ViableCities™
Smart, sustainable and attractive.

Artificial Intelligence in Cities of the Future

About Viable Cities

Viable Cities is a programme for innovation enabling smart and sustainable cities. It is one of 17 Swedish strategic innovation programmes jointly funded by Vinnova, the Swedish Energy Agency and Formas. The aim of this joint national effort is to create conditions for international competitiveness and address global societal challenges. Viable Cities is coordinated by KTH.

Table of contents

1 Liquid Roadmap

Viable Cities is a member-driven strategic innovation programme that will run for 12 years from 2017 to 2030. Special attention is given to member involvement and engagement, a common understanding of the programme, and a joint vision. This requires open and transparent cocreation processes for framing the programme's strategy. The Liquid Roadmap is one out of four strategic projects within Viable Cities and it is future-proofing strategic developments in the programme, using methods like networked foresight to control myopia and bias and to keep individual members active in the pursuit of long-term goals for smart sustainable cities.

To ensure the largest possible impact, the Liquid Roadmap strategic project started early on Day in Viable Cities, in January 2018, and it will run throughout the programme. Efforts include continuous renewal of the strategic agenda, and supporting exchange across thematic areas and sectors. It engages internal and external experts in the field to inform the discussion of the future strategic direction of Viable Cities, with a 20-year future outlook.

The goals are:

1. Unify and fix a shared vision of Viable Cities as smart and sustainable urban environments.

2. Identify and analyse drivers (trends and key uncertainties), challenges (including risks, vulnerabilities, and ethical issues), and opportunities for transition to viable cities.

3. Build a common understanding of key developments (institutional, technological and social) necessary for transition to viable cities.

4. Challenge the prevailing assumptions, attitudes, values, and norms connected to the development of smart sustainable cities.

5. Explore paths to viable cities, with sensible choices for future generations, and identify "no regrets" paths, taking disruptives as possibilities, and considering systemics (systems of systems, complex systems, feedback loops, cascading effects).

6. Define priorities for programme activities and participatory means to cooperative work.

2 Purpose

Sweden is currently pushing artificial intelligence (AI) to improve governmental services, planning, and policy in a cross-industry and cross-organisational fashion, making it possible for the Swedish government to understand how efficiently AI is used in industry and in society in general [Vinnova 2018]. For smart sustainable cities to be realised at their full potential in the future, AI must be employed for some of the technological functionalities required. How smartness will be realised in practice is an unknown, and no single individual or organisation can future-proof ideas for its realisation: large companies and even nation states (China being a case in point) are currently rolling out future AI agendas.

This report provides the reader with an outlook from a Swedish perspective, but the exact same problem is addressed internationally in many current projects and government initiatives [Lorimer 2018]. Societal concerns about the role that AI can play in the face of the 2008-2009 financial crisis are global. If AI is to secure democracy and help build open and free societies is to a large extent about how we as citizens use it in practice, and how we envision using it in the future. Coupled with other technological development strands (notably Internet of Things, Cloud computing, 5G, and Big Data Analytics), it provides a digital infrastructure.

In an optimistic future scenario, this digital infrastructure makes realisations of physical infrastructure like energy systems and transport systems easier and more efficient. This in turn takes load off the financial infrastructure like banks and insurance companies, and ultimately the households.

This report rests on the assessments and opinions from experts working with members of Viable Cities, providing a picture of what this member organisation can do already, and where the white spaces are. In particular, goal 3 above is addressed, challenging the most optimistic future scenario. The constructive critique that must underlie such a goal makes the challenges expressed in this report sound absolute at times, when they in fact are possible and probable to a very varying extent. Within Viable Cities, an internal consolidation process was also realised in terms of a SWOT analysis on AI for smart sustainable cities of the future [Boman & Kordas 2018], put together (quickly) for Vinnova. Refining that SWOT is not part of the purpose, but rather a positive side-effect. The purpose is instead to support the Viable Cities roadmapping process with concrete input to the foresight process (Figure 1). As a part of this process, this document will inform future steps in roadmapping, and also be used as a firestarter for discussions in a Methodology group, also part of Liquid Roadmap. That group had its inaugural meeting in the autumn of 2018 and its members are studying various methodological aspects of viability, with the hope of informing program policy and guiding the co-creation. Here, we consider AI methods and tools as strong components for success. We

also hope that this report might prove useful to industry strategists, to researchers working on smart city technology, to teachers, and to city analysts or planners.

Figure 1: Addressing the challenges of a partner-driven innovation program

3 Method

Where are cities today, and where are they in 20 years, when it comes to the employment of artificial intelligence (AI) techniques? This question was at the centre of a workshop held in Stockholm on May 14, 2018. Around 20 participants conceived and wrote down ideas, concepts, innovations, and concerns. Individual efforts were complemented by speedwriting in groups. The overarching method used was networked foresight, a kind of future outlook open to member organisations that may form trust networks with colleagues, possibly even with competitors. This report constitutes part of the output of the workshop and of the digital co-creation that followed via shared digital documents. Other tangible outputs include so-called innovation profiles, the Viable Cities chosen format to understand important future events. Intangibles include consolidation of ideas, networking between Viable Cities' partners, and ideas for new partners.

Olga Kordas and **Magnus Boman** led the workshops, edited all the co-creation material, and contributed desktop research for this report. Three people involved with Liquid Roadmap, not attendees of the workshop, have peer-reviewed earlier versions of this report, namely **Jakob Rogstadius** (Scania) and **Lena Smidfelt Rosqvist** & **Christer Ljungberg** (Trivector). In addition, **Sebastian Knab** (Rohrbeck & Heger GmbH) provided workshop support and important technical assistance. Last but not least, Viable Cities chairman of the board **Allan Larsson** provided perspectives on the purpose of this work as well as insights into various long-term strategy concerns.

4 Findings

There are two decidedly different futures associated with the city of 2038. The first is the future of any city, even a mega-city, being only a tiny part of a globalised world, in which the city borders mean very little. This is a highly connected world, not only with respect to energy distribution and consumption, but also to policy making, regulations, and democracy. The second is that of a city constituting a meso-world, more resembling a company or a gated community than a city of today. The macro-world (our planet) is then a network of meso-worlds (our possible future cities), inhabited by micro-individuals (us, as citizens).

The first future perspective sports open borders, few restrictions on markets, loose regulation, but possibly lots of government and company control of citizens, in the form of surveillance. Cities, regions, districts, and countries as we know them today are perhaps not very relevant in this perspective. The AI techniques, methods, and algorithms in the hands of a government in 2038 can be used globally, as the concept of "international" becomes meaningless. There can still be federal or local laws and regulations, but only one world government is there to optimise what is today our cities, even if places will still be called things like "Malmö".

The second future perspective is a network in which a node (i.e. a future city) is not only defined by what happens within its geographical or judicial borders, but also by its neighbouring nodes, the strengths of its links, and other so-called network effects.

Both of these possible futures are speculative rather than factual, and they can be analysed in terms of (i) technology development and (ii) its employment and appropriation by citizens. They are not mutually exclusive, and policy makers of today could do worse than beginning to consider them as at least possible futures. The two perspectives can also be analysed in the light of two outlooks that can be utopian or dystopic, depending on who you ask, namely those of "able people" and of "able machines".

4.1 Technology Development

Personal assistants is a promise so far not delivered upon, which arguably started with Apple's famous idea of the Knowledge Navigator [Apple 1987], continued with the company's introduction of Siri in 2011, and still ongoing, across industry. If and when it arrives, AI pets of various guises help you with physical as well as logical tasks, at home and at work. City planners, policy makers, and architects will have them too, perhaps even with brain-computer interfaces. AI will take care of all transactions (e.g., leases, contracts, rentals) in secure distributed ledgers.

Likewise, adaptive, autonomous, and automated transport is not yet everywhere, far from it, but it might be in 2038, contingent on laws and norms of future cities and their governance. With a time plan today of replacing the current vehicle fleet around 2035, it is conceivable albeit not highly probable that no one owns a personal motorised vehicle a few years later. Self-calibration, self-repair, and self-organisation of automated transport provide reference data, useful to furthering the ways in which intelligence can be utilised, e.g., for load balancing to keep the traffic flow optimally efficient and safe. AI enables short- as well as long-term city planning: voting for the new rugby centre, or on prioritising the transport solution for it.

All aspects of the city business ecosystem will be affected, and AI business model creation and testing will be a way to quickly analyse possible scenarios to e.g. assess environmental risks and stability. It is possible that some parts of some business are even run or at least controlled by AI, and an AI system might submit patents, certify procedures, control drones that inspect building safety, or other tasks today performed by humans. This would impact taxation, labour unions, employment, accountability legislation, intellectual property rights, and much more. A virtual infrastructure for AI might work as a sandbox: an experimental testing ground for AI. In particular, AI for optimising logistics for events is ubiquitous and low cost. To understand the true driving forces in partnerships, bringing down the walls in collaboration, then becomes possible. Resource location, allocation, and access are all provided by AI, in real-time. Everything has the potential to come online, and to link to sensor networks that provide open interfaces to flows of energy, water, air, wind, and people. AI techniques allow for more distribution in, e.g., energy consumption and production. AI support for global energy and climate efficiency will be operational at all times, providing decision makers with reliable online information.

4.2 Technology Employment and Appropriation

In the best possible employment of AI, the A no longer stands for "Artificial". Instead, just plain intelligence is offered, to be employed in real-world problems like increasing the quality of city air, or decreasing noise pollution. People in this way relearn what intelligence can be. Ethical AI algorithms are available for free or at least off-the-shelf, and possibly as black boxes. People do want guarantees in order to delegate tasks that require trust, in particular to machines, also in the future. Hence, any black box should either be possible to open up for inspection (unlike a car engine or an Apple computer today) or be interpretable as is, without much effort. Without this, there will not be enough acceptance. There is also a flipside to this thinking. As we start placing demands on the transparency of AI decision making, we also need to start thinking seriously about whether or not the same principles should be applied to human decision making. Much human decision making today can be considered, or can at least be experienced as, equivalent to black-box algorithms. Humans cannot explain their reasoning behind driving, speech, mistakes during product assembly or development, painting, employment decisions, disaster response, city planning, etc. Not to mention systemic

effects such as climate change, overfishing, migration, contagious disease outbreaks, or employee burn-out, which are all collective consequences of many individual human decisions. Who would ever want a human to make a decision if the machine can, at least on the average, make a better decision AND be more transparent with its decision process?

There are currently bias problems in AI that require transparency, accountability, credibility, and trust. People need to believe AI can provide or constitute the best possible system, and be prepared to transfer rights to the system. If they do not believe this, it is probably not true. People need to trust both data and algorithm, and possibly authorities too. In a double-sided game of "Who's the winner, who's the value gainer?", liability and fairness issues create expectations of value to get user consent:

- What do I give to the system?
- What's in it for me?
- What are the trade-offs?
- Are there hidden agendas?

Open data provided by cities fuel initiatives for further sharing that data, in top-down (government control) as well as bottom-up (citizen control) fashion. Open data should also be compared to general shareable data, in a "lose control vs. loose control" perspective. What does accessible data mean in 2038? Following standards of today might be less important in a city where much more data and information is easily available to all citizens. The same goes for marketplaces for data, they might be ubiquitous but they might also be superfluous.

In cities, all incident reporting is automated or just a click of a button away, thanks to the massive amounts of data available, analysed with the help of AI techniques. Does this create a 1984 society of surveillance and control, or just a safer environment for the city inhabitants? The AI becomes the ear, as it helps cross both digital and physical streets. Any city needs start-ups to create a playground for the new ecosystem. With AI, the microprosumers will possibly enable such a transformation. For instance, how could AI contribute to the transformation of a city's energy system, e.g. district energy, or to consumers as producers? Is open policy needed?

4.3 Able People

People might get logical twins, sometimes referred to as "digital doubles", in mirror worlds. In the real world, they might also have physical twins, which augment or replace them for certain tasks, although this most likely lie beyond 2038 for full implementation (cf. [Gelernter 1991]). There is also a possible focus on what human life will be like in these future cities. What will the sketched developments mean for the way we live and the way the city works for us? How will able people move? Live? Eat? Shop? Play? How will transport, electricity, and waste flows be affected by how these able people move around and meet?

AI and open data will lead to a rethink of democracy, it is often said, but how is this to be interpreted? Will AI provide high quality decision support to city governance and its servants responsible for policy implementation, or will those people simply be replaced by AI? In a two-speed democracy, AI is a supporting system, not a replacement. AI systems that take data and make decisions automatically, by looking at citizens' profiles, will be everywhere in 2038. Today, sometimes decisions made in and for society are not based on science, and AI-driven transparency could change this. Replacing or complementing judges, physicians, and politicians with AI (as the arguably logical step after pilots, bus drivers, and pop stars) will affect city governance. Individuals working in governments and companies can think beyond procurement, and move to innovation partnerships. Ideas can be generated within flying drone taxis and shared literally on the fly. There is a gap between replacing politicians with AI and seeing human support as a premium service worth paying for, and it is conceivable that this gap will take a lot longer than 20 years to fill, for both technological and social reasons.

When most work duties become unnecessary, this will lead to a complete rethink of today's societal economical structures. This has happened before, so it is not revolutionary in that sense. In the U.S. late 60s "revolutionary" city climate, there were plenty of analyses of the tension between citizens and the policy makers that governed cities, the most famous probably being the citizen ladder of participation [Arnstein 1969] (Figure 2). Democracy aspects are in 2038 still about litter on the streets, with garbage bins that signal for it, but also about things like an "AI translator for the people", allowing translations not just between languages, but between cultures and contexts, in real-time. As members of an open government, people use their smart whatever. This leads to a responsive city. In an immediate or "instant democracy", all types of reporting by citizens is made easy, like speaking through any device at hand. Feedback should likewise be easy to receive and understand.

Figure 2: The ladder of citizen participation, as defined by Arnstein
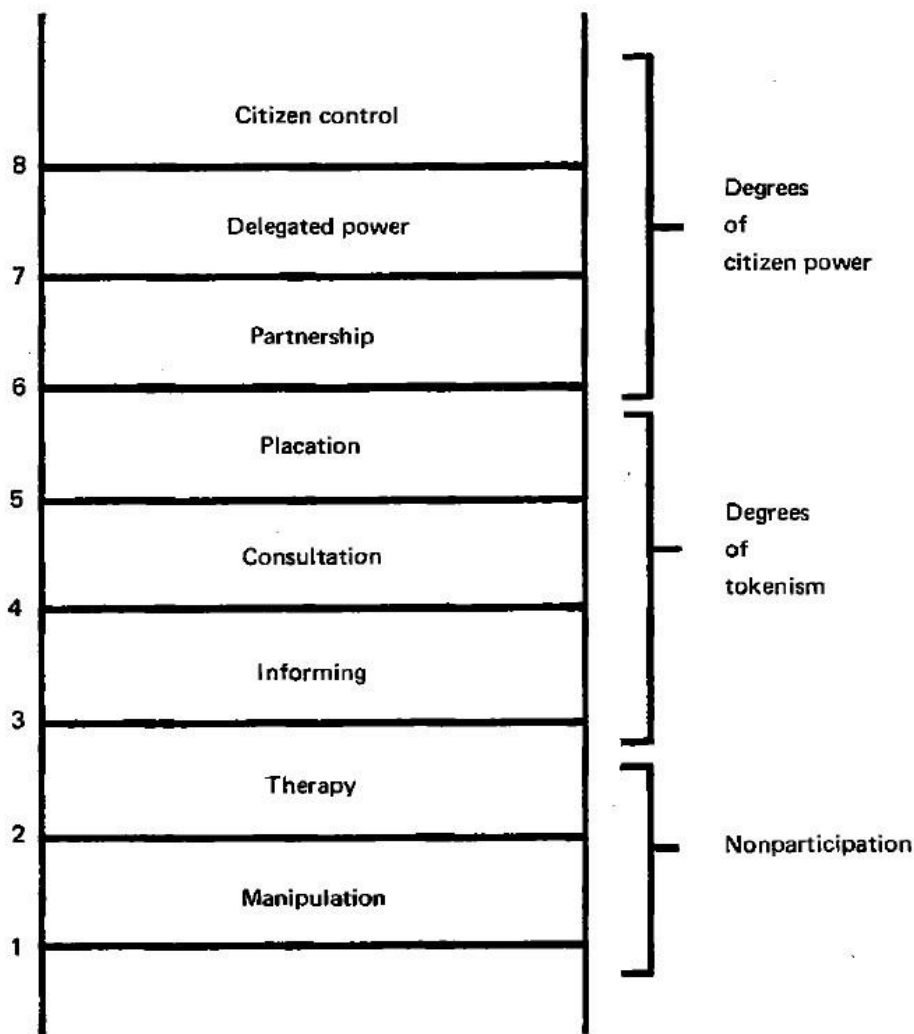
Remark: the lower rungs (1,2) are about educating citizens without giving them any power. The middle rungs (3,4,5) can use citizens as proxies for power but can also give a voice to the citizens powerless today. The top rungs actually put the have-nots in real partnerships (6) and ultimately in power (7,8). For a full explanation, see e.g. [Lithgow 2006].

4.4 Able Machines

Meta-intelligence, learning how to learn, is the way to 2038 for AI development. There is already a system of systems, and there is a feedback mechanism in the current system.

Machines too need to understand the culture: before you succeed, first you need to make mistakes. You cannot have fixed cultural norms in the system from the start, as this is a moving target, and people live by norms that are value-based. What was accepted 20 years ago is not accepted now, and the same goes for 20 years into the future. Transparent and interpretable AI is the target, challenged by the possible lack of

human trust. There is a trade-off between optimised machine learning code and interpretable machine learning code. AI techniques must be smart and also fair, with a common value base, which must be inspectable. A promise or a threat lies in "moral machines", depending on where the morals come from: ethical machines is what people really want. Machine to machine, or Robot2Robot, communication will be everywhere in the AI-powered responsive cities of 2038. AI algorithms audit, and there is transparency in transactions. Any government decision, e.g. about paying a fine, should be explainable, and the driving forces behind it should be clear.

5 Take-Home Message

There are tensions between technological development and appropriation, and between able people and able machines. To illustrate these tensions, we use one four-fielder for each of the two perspectives. In tech utopia, the upper left in Figure 3, technological development enables people support for doing the right thing, at all times. If machines are enabled more than humans are, upper right, the climate problem can be solved, not just for some cities but for the entire 'one-city planet". If people are enabled and enough trust is there for fullblown appropriation, lower left, the uppermost step of the ladder of participation can be reached. With fully able machines, lower right, and enough citizen trust, the dream of ubiquitous computing can be realised [Weiser 1991].

*Figure 3: The macro perspective four-fielder, emphasizing the "one-city planet"*
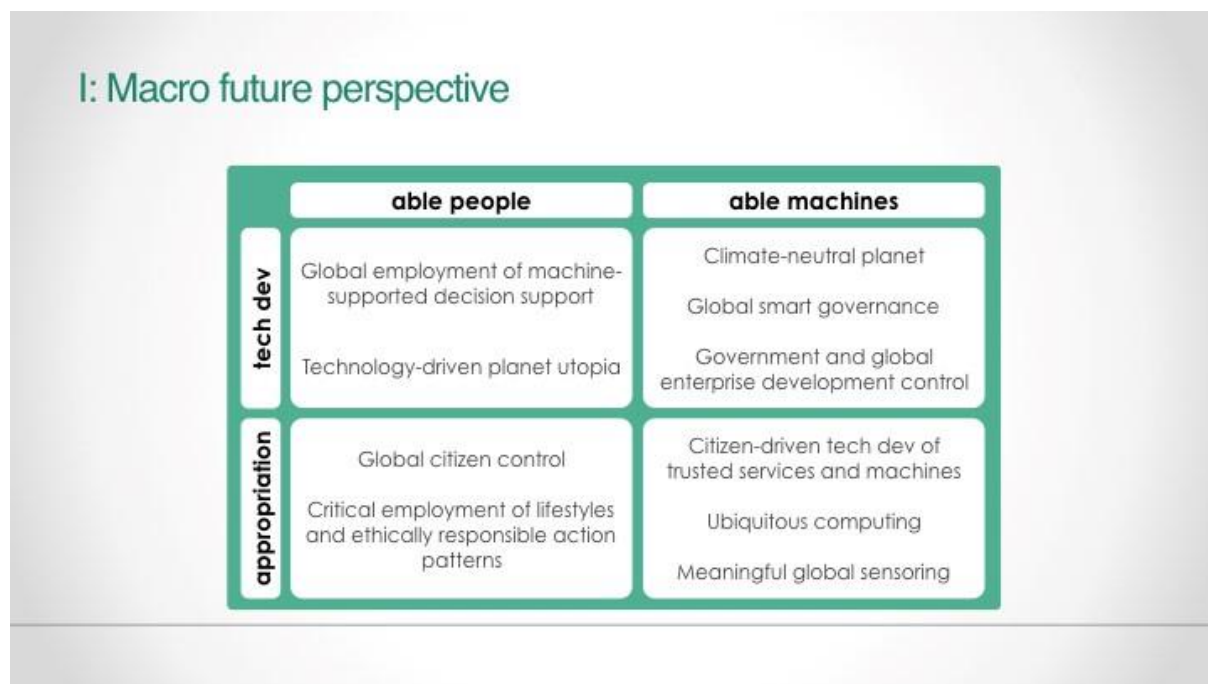
A somewhat lightweight example of which kinds of gaps that AI employment can create could in 2038 feature a premium service which is human, and a basic (affordable) service

which is AI-provided. You go to a clothing service and get your sizes automatically, while in premium mode, you have a human assistant. Pilots used to switch on the auto-pilot, now it is the other way around. Customising and bespoke companies might be more successful, for instance; if you can afford it, you go for a Morgan luxury car, human-made all the way. This possibility and its resulting gap could lead to a new aristocracy, and more generally, to further stratification of the human population.

There is segregation between people who follow what is dictated by AI technology and those who do not, and in the meso perspective (Figure 4) the extent varies a lot between cities. The meso perspective is very heterogeneous compared to the macro one. There could be some social groups that follow one set of principles and technologies, and others that are different in that applied AI would look different in cities in EU, China, and the U.S., for instance. There are lots of drivers for keeping cities separate in the meso perspective, keeping citizen migration as difficult as it is today, with transnational agreements like those of today's European Union. This entails a huge difference in city development, probably accentuated as compared to today, since AI technologies will face very different geopolitical and economic circumstances in this perspective. A radical example is that an intensional community with a few hundred people in a 2038 city can adopt AI full on, while another may choose a luddite (non-technological) basis for their community, excluding AI employment entirely.

Figure 4: The meso perspective four-fielder, emphasizing network effects and heterogeneity
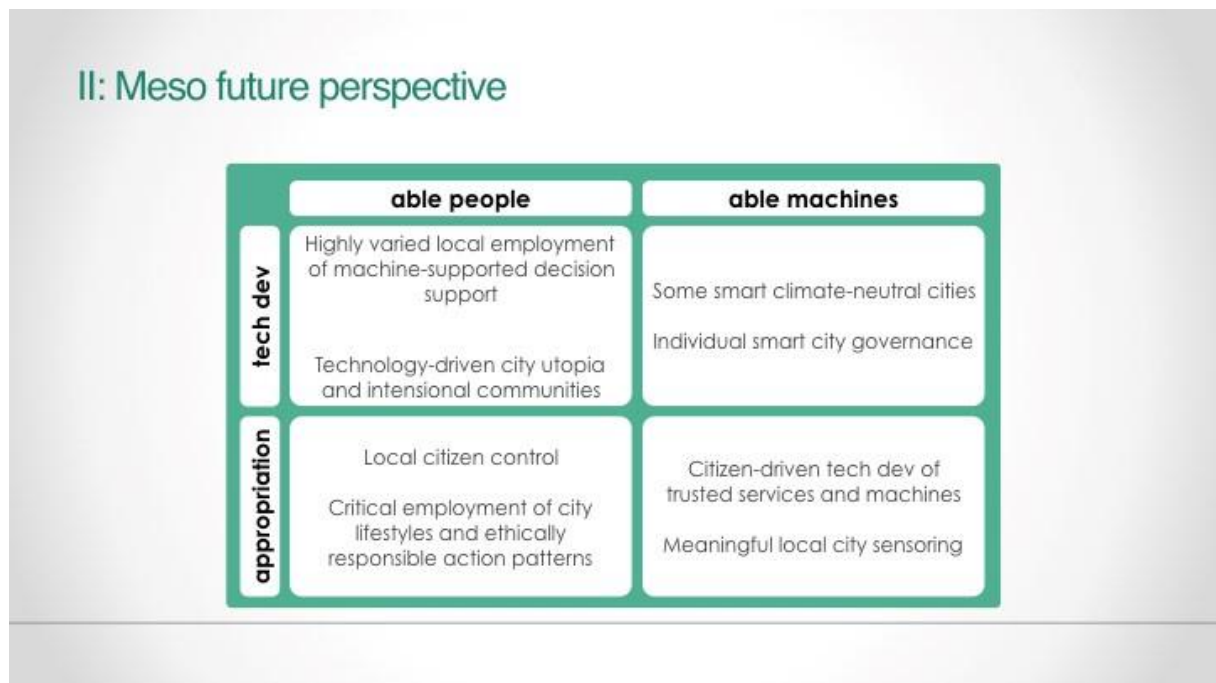
References

Apple Computer, Knowledge Navigator, promotional video, 1987
https://www.youtube.com/watch?v=mE2Z30pyw8c

Arnstein, S R. A Ladder Of Citizen Participation, *Journal of the American Planning Association* 35(4):216-224, 1969. DOI: 10.1080/01944366908977225.
http://www.participatorymethods.org/sites/participatorymethods.org/files/Arnstein%20ladder%201969.pdf

Boman, M & Kordas, O. SWOT-analys av hur artificiell intelligens och maskininlärning påverkar Viable Cities, Viable Cities INFO 2018:1, April 2018. In Swedish.
http://media.viablecities.com/2018/05/2018_-1_Viable_Cities_info-SWOT_AI.pdf

Gelernter, D. Mirror Worlds Or the Day Software Puts the Universe in a Shoebox - How It Will Happen and What It Will Mean, Oxford Univ Press, 1991; The Economist special report (Dec 3, 2011).
https://www.economist.com/node/21540383

Lithgow, D. A Ladder of Citizen Participation - Sherry R Arnstein, in *The City Reader*, 2nd ed., R. T. Gates and F Stout (eds.), Routledge Press, 1996.
https://lithgow-schmidt.dk/sherry-arnstein/ladder-of-citizen-participation.html

Lorimer, S. How our plans for Smart London compare to other world cities, *Medium*, Feb 6, 2018.
https://medium.com/@SmartLondon/the-vision-for-smart-london-and-how-it-compares-toother-world-cities-8c5bbde903b5

Vinnova. Artificiell Intelligens i svenskt näringsliv och samhälle. Vinnova rapport VR2018:08. 2018. In Swedish.
https://www.vinnova.se/publikationer/artificiell-intelligens-i-svenskt-naringsliv-ochsamhalle/

Weiser, M. The Computer for the 21st Century, *Scientific American* 265(3): 94-105, 1991.
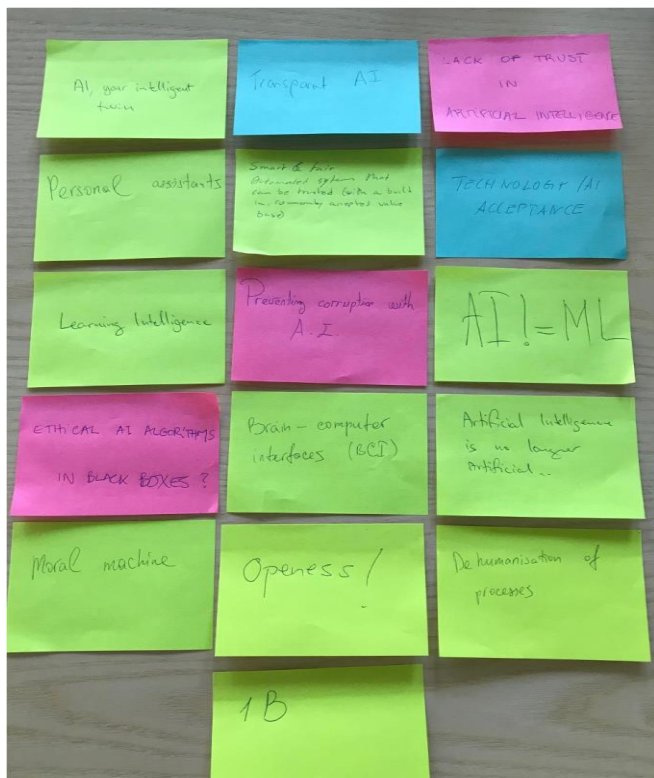https://www.jstor.org/stable/24938718

Appendix 1: Individual Workshop Notes

The individual brainstorming session at the workshop resulted in a number of notes, pictured below, and grouped into four clusters for the purpose of organising the group sessions that followed (Appendix 2).
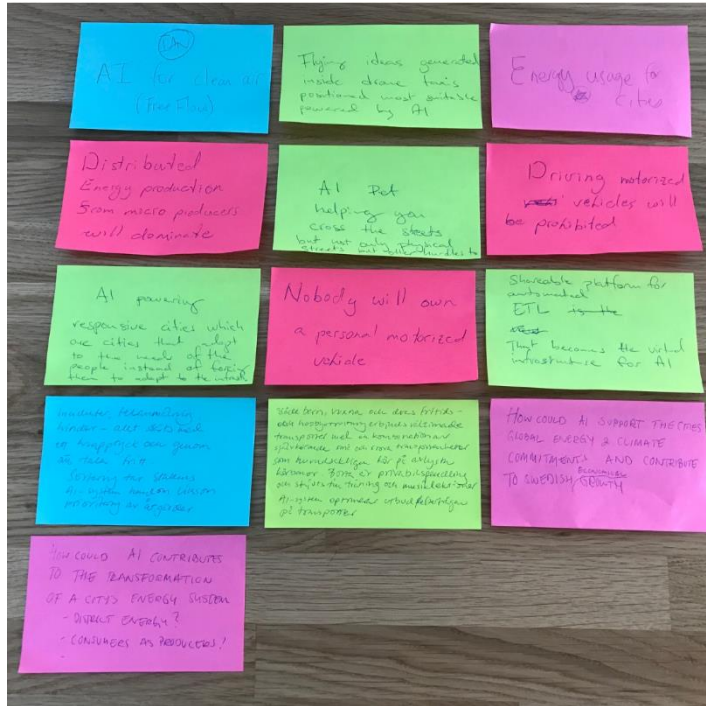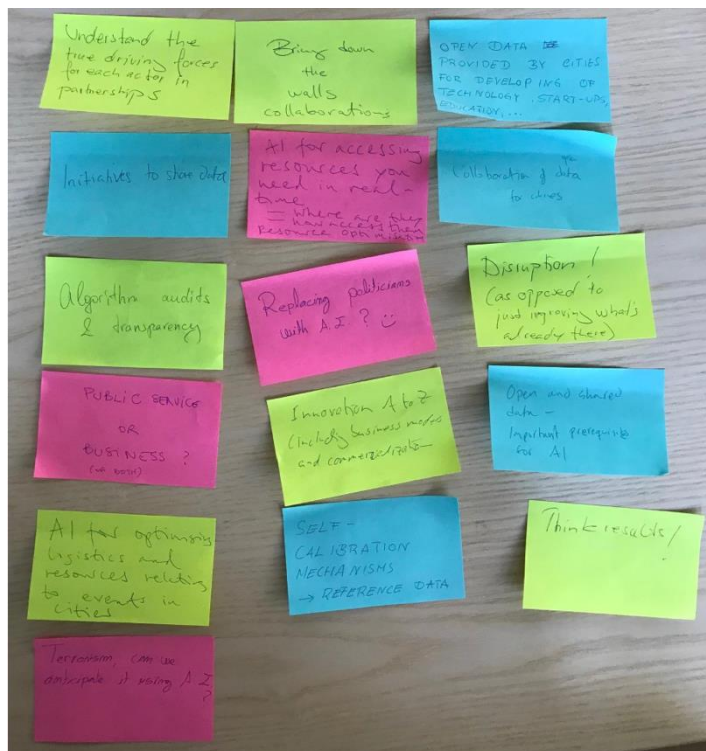
Session 1A: New and Cross Tech
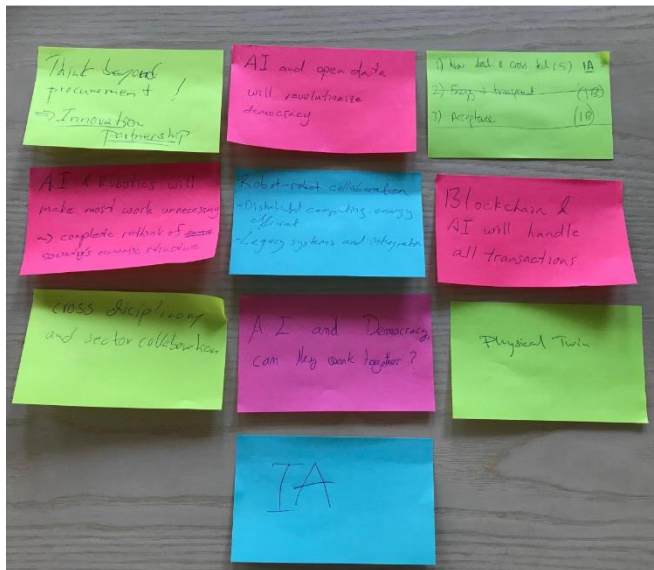
Session 1B: Mega-intelligence is the solution

Session 2A: AI applications

Session 2B: Closing the gap

Appendix 2: Group Workshop Notes

Each of the four themes discussed at the workshop produced notes, as a result of a 13minute speedwriting session, presented below with some post-editing and streamlining by the Liquid Roadmap team. The numbering comes from 1A and 1B first having been pursued, in parallel, followed by 2A and 2B.

Session 1A: New and Cross Tech

Transformation change to new citizens: transform to disrupt, use to the end.

Democracy aspects, littering on the streets, garbage bins that signal. AI translator to the people! Open government, people use their smart whatever. Responsive city. Social / Traffic - social traffic.

Sentiment(al) analysis

Demographic issues: people. Moving to a city and then moving away. Loneliness (Kungsholmen).

Data social issues
Open data vs. shareable data (lose control / loose control). Accessible data. Following standards. Important: Marketplace for data.

Technology
Blockchain important: AI trustworthiness. Making sense of algorithms (interpretability). Deep learning: AI filter bubble. People in the loop.

Interplay
Physical twins (Traffic light in Kista). Robot to robot. Autonomous vehicles. Eavesdropping machines (eavesdropping-machines): vehicles talking.

Future
Beyond procurement. Think ahead! Results in an ecosystem.

Session 1B: Mega-intelligence is the solution

Bias problems require transparency, accountability, credibility, trust: People should believe it is the best possible system, and be prepared to transfer rights to the system. The data you feed the system with, how do you ensure it is not corrupted in the process? You need to trust both data and algorithm, but is trust in authority required?

Double-sided game: Who's the winner, who's the value gainer? Liability and fairness issues create expectations of value to get use consent:

- What do I give to the system?
- What's in it for me?
- What are the trade-offs?
- Are there hidden agendas?

Meta-intelligence, learning from the meta-level, is the solution. There is a system of systems, and there is a feedback mechanism in the system. You need to understand the culture: before you succeed, first you need to do mistakes. You cannot have fixed cultural norms in the system from the start, as this is a moving target, and we live by norms that are value-based: What was accepted 20 years is not accepted now. We care less about integrity now than 20 years ago, for example. But it is questionable if the culture of society will change.

There is segregation of people who follow the technology and those who do not. There could be some social groups that follow one set of principles and technologies, and others that are different. Applied AI would look differently in EU, China, and the U.S.

The gap that AI can create holds a premium service which is human, and a basic (cheap) service which is AI-provided. You go to a clothing service and get your sizes automatically, while in premium mode, you have a human assistant. Compare: GMO seeds are cheaper now, but they were more expensive than organic seeds in the beginning. British companies would be more successful, for instance, if you can afford it, you go for Morgan. Driving will be prohibited, though. Will there be a new aristocracy?

Session 2A: AI applications

Immediate democracy: Make all types of reporting as citizens easy, like speaking through the mobile device at hand. Littering on the street, for example.

AI enables short- as well as long-term city planning. Voting for the new rugby centre, or on prioritising the transport solution for it.

Seaminglessly **Seamless infrastructure.** Adult (or children without a parent) transport via small pods. You are offered pods with goods or people.

In the future, people will think: what we did in the past is wrong. Energy distribution from micro-producers will dominate. Driving will be prohibited, because self-driving is so much safer. Why use door-to-door delivery?

More integration with AI in, for example, Nexus.

Waste-waster

Fusing data. AI for clean air, free flow. Sense the fusion, where are all things (where is everything?), temperature, **combining data-sources is needed**, as in wind and pollution. Clean the data first. (Other SiPs - combine!)

Local habitat. Vertical infrastructure to play. Responsive city. The AI becomes the ear: AIs help you cross both the digital and the physical streets. We need start-ups to create a playground for the new ecosystem. With the AI, the micro-prosumers will enable the transformation. How could AI contribute to the transformation of a city's energy system, e.g. district energy, consumers as producers? Is open policy needed?

We need an humanisation of AI: it is not something artificial. Open lab-student. The energy system, on a system level not involving vertical themes. A particular view on energy and AI is applied. Only able people in the future cities. Private and physical data, what is Sweden's position in this? Young people do not care about private data.

Competition, you can not handle it. For example, if Telia and Telenor is competing, you can not do "bad things".

How could AI support the cities' global energy and climate commitments, and thereby contribute to Swedish economical growth?

Session 2B: Closing the gap

Closing the gap between politicians and citizens

Combining, in a two-speed democracy. AI as a supporting system, not a replacement. AI systems that take data and make decisions automatically, by looking at citizens' profiles. Is direct democracy based on AI a possibility? Sometimes decisions made in and for society are not based on science.

City decisions sometimes must rely on data and facts, not politics or political factors. A separate rationale from politic interests. Machines should be objective, expose the rationale, and not be affected by political interests. AI systems could even be used for detecting any hidden agendas among politicians.

Open Data is the key to transparency. The Open Data strategy should focus on providing the information needed, and the corresponding answers.

Driving forces should be transparent.