Future Cities: Do Cities Have Limits?

A Workshop Summary

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On 18th April, 2016, the University of Glasgow's School of Engineering hosted a one-day workshop entitled "Future Cities: Do Cities Have Limits", funded by the University of Glasgow EPSRC Institutional Sponsorship Fund and EPSRC Impact Accelerator Account. The event was organised by the School of Engineering in collaboration with the Urban Big Data Centre, and the Glasgow Urban Lab at the Glasgow School of Art.

The workshop aimed to provide a platform for blue-sky thinking on the future of cities with a 50+ year time horizon. The objective of the event was to identify *key questions* for the deep future from a range of perspectives including engineering, architecture and the arts.

Workshop Overview

Chronological Summary

City Rules, Jesse H. Ausubel

The workshop's foundation was set by its first keynote presentation from Professor Jesse H. Ausubel, Director of the Programme for the Human Environment at The Rockefeller University in New York.

Professor Ausubel's presentation comprised an elaboration on 20 rules for cities, derived from seemingly invariant aspects of human nature. These so-called "anthropological invariants" have maintained a constant presence within the human condition for tens of thousands of years and their influence can be traced through the rise and fall of empires and the histories of cities past and present.

Humans are territorial by nature and always seek to expand the extent of their area of control or access to resources. However, this expansionism is constrained by a desire to limit exposure - humans will generally maintain a travel-time budget of a mere 60-70 minutes per day, at an expense of some 10-15% of income, and each day must end with a return to a place of fixed residence.

A city, then, is an emergent time-structure arising from the coalescence of these behavioural rules, and we should bear this in mind when designing the cities of the future - they exist, afterall, to service basic human needs.

With a fixed travel-time budget, the extent of a habitat is dictated by the speed of transport. Small, early villages relying on pedestrian transport alone span just 2.5 km in radius - the distance a human can commute in 60-70 minutes on foot - and split fractally into a reliable hierarchy - a central village, surrounded by 7 satellite villages. The motor car brings the travel speed up an order of magnitude, and with it, the radius of the city, setting up a new, larger hierarchy of towns as cities, as the pedestrian hierarchy is consigned to irrelevance.

Finally, we are advised that beauty relaxes, and is how we know we fit in the world. Therefore, the cities of the future will allow the continuing trend of reclaiming land for nature, and the cities themselves will be built beautiful if the architects are given the chance.

Design for Extreme (Extra)-Terrestrial Environments, Xavier de Kestelier

In the second keynote presentation of the workshop, Xavier de Kestelier, co-head of the Specialist Modelling Group within architectural firm Foster and Partners, provided an overview of his group's work on Lunar and Martian habitations, commissioned by the European Space Agency.

Xavier began with a strong emphasis on the importance of designing within the unique contextual parameters of each project - particularly climatologically, providing examples of such designs from Foster and Partner's global portfolio of architectural design. With that in mind, Xavier then moved on to discuss work on Lunar Habitation, which clearly provides the greatest challenges in these regards.

The moon provides a challenge from the very first step of the architectural process - taking inspiration from existing structures in the area. Given that the architectural legacy on the moon consists of 40-year old lunar landers whose functionality was required only for the length of a camping trip.

However, some inspiration can be drawn from the International Space Station and its predecessor, the Russian Mir Space Station, as the lunar habitation project shares at least one constraint with these structures - it will be made of parts launched from the Earth on standardised rockets. However, as the Space Stations demonstrate, habitations constructed based on the maximum volume of, say, an Ariane 5 rocket, make for cramped living conditions - not ideal for long-term operations. The solution, then, is most likely inflatables - structures which, when compacted, can easily fit into a rocket, but which can be inflated in-situ to a more comfortable and practical size on the moon.

The moon also provides severe environmental challenges - without an atmosphere and a magnetic field, the habitants on the moon are vulnerable to solar radiation, regular and unpredictable meteor impacts and extreme variations in temperature. Hence, after picking out a site for the moon base at the edge of the Shackleton crater near the Moon's south pole, where constant daylight and the possibility of water within the shaded depths of the crater solve at least some potential problems, Xavier proposes that a dome must be built around the moonbase's proposed inflatable internal structure. Sticking with Foster and Partner's desire to source local building materials (made more pressing by the immense cost of moving just 1kg of material from the Earth to the Moon), the dome should be built from the lunar regolith, and constructed by remotely operated"3D printer" rovers which collect, treat and shape the regolith into a strong, light cellular foam structure inspired from natural structures.

Having tested small-scale 3D printing technology of this kind within a vacuum and using moon regolith "simulant", de Kestelier is confident in the practicality of such an approach to lunar construction.

Once constructed, these regolith-covered inflatable habitations can house 4 people, and can be connected together using cylindrical corridors which originally housed the inflatable structures and act as airlocks.

Finally, Xavier extended his considerations to Mars, where many of the problems of a lunar habitation apply yet again, but under even more challenging circumstances. For one, the huge communication distances between Earth and Mars preclude the use of remotely-operated construction robots, instead requiring artificial intelligence, autonomous navigation and cooperative algorithms.

Xavier relishes the challenges though, and the technical problems do little to perturb his confidence in the future of human habitation on the Moon and Mars.

Reduce, re-use, recycle? Solving the water-energy nexus in growing cities, Paul Younger

Professor Paul Younger, Rankine Chair of Engineering within the University of Glasgow then delivered his message concerning the water-energy nexus in growing cities.

Younger started with a strong message - *respect the physics*. When it comes to building sustainable energy and water infrastructure for the future, paying mind to the physics of the system is unavoidable. After outlining some important facts about the current energy-water system (e.g. by far the most significant energy-consuming activity in publicly owned facilities is sewage treatment, and of that treatment, more than 50% of it is dedicated to aeration), Paul introduced the waste hierarchy - reduce, reuse, recycle.

With capture, treatment, distribution and disposal of water being so cost, energy and carbon intensive, we must *reduce* our consumption of water by improving our efficiency in its use, then ensure that we maximise *re-use* of water, and only then should we *recycle* it either naturally or by use of storage and pumping.

Some cities are living beyond their means in terms of water usage - peak water demand in London, for example, exceeds the natural yield of the Thames catchment, and therefore has relied on energy and carbon intensive desalination in recent years. For now this is unsustainable, but in the future the utilisation of new materials such as perforene may reduce the costs of desalination, allowing cities to normalise its use to meet growing water demand in cities.

Paul's overview of the water-energy situation in the fake garden city of Riyadh - where 40 decades of irrigation to sustain a garden city in the desert has led to flooding and the requirement to pump some 2 Ml/d of water to lower the groundwater - serves as a stark warning for future cities.

Professor Younger than elucidated on a range of water/energy solutions for future cities, including borehole cooling, groundwater cooling.

Turning specifically to the future of Scotland's water-energy system, Younger began by explaining that 55% of energy useage in Scotland is in the form of heat, and proposes that Scotland's widespread network of flooded mines may provide a heat source and storage solution, particularly in the central belt. Despite some technical caveats such as mine structural considerations and water quality, the concept is compelling, and an example of such a building operating in Glasgow's East end and pumping minewater from a borehole provides the proof-of-concept.

Finally, Younger proposes that sewer heat is also an option for meeting Scotland's heat-energy demand, citing the Borders College sewage heat-pump in Galashiels as a successful example of such technologies.

Concluding, Professor Younger leaves with a message of optimism - there are *lots* of options for increasing the sustainability of water and energy use in future cities. However, adopting these solutions requires that we cast off the silo mentality that currently operates the water and energy systems in isolation, and a reform of natural resource legislation to provide the holistic approach that is needed to maintain the life-blood the densely-populated cities of the future.

Future human and freight mobility and potential impacts on cities, Vonu Thakuriah

The cities of the future will be powerhouses of concentrated innovation and economic growth, benefiting from rampant urbanisation and the rise of mega-cities and mega-regions, according to Professor Vonu Thakuriah, Director of the Urban Big Data Centre and Professor of Urbanism at the University of Glasgow. However, with these changes will come extreme challenges - human, social, environmental and physics and economic.

As far as future city transportation is concerned, issues will be raised in providing transport for access to social and economic centres, reducing traffic congestion, reducing environmental impacts of transportation, reducing road fatalities and injuries, building a transportation network that is physically and economically resilient, structuring our cities around transport options, and ensuring sustainable funding for scalable transport systems.

Professor Thakuriah outlined the current trends in transportation: the growth of cities is linked directly to the speed of transport, and the motorised automobile seems to be

reaching the limits of what it can achieve for city growth, with vehicle numbers leveling off in industrialised countries, and leveling off at much lower levels and much more quickly in emerging economies.

There is a trend towards "mass movement transportation", with recent examples such as the Beijing Subway, the Delhi Metro, high speed rail in Shinkansen Japan, and there are exciting developments promising to revolutionise urban transport - Elon Musk's hyperloop, for example, which aims to employ MagLevs to reduce the journey time from Los Angeles to San Franscico to just 35 minutes.

So, the car has peaked in ownership, miles driven and in encouraging city growth, and a huge proportion of the urban millenial generation are rejecting the personal vehicle as the powerful symbol of personal freedom that it once was, and opting instead to lead a resurgence in human-powered transport - although this may be tied to the recent economic recession rather than a paradigm shift in cultural attitudes towards transportation. In any case, oil has likely peaked, and we are seeing changing patterns in human transportation in tandem with an explosion of ICT solutions and utilitisation of data - what effect will this have on travel behaviour? Will the data revolution increase speed, or will it substitute or compete with transportation as people give up the physical workplace for a virtual presence?

Professor Thakuriah posits that, given these trends, the near-term future of transportation could be to provide on-demand mobility services, with the aim of not just increasing speed, but of increasing choice of modes of transportation.

Five key transportation concepts that will dominate the near-term future of transportation are the:

- **Autonomous Vehicles** - vehicles fitted with sensors and impressive computing power to eliminate human error and distraction. This could be employed at the personal vehicle level, as with Google's upcoming autonomous car, or in the haulage industry where a current shortage of long-haul operators is motivating a move towards driverless vehicles.
- **Connected, Cooperative and Anticipatory Transportation Infrastructure** - future vehicles will share data amongst themselves, as well as with central traffic management centres, and other transportation management systems and sensor networks to allow individual vehicles to cooperate their manoeuvring in order to optimially utilise the infrastructure and to eliminate the possibility of accidents due to lack of road information.
- **Uberification: The Share Economy** - With the rise of companies like Uber and a whole host of similar services for sharing vehicles, bikes, activities, journeys, tools and premises, we could see a revolution in how transportation is done. This system sees the end of privately owned vehicles and replaces it with an efficient on-demand system where users pay for what they use, before they return the vehicle to the network.
- **Personalised Transport** - That is not to say that there is no room for personalised transportation, even if not through the medium of a privately owned vehicle. We could have predictive mobility systems which proactively make transport recommendations on the basis of unique behavioural data.
- **Transport Integration** - Most definitely, we will see the transportation network become integrated with a host of other supporting services, including mobility assistance, mobile-commerce, social networking, personal mobility hubs, community transportation, navigation and routing, personal and vehicle safety and security and demand management, all driven by data.

Professor Thakuriah concludes that we can expect a complete reform in city transportation driven by emerging entrepreneurs which will generate new business and novel revenue generation models. To keep up, a new regulatory and liability environment will need to be erected. We can expect this future vision of transportation to return many resources to

the cities - car-parks and streets once clogged with privately-owned vehicles abanadoned until the end of the work day will instead be available to serve the rest of the city.

We can expect a huge increase in road and transit capacity as we shrink the mobility inequality gap, and this will have consequences both foreseen and unforeseen. But of course, such developments always add more questions than answers - what are the limits to healthy, safe and sustainable behaviour-modification? What are the implications for citizen privacy and service security and who has the responsibility? What are the true effects of shared, autonomous hypermobility and "robo-chauffeuring" in future cities?

The new urban agenda and metropolitan trends in the global north, Brian Evans

The next speaker, Brian Evans, is Professor of Urbanism and Landscape at the Mackintosh School of Archiecture, Glasgow School of Art, and director of the Glasgow Urban Laboratory. Brian spoke about his work advising to the UN on cities in the the lead up to the United Nations Conference on Housing and Sustainable Urban Development - Habitat III, to take place in Quito, Ecuador, from 17-20 October 2016. In particular, he addresses the contents of the upcoming Habitat III Regional Report on Housing and Urban Development for the UNECE region.

After a brief overview of the previous 2 Habitat meetings, Brian reinforced the views of Joan Clos, Executive Director of the United Nations Human Settlements Programme, who promotes Habitat III as a paradigm shift from issues to action, with the meetings aiming "towards a city-focused, people-centred and integrated approach to the new urban agenda".

Brian then launched into an overview of the current urban trends in the UNECE region - the rural population is static, and the proportion of urban dwellers is very large. Cities are becoming more concentrated, and agglomerating with nearby cities to create super-cities in clusers, while other cities shrink. Cities are tending to sprawl as they grow in response to ageing populations and a diverse influx of migrants. Although there is a still a wide diversity between cities - with an illuminating example contrasting the carbon production of Atlanta and Barcelona - despite very similar populations, Barcelona's much smaller physical footprint leads to carbon production almost 10% that of Atlanta.

Cities have undergone an economic transition in the last two decades, with a move from centrally planned to market economies being apparent. This has been in response to the decline in manufacturing, and the rise of the knowledge and digital economies. These economic changes have huge impacts on cities, not least because digital innovation provides new tools for urban development, and the shifting economic outlook have changed the context in which that development takes place. The fact that the locations of the biggest cities correlates with the locations of the world's best universities and research intitutions is no coincidence.

Life in cities has unfortunately become more unequal in recent years, exacerbated by the global financial crisis of 2008. This has led to privitisation on a large scale, and a reduction in pure social housing. However, there is increasing support for the idea that the health and well-being of city dwellers is congruent with supporting equity in the city.

Environmentally, the UNECE region is failing drastically. The region is among the largest emitters of greenhouse gases per capita, and the cities of the region are vulnerable to air pollution, flooding and heatwaves.

City governance has also changed significantly in recent years, with local authorities taking a more cental role and fostering new city networks, while the role of the private sector in urban transformation has also increased.

The outlook for the future then is to favour compactness in cities in order to achieve equity, integration and cohesion in our ageing and diverse societies. Scientific, educational and technological excellence should be fostered to allow cities to flourish in the knowledge economy and take advantage of opportunities for collaboration, consensus and positive

action between government, stakeholders and the community brought about by the digital revolution.

Importantly, there must be a drive towards accelerated de-carbonisation of urban life to limit the effects of climate change.

Trends of urban concatenation are likely to continue in the creation of super-city clusters, fueled by short range transportation projects and the collaborative opportunities of the knowledge economy. Demographically, the ageing of the naturalised population will provide economic opportunity for migrants in successful super-cities, and more cities will make the transition from industrial to knowledge economies.

However, these trends do leave negative urban cycles in their wake - cities too isolated to enjoy the benefits of urban concatenation are likely to shrink as migrants flee to the economic opporunities of the super-cities, leaving behind surplus land and buildings, and an over-sized infrastructure which constraints future growth, and a limited tax base with which to progress. Other cities which adopt the sprawling city model will most likely suffer from dysfunctional transport systems, erosion of the function of the city core, and an over-dependence on inefficienct personal transport solutions.

Turning his focus to Scotland, Brian displays some analysis of commuting and population data for Scotland's local authorities which suggest that growth across central Scotland could result in the formation of a caledonian 'super-city' spanning Glasgow, Edinburgh and Aberdeen.

No Man's Land: Just Beyond the City Limits, Francis McKee

As we consider how the boundaries of our cities expand, Director for the Centre for Contemporary Arts Francis McKee tells us not to forget about the boundaries themselves. As the place where nature gives way to urban form, the boundaries exhibit some unique properties.

The first task in studying the city limits is to decide where they are. Cities are organic and unorganised - their boundaries are forced into existence "without choice or expectation", and often follow no distinct geometrical heuristics. Each person may have their own particular definition of the city limit. For a taxi driver, the city limits are well-defined boundaries where the fare changes; for a person with ill-intentions, the city limit could be the line where the CCTV cameras begin to point inwards towards the city centre; for a city planner, the city limits may be marked by the presence of derelict land.

Having identified the limits, McKee then takes us on a photographic tour of the limits of our home city of Glasgow, which provides a fascinating case study. We see the last-standing buildings of long-demolished developments, boarded up pubs (one, delightfully called "The Boundary") which litter the run-down main streets, non-descript industrial plants scatter the otherwise barren countryside, and a few 4 x 4 timber sleepers sloping into the Clyde leave behind the last evidence of disused dock yards. The city limits are places of decay and abandonment; sites of forgotten industries.

To the West of the city centre, around Glasgow airport, the derelict land is juxtaposed with the growing hustle and bustle of the city's main transportation hub, and the brand new campus of West College Scotland. Beautiful, modern, affordable housing developments are popping up in these areas, but the views from these homes leave a lot to be desired: vast swathes of brownfield land dominate the suburban landscape.

The city limits are also the home of informal settlements of travelers, who claim this disused land for themselves, and fill it with cars, trucks, caravans, and vehicles dedicated to their traveling trade: surreal and colourfully painted carnival rides and snack vans provide some respite from the dull grey and brown tones of forgotten car parks.

The city limits, however, are ripe for creative output, fuelled by their unique culture and historical trajectories. For McKee, 2013 sci-fi horror film *Under The Skin* starring Scarlett Johansson, which was set in Glasgow, demonstrates how the city's limits can create a unique, dark atmosphere where stories can thrive - particularly if you don't force it. Many

of the local people featured in the film were not aware that they were interacting with a work of fiction, reflecting the surrealism that is inherent in the life of Glasgow's boundary dwellers.

There is also a lot of potential within the remaining but condemned structures and facilities of the city limits. Disused swimming pools, theatres, docks, schools, gyms, etc are waiting for a new lease of life. However, as the final few photographs of Francis' presentation show, if we are not willing to use our city limits, nature is more than willing to reclaim them.

The city limits, then, are places where there exist and hidden culture that arises from their historical context. They are places where laws and regulations shift from one regime to the next, and where the cameras turn inward, providing some opportunity for criminal enterprise. They are graveyards for forgotten industries, lost communities and 19th and 20th century vitality. But they are also places of imagination and creativity, and a place where nature has the opportunity to rebound.

A History of Future Cities, Garrie Mushet

In the final presentation of the workshop, the University of Glasgow's Garrie Mushet gave a brief history of future cities from the point of view of our "futurological ancestors" - the great minds of the past who dedicated their efforts to considering how the world would be for us.

From Buckminster Fuller's notion of cities anchored to a geodesic sphere which is suspended in the air, to Oscar Newman's predictions of underground cities fed by air filters, we learned that the futurology of the past is a diverse plethora of ideas, hopes and aspirations for our cities. Some of these ideas have come to fruition - though usually not on the same scale as they were originally imaged, and others have not.

In contrasting current thinking with the thinking of the past, we see that futurology is a subject wrought with pitfalls, and more than any other field of enquiry, we must take extra care to ensure that we are systematic, critical and scientific when we approach the questions of the future, lest our biases of the present be projected into the cities of the future.

Futurology, though, is not simply the science of propagating equations and trends forward in time to see where they land; we are architects of the future with the power to tune the parameters of the equations themselves, and it is therefore vital that we do so with the confidence, ambition and optimism that fuelled the imaginative contributions to the futurology of the past.