of city data, and also the logical means to integrate all city data – '*everything happens somewhere'*. But little investment is being made into this key component of a city data infrastructure; in many cities the arguments still need to be won.

The United Nations has recently released two globally endorsed documents. The first sets out a set of 14 fundamental geospatial data themes, giving clarity on the components, but not design, of a nation's foundation geospatial data. It has also released Part 1 of its Integrated Geospatial Information Framework (UN-IGIF), aimed to help nations use geospatial information to realise social, economic and environmental benefits. Both these documents apply equally to cities. (UN GGIM, 2018)

In nation's endorsing these, two powerful tools were unleashed onto the global community in one meeting. These global frameworks will enable better data integration and interoperability across cities and between public and private sectors. They set the scene to enable smart cities, 'Digital Twins', integrated planning and better citizen services, whatever the particular vision of a city

The Paper looks at these tools and how they might apply at city level, as well as demonstrating how they will help overcome some of the key geospatial data challenges cities face. It demonstrates that the city vision and the needs of stakeholders are the start point in a journey towards being data-enabled, as every city is different. It reinforces the need for cities to have a geospatial data strategy, or a data strategy with geospatial data and a location approach as its core.

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1. CITIES OF THE FUTURE

We live in an age of terminology that conjures a sense of fantasy, and fantastic opportunity. Cities that are smart, with transport that takes individuals to destinations at a time of convenience, with no pollution, with green spaces and quick access to schools, health and services, with refuse collected and high bandwidth connectivity, clean water and uninterrupted power, and short journeys to work for all. We see automation and applications using sensor technology and AI to improve our lives in every respect, and reducing municipality management costs, whether for city maintenance, health or services, all of which are online and comprehensive.

But is this realistic? Is this smart? Are we forgetting the digital divide or do we have an opportunity to break through this divide, for cities to leapfrog each other on the journey towards harmony?

Take 3 different scenarios:

- Manchester UK. A city that has grown over the last 250 years as the industrial revolution progressed.
- Dar es Salaam, Tanzania. Largely unplanned and with population expected to double in 20 years.
- Dubai, an international city where the third dimension plays strongly.

Each has a different vision as it develops:

1.1 Manchester City Vision

By 2025 Manchester will:

- have a **competitive, dynamic and sustainable economy** that draws on our distinctive strengths in science, advanced manufacturing, culture, and creative and digital business – cultivating and encouraging new ideas
- possess **highly skilled, enterprising and industrious people**
- **be connected**, internationally and within the UK
- play its full part in **limiting the impacts of climate change**
- be a place where residents from all backgrounds feel **safe,** can aspire, succeed and live well
- be **clean**, attractive, culturally rich, outward-looking and welcoming.

1.2 Dar es Salaam City Vision

Dar es Salaam City Council intends to build a City:

- with **sustainable development** managed on the principle of good governance,
- where **residents do not live in poverty** and have decent standards of living and
- a city with competitive environment which **attract investors**.

1.3 Dubai City Vision

And Dubai city's vision for 2021 is:

- The People: "City of **Happy, Creative & Empowered** People"
- The Society: "An Inclusive & Cohesive Society"
- The Experience: "The Preferred Place to Live, Work & Visit"
- The Place: "A Smart & **Sustainable** City"
- The Economy: "A **Pivotal Hub** in the Global Economy"
- The Government: "A **Pioneering and Excellent Government**"

1.4 Differences and Similarities

Dubai has a vision that includes 'Smart' as an end in itself, but for most cities a smart city is a means to an end. Each vision places each city is on a differing digital journey but have in common the need for quality geospatial and statistical data. There is no 'template' for a smart city. Many influencers, such as the United Kingdom Foreign and Commonwealth Office favour 'future cities' over 'Smart cities'. For many cities, having data to plan city develop would be regarded 'Smart'; the authors have experienced the frustrations of city mayors who don't have a picture of existing infrastructure to enable planning sustainable development.

Whatever the differences, there are similarities as urbanization progresses toward 70% of the World's population by 2050.

- All cities will have a vision, strategy and plan.
- Cities are rapidly developing and peri-urban areas being subsumed. Resilience, safety and security are critical to all.
- Ensuring the resilient delivery of services, whether utilities, healthcare, waste or education.
- Reducing congestion and pollution.
- Making lives better for citizens.
- Employment.

Deployment of technological advances helps to achieve these visions and overcome these common challenges. The greatest technological advances are data-centric.

2. ACTIONABLE DATA IS THE WINNING RESOURCE

'*Data are an infrastructural resource – a form of capital that cannot be depleted and that can be used for a theoretically unlimited range of purposes.*' (OECD, 2015)

OECD likened data to roads and bridges that support a wide range of national and local uses from healthcare to profitable business, some unanticipated. The cost of such infrastructure is significant and the benefits are so widespread that no one use case can justify the investment on its own. Funding an underpinning, cross-cutting, data infrastructure therefore needs to be considered centrally by city governments.

Most applications have location as part of the tool; install a new app on a smartphone and users are asked if they can share their location, dispatch an ambulance to a place, determine the routing of efficient school transport. Even games are increasingly using the real world.

2.1 Moving up the data value-chain

Data is both infrastructure and fuel for cities. Just as oil is refined into petrol, data needs to have the right content, currency, quality and standards to power cities. And it should be accessible to the city economy at large. Most data has location associated, or could do, and location has become a prime means to integrate data and interoperate across systems, departments and businesses. As automation takes hold and more sensors are deployed, then the proportion of data with location increases, and equally so too the proportion with a time stamp.

The 4th dimension in a city is increasingly important. Predictions to the future are well understood, whether traffic flows, pollution, demand for goods and services. Good data coupled with Artificial Intelligence and deep learning enables far greater precision in prediction. But equally this provides the means to review past actions based on data available at the time, whether planning permission, land rights or automated vehicle accidents. New South Wales in Australia sees the 4th dimension as a critical component of its digital twin. But this importance also reflects the importance of data currency in a city.

It will not be possible for humans to keep pace with this data deluge. Automation and AI will provide support, to get value from this data, and provide actionable data that starts to have genuine value. Actionable data is machine-ready, mission-ready, analysis-ready. To be effective it will have the attributes shown in Figure 1.

Figure 1: Attributes of actionable data.

Like all commodities data is not free, particularly trusted data to be used across a city. Whether based on cost or value, capturing, processing, maintaining and serving data requires resource. Much of the data collected across a city has very little or no value. This will increase as collection increases. Data can be moved up the value chain to generate understanding, decision making and measurement. This was why the world developed maps, probably one of the most efficient means of communicating information. Understanding can be gained, evidenced decisions taken and measurement made directly, as well as a full range of wider spatial data integrated.

Location data, or spatial data, is all data with position. It is incredibly broad in nature and touches all aspects of socio-economic development. But, just as cities need trusted statistical and wider management data, much of which is location-based, so too the need for trusted fundamental geospatial data that enables a foundation of knowledge. This is often missing, hence Dar es Salaam's World Bank funded programme to capture OpenStreetMap. It is often disparate, held in pockets by different departments to different standards and conflicting content. Integrated city systems require common underpinning trusted data, and need it managed efficiently and throughout the city. If automated private vehicles use different data to government automated vehicles, if address systems are incomplete in the tax system, or if different emergency services use different coordinate reference systems, the potential for inefficiency or death is evident.

In Summer 2018, the United Nations Committee of Experts on Global Geospatial Information Management endorsed the first part of the Integrated Geospatial Information Framework and the structure and style for the rest. This is a landmark step in guiding nations on a geospatial journey. It provides both a strategic approach and the means to justify, plan and deliver geospatial enablement.

In the same United Nations meeting the Expert Committee also endorsed the 14 fundamental geospatial data themes described below; the core data themes deemed appropriate for all nations.

In agreeing these, two powerful tools were unleashed onto the global community in one meeting. These global frameworks will enable better data integration and interoperability in the public sector, and much greater innovation in both public and private sector.

2.2 Fundamental Geospatial Data Themes

Fundamental geospatial data is the framework upon which all location data can be referenced and the underpinning digital twin of the real world. The first theme is not data at all – it is the Global Geodetic Reference Framework that enables position to be determined to a common reference, so that it can be used and integrated however and wherever collected. The other 13 cover: addresses, buildings and settlements, elevation and depth, functional areas, geographical names, geology and soils, land cover and land use, land parcels, orthoimagery, physical infrastructure, population distribution, transport networks, and water. These are shown graphically, with agreed symbology, at Figure 2

The United Nations work links the themes to standards and to the sustainable development goals but it only defines themes. The authors, led by Great Britain's Ordnance Survey, fully recognised that nation and city datasets are national, and by implication, city matters. In Manchester, a smart city experiment, CityVerve, determined that data with more features at far greater detail, accuracy, content, and currency will be demanded in cities looking at future technologies, including smart and 5G. This requires different data sets to those potentially needed in Dar es Salaam, but the data themes are common to both.

Figure 2. United Nations Fundamental Geospatial Data Themes. (UN GGIM, 2018)

The authors have previously discussed the links between these themes and the sustainable development goals at national level. (Kedar, 2018) Nations such as Mongolia are using these UN themes as a basis to assess the nations fundamental geospatial data assets.

5G is a good example. When combined with fibre, 5G will provide connectivity across cities for all people and things, as illustrated during a 5G trial in the city of Bournemouth, where the City, Ordnance Survey, the Meteorological Office and Surrey University pioneered thinking on how to efficiently site 5G infrastructure. It is not just a 3D problem, as demonstrated in Figure 3, the fourth dimension encompassing seasons for foliage on trees, the timing of heavy traffic and building surfaces all must be considered.

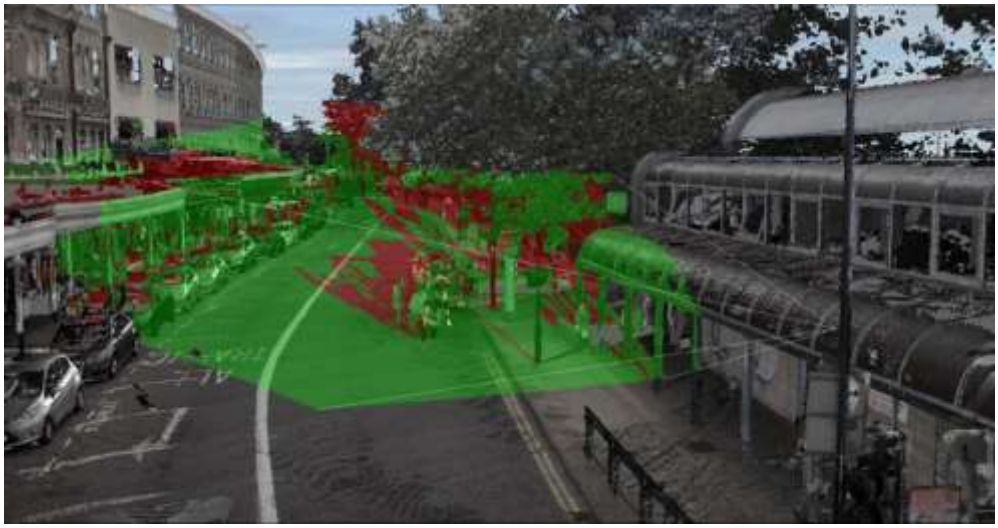

Figure 3: A 5G experiment in Bournemouth, UK, determined geospatial data requirements and algorithms necessary to efficiently deliver ubiquitous very high bandwidth connectivity to a city (Ordnance Survey, 2018)

The value of data to cities is further illustrated by Arusha in Tanzania. To collect revenue for the City, a complete geospatial database was created to support a revenue system. (McCluskey, W, 2017). That same data clearly has wider applicability for city management, planning and emergency response, for example.

The value of data integration by location is widely experienced without realisation and the framework necessary to deliver it often not understood. We see it in government - managing coastal zones in Zanzibar to balance land tenure, environmental, fisheries, oil industry, urban growth and tourist industries is a geospatial challenge. Bahrain has a significant land management challenge, there is no room to expand and already 10% of the island city state is reclaimed from the sea and yet underground assets are not well recorded, an issue that Bahrain seeks to resolve.

In some Indian cities, GI provides spatial insights on basic infrastructure, other services and facilities, and the environmental condition of slums. This empowers local Government authorities in planning and executing slum improvement plans. Sustainable planning and management of population growth and urban expansion are achieved through continuous monitoring of an area. (Chopra, R, 2016)

Climate change in the Indian Ocean impacts Bangladesh, where the monsoon season results in major changes to rivers and thus people and their livelihoods. This can only be managed in cities such as Dhaka through integrating fundamental geospatial data, statistics, environmental data, climate data and more.

3. DELIVERING ACTIONAL GEOSPATIAL DATA

To plan and manage a future city; for businesses to thrive and for citizens to feel valued with improving lives, leaders must consider how to achieve their visions. Smart provides a means towards an end for cities but cannot be an end in itself as cities will always transform as new technologies, ideas and citizen demands have materialized. Sewage systems are arguably the smartest step forward for cities. Town centre shopping was a victim of smart 'Mall shopping' long before internet shopping was developed.

Nearly all digital technology in government and business utilises location and many applications also directly use fundamental geospatial data. This utility of geospatial information provides real opportunity for cities to promote innovation, develop the digital economy and create new jobs.

Data is one part of a wider city infrastructure in two respects. The first is the 'digital twin' construct intended by UK's National Infrastructure Commission. The National Infrastructure Commission is clear: '*The UK will develop a national digital twin: a virtual model of our national infrastructure which will both monitor infrastructure in real-time and have predictive capability. This will help manage, plan, predict and understand the UK's infrastructure, delivering resilient, responsive, high-performance systems*.' A digital twin is a realistic digital representation of assets, processes and systems in the built and natural environments.

The second is in its relationship with the community, through an enabling infrastructure, users and partners with the benefits the community seeks. This is illustrated at Figure 4.

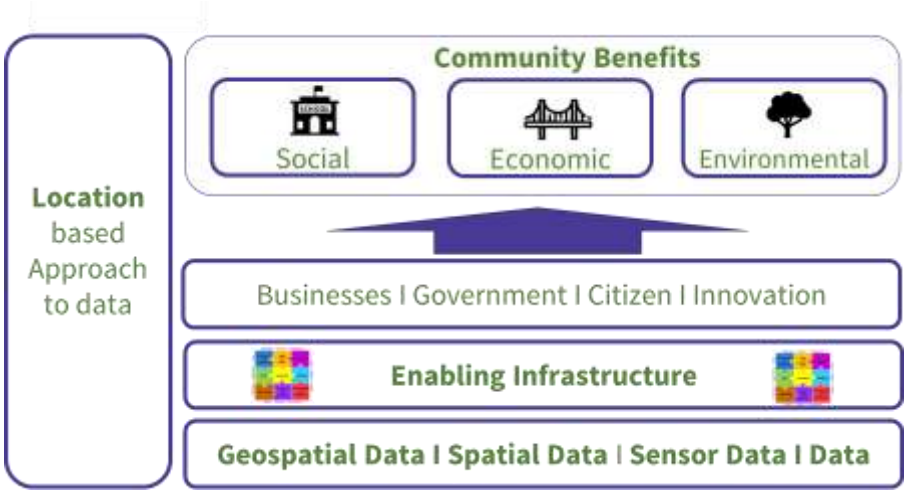

Figure 4. The relationship between Data and the community.

3.1 UN-IGIF

The enabling infrastructure can sometimes be termed a Spatial Data Infrastructure, but the term has lost impact and has a feeling of 'technicality' to it, even though very broad. However, the United Nations is developing an Integrated Geospatial Information Framework (UN-IGIF) to guide nations and cities in the development and management of their geospatial information resources. It is in 3 parts; part one explores 'why?' and is aimed at a broad readership and decision makers. Part 2 considers 'what?' across a range of pathways covering governance, technology and people. Part 3 sets out the concept and format of a national action plan that sets out the roadmap and benefits case for geospatial enablement of a nation.

The UN-IGIF is being written by experts across the World, including Ordnance Survey in the UK, and is a cooperation with the World Bank. Importantly, sustainability and the whole user community are considered in its approach. It is not just a framework for low- and middle-income countries. In 2018, just months after Part 1 was endorsed, Ireland embraced it in developing Ordnance Survey Ireland's strategy.

The UN-IGIF sets out 9 strategic pathways to guide governments towards implementing geospatial information management to deliver real social, environmental and economic benefit. These are shown in Figure 5. The are interconnected, hence the puzzle pieces. Part 2 of the UN-IGIF, in preparation during 2019, will look at each of these pathways in greater detail.

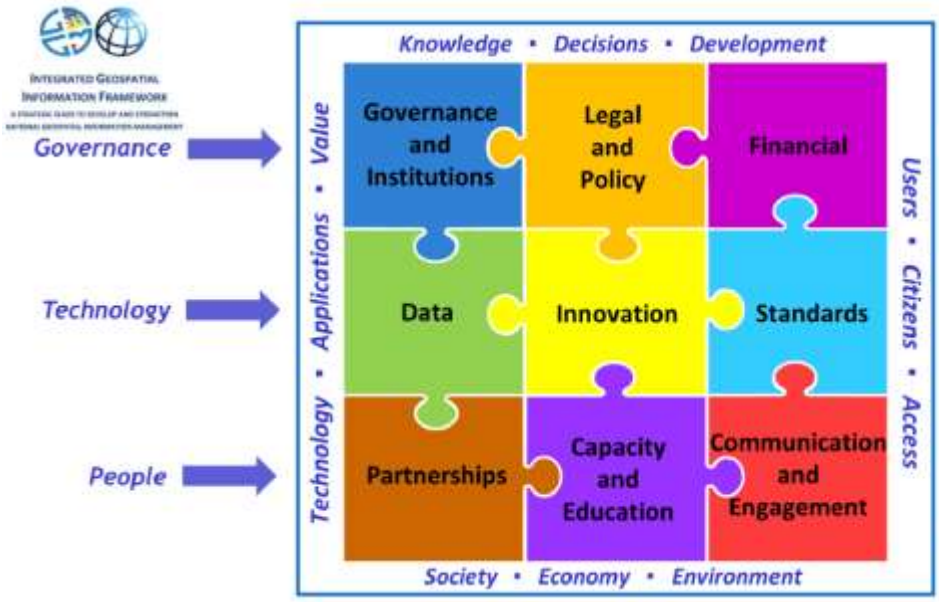

Figure 5. The UN-IGIF strategic pathways. (UN GGIM, 2018)

This paper will not reiterate the detail of this framework but rather focus on some challenges faced in meeting a city's data needs. These include:

- Understanding City and citizen priorities. (Communication and Engagement, Partnerships, Governance)
- Cost of maintained data services. (Financial, Innovation, Data, Partnerships)
- People – whether in businesses, government or are innovators. (Capacity and Education, Partnerships, Innovation
- Policy to drive new behaviors. (Standards, Legal and Policy, Governance and Institutions)
- A project approach to delivering outcomes. Transforming a city to be smart, integrated or digital is a long term and sustained programme of activity. (Partnerships, Innovation, Financial)

Note that these challenges have been linked to IGIF strategic pathways (in parentheses), to demonstrate the utility of this new framework to cities.

3.2 Understanding City and citizen priorities

A city must be connected to its citizens. All 3 visions (Manchester, Dar es Salaam and Dubai) focus partly on people: '*not live in poverty'*, '*residents feel safe'*, '*happy people'*. And to be connected to citizens the whereabouts and needs of those citizens needs to be known and communication channels open.

The geospatial community needs to reach into city leaders and converse in their language. Only by understanding policy drivers can a geospatial framework make a step-change. Rather than telling customers what they will get, cities need to start with the customer drivers, e.g.

'*Dubai, the happiest city on earth'*, and work back to the data and infrastructure needs. Then the data community must actively demonstrate the benefits that GI brings into achieving these priorities.

Thirdly, cross department governance is essential. Data will be under different departments custodianship and breaking down silos can only be achieved through key stakeholders being central to governance.

3.3 Cost of maintained data services.

The CityVerve programme in Manchester brought a range of lessons on the geospatial data required for use cases as diverse as urban environment and mobility. Such data has additional cost but innovative approaches can reduce this, including remote sensing, crowd sourcing, automated feature extraction, automated generalization. Many geospatial agencies are actively pursuing and finessing these technologies. As sensor numbers increase in cities, geospatial agencies can utilize them to help maintain current and detailed data. Such a partnership was recently announced between Mobileye, an Intel automated vehicle company, and Ordnance Survey.

Equally cities could look to existing geospatial Cloud services and reduce capital outlay, stay abreast of technology and benefit from the knowledge of a partner to get best value from location data. Bahrain only this year declared that it will move government onto the cloud, could the geospatial 'factory' sit on the cloud too? Another city/national geospatial agency may well provide the best partner in this context, sharing challenges and innovation towards common goals.

3.4 People

People make decisions and drive change. People connect with people, and common language is essential. The geospatial community must learn the language of decision makers and communicate in that language; it is about jobs, votes, tax revenues, health, happiness – and the very words in the 3 city visions above.

City residents and city visions must drive future cities – smart approaches and technologies are part of this where they add value. Do citizens prefer to know exactly how long the next bus will be or do they want to be empowered to engage with city services online? Tel Aviv has found that eGovernment services are the true 'smart city' desire of its people, so it is focusing on delivering them.

A major challenge facing future governments is the lack of skilled manpower to develop and implement emerging technologies of all types. Cities seek to build skilled work and business, whether the city vision is '*investment*', '*skilled workforce*' or '*happiness*'. Cities can help this by proactively ensuring the right training and education is available, and equally by supporting digital innovation in partnership with industry, investors and academia. In UK, a geospatial incubator in London has helped over 1000 start-ups with missions as diverse as

improving sanitation in Kenya to off-piste skiing in the Alps, creating 250 new jobs and gaining $25million investment in start-ups in 3 years. Singapore has created a similar incubator and other cities are considering similar hubs.

3.5 Policy

Little policy investment is being made into national or city geospatial capabilities, the arguments still need to be won.

The OECD stated: '*Physical infrastructure such as roads and bridges enables benefits to 'spill over', for instance, by fostering trade and social exchanges. In the same way, greater access to data also has beneficial spill-overs, whereby data can be used and re-used to open up significant growth opportunities, or to generate benefits across society in ways that could not be foreseen when the data were created. But some of the spill-overs of data cannot be easily observed or quantified…. As a result, countries – and governments in particular – risk under-investing in data and data analytics and may end up giving access to data for a narrower range of uses than socially optimal. This risks undermining countries' capacity to innovate…*' (OECD, 2015)

So, whilst the direct benefits of an infrastructure might be observable and measurable, and contribute to a business case, the spill-over benefits are not. The relative invisibility of these can lead Government to under-prioritise funding for the infrastructure. A paradigm shift is required: from government-funded data collection for its own purposes, to funding the facilitation of an ecosystem around an infrastructure.

Key to policy changes therefore, is the need to understand the true value to a city of embracing data and a location-based approach, enabled by a framework such as the UN-IGIF. Policy can then consider resources and a range of issues such as data protection and accountability, and to drive the sharing of existing data assets.

3.6 A project approach to delivering outcomes

Transforming a city to capitalize on the benefits of a location-based integrative approach takes time. There is often a desire to implement a textbook spatial data infrastructure (SDI) in a city, but a full-blown implementation is not always necessary or appropriate, indeed in many African nations SDIs have not progressed beyond draft policy or a governance committee. A typical project might deliver data but not the means to maintain it, systems but not sustainability nor capacity. In addition to its stated aims, the UN-IGIF also provides a level of assurance to city governments that its data strategies are coherent.

Solutions that simplify, build on known success but take local factors into account and deliver early success, such as actionable data and building a user base, will succeed. This explains why the UN believes partnerships, including international collaboration, is a strategic pathway in its own right.

3.7 City Geospatial Action Plans

Part 3 of the UN-IGIF introduces National Action Plans. These can equally be aimed at the City as an entity to make balanced investment decisions to be taken. Part 3 is being developed, led by the World Bank which has stated an intent to deliver 30 action plans over the next 3 years. As work in progress, there is no set model but the authors view is that there are three components, set out in Table 1. We acknowledge credit to World Bank for much of the thinking on the Roadmap and Value Assessment.

Such geospatial maturity assessments are already being used at city level. Ordnance Survey has a well-practiced model that considers maturity across 24 aspects of geospatial enablement including: business processes, stakeholders and customer understanding, data, policies, processes, technology that has ben deployed globally.

City Geospatial Maturity	**City Roadmap**	**City Geospatial Value Assessment**
Current State Stakeholder engagement City Vision and Plan City Data Strategy Future State	Stakeholders Objectives Sustainable outcomes Activities Partnerships and capacity development Deliverables Timeframe Operational considerations Risks and mitigation Budget and funding	Economic value Government revenue Social value Environmental value Political value Digital innovation Government, business, citizen

Table 1: The authors view on the components of an UN-IGIF City Geospatial Action Plan

4. CONCLUSION

Cities, whatever their visions, can benefit significantly by embracing a location-based approach to integrated planning, management and services using data from all sources, AI and deep learning technologies. At the same time this approach opens doors for innovation and new businesses. Part of the city data infrastructure includes a need for common fundamental geospatial data, supporting understanding, integration, planning, delivery of projects and services, and measurement of impact.

The UNGGIM Committee of Experts has provided a pathway. It helps bridge the ‘digital divide’ and will help achieve SDGs. It will show why a national, and/or city approach and investment is the most appropriate means to tackle the development of the institutions and ecosystem that will deliver this sustainably and propose an innovative approach to geospatial

innovation. Cities can use the UN-IGIF as a tool, and critically examine existing processes, capabilities and gaps.

The UN-IGIF will include a template for national action plans. These apply equally at city level, with national geospatial data agencies being key stakeholders. These action plans will point the way and provide justification for investment. In parallel, partnerships and new technologies, including cloud based geospatial platforms/services, may provide enhanced and more-affordable solutions to cities.

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BIOGRAPHICAL NOTES

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