Urban Mobility utopias: alternative approaches to deal with mobility in denser urban fabrics

Utopias da Mobilidade Urbana: métodos alternativos para lidar com o desafio da mobilidade em tecidos urbanos mais densos

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ABSTRACT

This article derives from an international collaboration created for two MSc theses with matching interests, both held in T.U.Delft, in The Netherlands, in 2012, by one Brazilian and one Italian Architect and Urbanist, same authors of this text. The aim of the original collaboration was to investigate the phenomenon of urban densification and learn from existing urban relations in dense scenarios, in a search for ways to create the “future city” within the fabric of the current one without compromising its spatial quality. This article compiles parts of those theses that relate more to Urban Mobility and to the analysis of the City as a living organism. The question raised is: what is the future of mobility in this dense and complex scenario of tomorrow’s cities? Then investigation leads towards previous researches that seek for alternative strategies, with the creation of new layers for the city, as well as to instigating projects, both realized and utopian, that push the boudaries of creativity and technology when concerning to Urban Mobility.

KEY WORDS: Urban planning, Future, Architecture, Urban densification, Mobility.
**RESUMO**

Este artigo deriva de uma colaboração internacional, criada por ocasião de duas teses de mestrado com interesses afins, ambas defendidas na Universidade Técnica de Delft, na Holanda, em 2012, por um arquiteto e urbanista brasileiro e uma italiana, mesmos autores deste texto. O objetivo da colaboração original era investigar o fenômeno do Adensamento Urbano e aprender com relações arquitetônicas existentes na busca por estratégias para criar a “cidade do futuro” dentro do tecido urbano da cidade atual sem comprometer a sua qualidade espacial. Este artigo compila as partes dessas teses que são mais relacionadas à Mobilidade Urbana e à análise da Cidade como um organismo vivo. A questão que se coloca é: qual o futuro da mobilidade nesse cenário denso e complexo das nossas cidades de amanhã? A investigação leva a pesquisas anteriores que procuram por estratégias alternativas para mobilidade em cenários densos, com a criação de novas camadas para a cidade, bem como a projetos, tanto utópicos como construídos, que expandem as fronteiras da criatividade e da tecnologia quando o assunto é Mobilidade Urbana.

**PALAVRAS-CHAVE:** Urbanismo, Futuro, Arquitetura, Adensamento Urbano, Mobilidade.

**BACKGROUND**

In the current context of exponential growth of the global urban population, a series of issues connected to this phenomenon are coming to the surface. The UN Department of Economic and Social Affairs projects that by the year 2030, 60% of the estimated 8.2 billion people on earth will live in cities.¹ In that sense, the dilemma is not in the growth of population itself but in the limited response that our increasingly saturated cities are able to provide. The space available to host this load of people is, in fact, finite.

As a consequence to this phenomenon, cities can react in two ways: they can grow horizontally, covering more area, or become denser, decreasing the available amount of space per person. On the one hand, it is a case of simple expansion, while on the other it involves a process of metabolic regeneration. (DAHIDEN, 1972) This kind
of space recycling process, as an ‘inward expansion’, was very common in medieval towns, where growth, limited by walls, was achieved by increasing the density of the existing urban area.

Nowadays the same restriction is imposed by different limits. When cities spread horizontally, in a phenomenon called Sprawl, eventually they start clashing with neighbour cities, creating a well-known and studied kind of urban structure: the Conurbation. This clash between urban areas is widely happening worldwide and represents a strong physical limitation for many cities. At the same time, when not provoking clashes with other municipalities, sprawl often swallows the countryside and agriculture areas, which are slowly disappearing to give space to urbanization. This option is also to be discarded, given the importance of natural landscape in so many senses. In this scenario, the current urban planning response is pushing each time more towards the densification of urban areas as the most plausible solution for answering future development’s space demands.

In an urban context, densification means to have more inhabitants occupying the same ground area. This differs in a very basic factor from the definition in physics. While originally it is a measure that takes into account quantity and volume, in architecture it uses ground surface instead of volume as the spatial factor of the equation. That is why, in architecture, high-rise areas are considered more dense than low-rise ones. In this way, horizontal distances between people and places decrease, bringing along both positive and negative effects in different fields and at different scales.

The drastic reduction of private and public spaces to reach the goal of “more people in the same space” can lead to health or psy-
chological issues of stress, loneliness, pollution, contagiousness, over-
production of waste, and so forth. On the other hand, from an envi-
ronmental point of view, dense cities use less energy and produce
less CO2 per person than more dispersed suburban and rural areas,
and usually provide faster and cheaper public ways of transportation.
Regarding resources and services distribution, urban areas are usu-
ally more efficient, providing structures that are more accessible and
being able to answer more specific demands. Finally, living in dense
cities increase the possibilities of human interactions and provides
places for people to gather, giving them voice and power to attend
their needs (HINDLE, 2008).

These facts push cities to the forefront of environmental sustain-
ability issues and make the question of density critical in the 21st cen-
tury’s scenario, even because the exponential growth of population
becomes even more critical in urban areas due to the migration ten-
dency towards big centres. In March 2010, the British newspaper The
Guardian published a headline in an alarming tone: “Urbanization is
unstoppable, says UN”.

By then, according to the report from United
Nations, for the first time in history, more people lived in cities than in
rural areas. To make it more dramatic, for the following four decades,
3/4 of the Earth’s population is expected to live in cities. In short, once
densification is a fact, solving its issues becomes a primary urgency in
both urban and architecture fields.

Image 2: Conurbation between Milan and its “satellite” suburb-cities.
Credit: website “Geology”.

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CURRENT CHALLENGE: INCREASE DENSITY WITHOUT COMPROMISING SPATIAL QUALITY

The current challenge, for the new generation to respond, is how to add density through this process of inner growth not only maintaining but increasing the original quality of the urban space. Currently the most common way for densifying urban areas is demolishing old and inefficient buildings and substituting them with denser and more efficient ones. But what will happen to historical sites when this pressure for more density reaches an even higher level of saturation? Nowadays the practice of demolition and reconstruction usually occurs in the outskirts of cities, where the existing built environment does not often constitute important heritage. Most European cities, nevertheless, carry in their city centres a history of thousands of years, and due to such a historical background, a big part of their prestige.

There is no doubt that historical centres need to be preserved from the voracious progress of urbanization, but on the other hand, they need to stay alive and respond to the changes in society's lifestyle. These areas cannot become open-air dead museums. Cities like Rome are often so untouchable that they begin silently to decay over the decades, in a process that also makes its memory slowly fade away.

It has been proved, instead, that preservation does not mean untouchability or museification; on the contrary, when an historical building is being used, it will receive constant maintenance, inspection and restoration, as if it could live a second life. What is left empty and unattended, instead, goes through a way faster end.

In this sense, it becomes interesting and challenging to investigate how to attend the new demands brought by the densification process in those precious historical centres without altering their evocative capability. This task requires that old and new find a very particular balance between them, keeping rooted to the origins but opened to the future. And if we look back, it is not hard to find scientists and researchers challenging this time-link when they look forward to try understanding and foreseeing solutions for challenges like this, that are repeatedly presented in cycles throughout time. In these researches, one of the most common starting points to try finding a solution for a design challenge is the comparison with successful strategies of Nature. Therefore, a step back to understand this kind of analogy becomes necessary.
ANALOGIES IN ARCHITECTURE

In 1965, Professor Peter Collins published the book *Changing ideals in Modern architecture*, a deep review about modern architecture tracing the theories and ideas that, during 2 Centuries, made modern architecture what it was at that point. During the course of that history, Collins’ description reaches a point, in the mid nineteenth century, where the continuous cycles of analogies with past trends in architecture were not enough anymore to satiate the urgency for a new architecture. The striving of the historians to evolve a new architecture by analogy with earlier architectures seemed to have failed; but their failure had at least one important result. It forced theorists to study the heuristic possibilities of other kinds of analogy (COLLINS 1965).

These new analogies, described by Collins as the only possible ones left by that moment, were functional analogies: parallels with living organisms (biological), machines (mechanical) gastronomy and language. Specifically about the most relevant one for this article, the biological analogy, Collins traces back its origin to 1750, when two epoch-making scientific books were published: *Species Plantarum*, in which Linnaeus classified the entire vegetable kingdom and Buffon’s *Histoire Naturelle*, with an attempt to bring all biological phenomena into a general interpretation of the laws governing the universe.

Professor Collins points that Buffon’s vision that all species must have derived from a single type would be very much used later by architectural theorists, with two important features that deserve mention: the first is that his idea of evolution was based in a process of degeneration, and not of improvement, once his (and his time's) religious beliefs prevented him from assigning the evolutionary process to any but the lower animals. On the other hand, he was the first one to distinguish between “vegetative” and specifically “animal” parts of animals, whereby an animal may be regarded simply as a vegetable organism able to move from place to place.

According to Collins, as a consequence of these two important books, “organic life” has come to mean for architectural theorists, the sum of the “vegetative” class, present in all living organisms, plants or animals. In that sense, this was when “the asymmetry of plants and viscera, rather than the symmetry of animal skeletons, came to be accepted as characteristics of organic structures”.
But in order to understand better what previous studies can bring to the discussion presented here, the analogy must step away from the comparison with architecture as an organic body to upscale and approach a comparison with the city as a body, as Collins himself suggests that happened with the discussion during the twentieth century. He points out that Claude Benard’s discoveries concerning the way the body adapts itself to changing conditions suggests clear parallels its urban context.

In this sense, becomes interesting to analyse other studies that deal specifically with this urban context about which Collins refers. The intention here is to put together other sources that focus their analogies in different specific systems or mechanism of the human body, like:

- The blood circulation and its distribution strategies;
- The skin and its sensitivity mechanisms;
- The guts of the city, with its infra-structure under the streets playing the role of our nerves, veins and digestive system.

**LESSONS FROM BLOOD CIRCULATION**

In 1867, the Catalan Ildefonso Cerdá based his most influential work in the metaphor of the city as a body. Through that comparison, in his *General Theory of Urbanization*, he explores the complex and heterogeneous origin of the present organism of our cities (CERDÁ, 1867). He describes the task of urban planners both as a diagnostician, who shall understand sick areas of the city, and as surgeons, with “a true anatomical dissection of all cities and of all their constituent parts”. Even though Cerdá was not the first one to make this link between cities and human bodies, he is the first one to give it a special role in his work, establishing not only a metaphorical, but also a methodological significance to this comparison. Françoise Choay, in her book *Modern city: Planning in the Nineteenth century*, points out that not only Cerdá’s Barcelona, but also the revolution made in the urban landscape of Paris by Georges Haussmann (1809-1891) reproduced its streets as arteries in the model of a general circulation system.

Benjamin Frase recently approached the same subject in his book *Henri Lefebvre and the Spanish Urban Experience: Reading the Mobile City*. According to him, despite the prominence of this metaphor in the work of Nineteenth-century well-known figures such as Cerdá and Haussmann, the notion that the city could be conceived as a body is
from far earlier (FRASE, 2011). He points out that the Seventeenth century had seen the discovery of blood circulation, generating quick responses in the way of thinking cities. The urban critic Richard Sennett, referred to the relation between body and city when he wrote about a bodily perception of the city (SENNET, 1994). Recently, in his book *The Craftsman* he went back to the theme, writing about the influence of that discovery in the Seventeenth century.

The Scapel had permitted anatomists to study the circulation of the blood: that knowledge, applied to the circulation of movement in cities, suggested that streets worked like arteries and veins; this was thus the era in which planners began to incorporate one-way streets in their designs (SENNET, 2008).

**THE BOWELS OF THE CITY**

In 1976, David Macaulay draws images of the city of New York without its top layer, showing the amount of systems current society hides under its “skin”, just like our body. In 2003, in his book, *Guide to Ecstacity*, Nigel Coates brings up images and collages to materialize this metaphor of what he calls “the bowels of the city”, pushing the body-city metaphors to a visual field.

Four years later, writing directly from the underground of New York, a Journalist from The New York Times, and Nature, Jonah Lehrer wrote an article for the Seed magazine about his experience inside what he called “the guts of the city”. In this article, he states that the
experience of being in contact with the infrastructure of the North American metropolis turns the metaphor quite literal, with the big pipes playing the role of “metal intestines”, fiber-optic cables working as nerves, and subway tunnels as “thick jugular veins”. He goes on with the direct comparisons; in his words: “Energy is distributed, and waste is digested. All this generates a sort of animal heat, which escapes from the grates in the gutters. The foul steam is exhaled breath. But how true is this metaphor? Are cities really like living things?”

To answer his own question, Lehrer points at the work of a team of physicists and economists led by Geoffrey West at Santa Fe Institute. According to their research, in many respects, cities act just like creatures: “They obey the same metabolic laws that govern every organism. Their infrastructure follows a distinctly biological design, which helps explain why cities are able to grow.” Pointing exactly towards the direction Collins predicted five decades earlier.

METABOLIC LAWS

These metabolic laws were studied in the early 1930’s by the biologist Max Kleiber, who measured the metabolic rate of a vast range of different animals. He discovered that in virtually every species, the metabolic rate is equal to the mass of the animal raised to the 3/4 power. This simple equation could describe cows and humans and
elephants and mice. It did not matter what the creature looked like, or where it lived, or how it evolved. The formula always worked. This means that animals with a bigger mass will consume less energy per pound than smaller animals. As life grows, it develops enormous economies of scale. The elephant is much more metabolically efficient than the mouse. Humans are more efficient than hummingbirds. Girth is a good thing, at least from the perspective of energy consumption (LEHRER, 2007).

Working on this analogy, West and his team analysed data from various cities and concluded that in an urban context, this statement is also true: big cities are more “metabolically” efficient than smaller cities. According to their research, cities are like elephants. They get more economical with size the indicators of urban `metabolism`— like the per-capita consumption of gasoline or the surface area of roads or the total length of electrical cables — scaled to an exponent of (population) 0.8, which is very similar to the biological equivalent of (mass) 0.75. This means that a city can double its population without doubling its resource consumption. One of the basic principles of cities is that it’s more efficient to bring people together. You need a little bit less of everything per person. It’s the exact same way in biology. As animals get bigger, they require less energy to support each unit of tissue (WEST, 2007).

In his text, Lehrer points out that despite the bucolic image that a rural area can present, cities are much more of environmental-friendly places. He calls Cities “bastions of environmentalism”, because they consume fewer resources per person and take up less space. While rural towns might look green, their per-capita rates of consumption and pollution are significantly higher. The secret for creating a more environmentally sustainable society is making our big cities bigger. We need more metropolises (LEHRER, 2007).

Nevertheless, even reaching sustainability through the obedience to biological metabolic laws, cities present an essential difference to animals: In bigger cities, people live - literally - faster, while in biological systems, the opposite trend occurs. As creatures get bigger, their bodies slow down. Pulse rates decelerate. A brake is applied to the heart. This is why elephants live longer than mice: their bodies operate at a more leisurely setting. But West’s research shows that in a city, as it gets bigger, each individual gets more and more pro-
Inductive. A doubling of population leads to a more than doubling of creative and economic output. Lehrer puts this point in a simple way: “Imagine an elephant that never stops growing, and whose growth just encourages more growth. That’s what a city is like”.

However, even when a city doesn’t face, like elephants do, a physical limit to its growth, at a certain point it tends to run out of resources. And there is one way to deal with this limitation, as West’s research point out: they innovate. The only way to avoid stagnation from a shortage of resources is to change something. You have to reset the clock, reset the initial parameters of growth. We call this an innovation cycle, and they are clearly apparent throughout history. There’s the invention of the steam engine, the car, the digital revolution. What these advances all have in common is that they allowed cities to continue growing. (WEST, 2007) A city that isn’t innovating is on its way to collapse. West points to Detroit as a city that has failed to reinvent itself and suffered the consequences. Examples like this show that finding innovative ways to grow is essential to a city’s health.

THE SKIN

More than a simple layer to cover the city, the skin of an urban environment has an important role in its life (SOLÁ-MORALES, 2008). The comparison between the surface of a city and the human skin is a central narrative point of the book A Matter of Things, in which Solá-Morales defends the practice of urbanism as both “acupuncture” (a gaze upon the city, that can be related with the diagnosis role Cerdà wrote about) and “prosthesis” (incision projects, or Cerdà’s surgery). Solà-Morales indeed goes beyond and states his interest in what he calls “the skin of cities”, revisiting the classic Epidermis of the Earth (TRICART, 1969). In Solà-Morales’ definition, this skin is constituted of “constructions, textures and contrasts of streets and empty spaces, of gardens and walls, of contours and voids.”

Morales uses the analogy with acupuncture to express the importance of the city skin, not because it involves using needles or making small incisions, but because the epidermis is understood to form a system, not the covering of the interior, but the principal structure of the organism, the clear expression of its nature. To act with punctures, pressures, injections
is to distribute energy through the skin. (SOLÁ-MORALES, 2008) This analogy has been very much explored by contemporary urban planners, like Jaime Lerner, the former mayor of Curitiba that reinvented the State capital in the south of Brazil. Leading a constant tendency in South America, cities in Brazil tend to grow fast and quickly become big metropolises surrounded by dependent cities. These so-called “satellite-cities” tend to be dormitory places and drastically increase the challenge to the transport system.

LACK OF FREE SPACE VS URBAN Voids: INFILL DEVELOPMENT

The concept of free urban space is becoming a far memory. Cities are made of a tight, compact, continuous and dense fabric of buildings, streets and squares. On the other hand, though, in the same context of development that generates this lack of space, cities often also experience an opposite phenomenon: with the creation of new centralities, the regrouping or rearrangement of dwellings and services tends to generate ‘leftover urban spaces’. Together with a broader set of unused spaces, these gaps in the urban fabric are called ‘ur-
ban voids’. Most of the times they represent very disagreeable areas that often grow and deform together with the city pattern, like scars that tell something about the local development’s history. The expression ‘urban voids’, however, is extremely wide and has been used to describe many different situations, like these examples illustrated on the right side of this page.

As a result of this equation between the lack of free spaces and the creation of urban voids, a specific urban planning and development tool has recently been considerably explored: it is known as urban infill. This involves the use of gaps within a built-up urban area for further construction, focusing on the reuse and repositioning of obsolete or underutilized buildings and sites. Infill buildings give new meanings and functions to obsolete spaces that have lost their functionality.

This is one of the possible urban tools that allow a city to host more of its functions - and, subsequently, more of its inhabitants - in less space. However, there is one essential function of the city that cannot be fitted in gaps or leftover spaces, and it is an essential one for the good functioning of a city: Urban mobility.

NEW LAYERS FOR THE CITY

The perimeter of our cities is made of a continuous and tight built pattern. At ground level, streets and walkways represent the scene for human interaction and movement; the interiors of buildings accommodate, in its many levels, private and collective spaces; and at underground levels fast lines of transportation have been created. In the context of urban densification previously described, it becomes necessary to explore alternative ways to respond to the challenge of how to move within these new cities. Proposals for the creation of new layers for the city have been under investigation, mostly as a scenario for movies about the far future or as basis for utopian projects not really meant to be built. But quite often these utopias inspired projects that have been built, actually much more often than we commonly think.

Two layers that have been considerably explored are the immediate contiguous levels that frame the existing layer: the upper and lower levels of our cities. In many cases these proposals had the specific intention to work as an answer to densification demands.
In the course of the historical development of cities, each time dictated by a different trend of expansion, urban planners have envisioned innovative ways to expand city boundaries, not only in a horizontal way. The examples collected hereafter show how the creation of such layers has been treated throughout history.

THREE LAYERS OF MILAN

At the end of the 15th Century, Leonardo da Vinci was working for the Sforza family, in Milan. For transport efficiency reasons, he designed a network of navigable artificial canals that connected the city of Milan with the nearby river Ticino. He therefore thought of a new circulation arrangement, so that transportation via water was placed just below the ground level. In his proposal, at the street level, the public flow was kept. The first floor, in the meanwhile, was reserved for the nobility. This kind of arrangement represented one of the first functional solutions for solving problems related to congestion of traffic (people and goods) when cities were starting to be involved in
global trade. Only the space at ground level was not enough anymore, and new layers of circulation had to be integrated with the traditional ones. This represents one of the first upwards and downwards expansion in history, and is clearly relevant until nowadays, given the underground transportation systems developed since then.

RAPID TRANSIT SYSTEMS

It took more than three centuries before the suggestion of developing urban circulation in new layers of the city would start to be considerably developed and applied in other cities. In 1863 the first section of underground railway was built in London. Since then, rapid transit systems, typically located either in underground tunnels or on elevated rails above street level, spread to other cities in Europe, to the United States and then to the rest of the world. Elevated systems only began to be integrated into these networks three decades later, in 1893, with the Liverpool Overhead Railway. These systems are still the basis of urban mass transportation in the biggest capitals of the world.

Image 8: Sketches of Leonardo Da Vinci’s proposal. Credit: Images from the website “Il Cuore di Milano”\textsuperscript{10}.
world and their success is due to the same logic that da Vinci explored - the use of an alternative layer for circulation, in order to avoid the over-saturated street level.

Nowadays the upper and lower levels of big cities also extend the offer of alternative levels for cars and pedestrians - either in networks to complement rapid transport, like in Paris - or in independent networks, like numerous examples of underground and skyway pedestrian connection systems.

**HELSINKI’S UNDERGROUND CITY: MASTERPLAN AND 3D PROPERTY MAP**

In Helsinki an impressively extensive use of the underground level is shared by subway trains, pedestrians, cars, stores, public squares, an underground swimming centre, escape routes for important official buildings (like the parliament) and even a church, the Temppeliaukio kirkko, excavated and built into the rock in the neighbourhood of Töölö. The success of this strategy spread throughout the city centre and reached the outskirts, stimulating also the creation of a tunnel under the water to connect the neighbour island of Suomenlinna for emergency use.

Over several years, the Finnish capital has built this vast network of tunnels under its bedrock. The main difference with most of the underground networks is that Helsinki’s does not focus on expanding the commercial retail space of buildings, but on hiding industrial uses from the city’s historic core. Its Underground Master Plan (the first one in the world) involves utility services like district heating/cooling, coal storage, data centres, and various other uses that do not need the scarce Nordic sunlight.

However, the scale and depth of this network introduces a problem of underground property ownership. Helsinki is trying to solve property registry conflicts by taking them literally to another dimension. Property registration is becoming a 3D record moving beyond just a 2D plot of land. This makes it very different from the U.S.A. Model, where flat maps guarantee property rights to the owner from the core of the earth to the sky extension over one’s land. Those rights, then, need to be regulated by various governmental agencies; the General mining act for the underground, municipal zoning at ground
level, and the FAA at a given height. The experience of Helsinki, on the other hand, acknowledges that ownership based on height can allow separate owners on the same plot at different levels. Helsinki’s 3D approach exemplifies the future of property registration for urban landscapes under continuous densification.

According to the CNN program “Europe’s underground city” 12, in order to keep the low-rise characteristic of the city and avoid urban sprawl (once limited by the river on one side and the existing buildings on the other) towards the underground was the most plausible space for Helsinki to advance. And what made it possible was the hard bedrock over which the city lies.

The program emphasizes the functional variety of Helsinki’s structure that differs its underground network from others elsewhere: “The policy of putting industrial facilities beneath the surface helps to free up land above ground for more profitable real estate developments. Down below there is the only world’s fully automated underground coal storage facility. Four enormous silos store enough coal for half of
the city’s annual consumption and all that remains on the surface is a discrete coal shaft. Perhaps the most extensive use of the bedrock is within the city’s district heating and cooling system. 60 km of tunnel, deep beneath the surface, provide heating and hot water to Helsinki”.

Juha Sipila, employee of Helsinki’s energy company, explains the advantages: “In most cities, all the cables and pipes go underneath the asphalt and for maintaining you need to break the asphalt and have a digging machine in between the cars and the traffic. But in Helsinki we have a very good tunnelling network crossing underneath the city and we can supply all the cables and pipes from tunnels and don’t need to disturb the traffic”.

CNN Reports also comments the attitude of the government towards the clash between heritage and the city’s development: “the magnificent Uspenski Orthodox Cathedral is proof that no part of Helsinki remains untouched by the underground city. The old and the new come together whether it is the pipes providing the heat for the worshippers here or the revolution going on down below in the Cathedral’s bomb shelter: 30m beneath the surface two Finnish companies have joined forces and created the world’s greenest data centre of its time”.

Jarmo Tuovinen, speaking in name of the companies, sets the picture: “data centres are consuming at least 2% of all energy consumed in the world. In most data centres, the computers themselves use just half of the energy consumed. The rest is used to cool the computers down.” The difference is that in the case of Helsinki’s data centre no energy at all is used for cooling purposes, due to the good temperature insulation on the underground and the opportunity of being just by the freezing Finish Sea that provides an abundant source for direct exchange of temperature to cool the computers. The heated water created by this exchange, in the words of the reporter “leaves the data centre through pipes which carry it 70 m down to the underground tunnelling network that lies beneath Helsinki. From here that heat continues its journey through the pipes and arrives at its final destination heating people’s homes”.

Interviewed for the program, Helsinki’s mayor Jussi Pajunen says that it is relatively inexpensive to build in the underground and answers the reasons to use that space with another question: “Why not?” The mayor’s vague answer about the costs of building in the underground, however, finds in another Northern European country a very precise set of calculations to support his opinion.
THE NEW UNDERGROUND PLANNING MAP OF THE NETHERLANDS

Following the example of Helsinki’s underground Master plan, in 1998 a Feasibility Study of the Possibilities for the Use of Underground Space in the Netherlands was conducted, aiming for a more large-scale and systematic use of the underground in the western part of the country, the so-called ‘Randstad’. In a country where land reclamation from the water plays a central role in the search for new usable space (constituting 26% of the current area of the country), the government has foreseen the potentials of “space-reclaiming” also from the underground and elaborated a complete document about all the advantages, difficulties and consequences of the possibility.

According to a study published by Elsevier Science (a global company headquartered in Amsterdam), the Feasibility report from the government examined the possibilities of improving an idealized model of the future spatial development by using more extensively the underground space. Improvement meaning an enlargement of the efficiency of the use of space and maintenance or enlargement of the spatial quality of the area. Societal, cost, groundwater and policy aspects were investigated. (MONNIKHOF, EDELENBOS, VAN DER HOEVEN, and VAN DER KROGT, 1999) Summarizing the document, the study from Elsevier Science exposes eleven important points, from which a core of five was extracted and briefly explained hereafter:

1. WHY TO GO UNDERGROUND?

In the study, three basic reasons for going underground were identified:
- To strengthen the quality of the living environment. By constructing certain functions underground, nuisance and hazard can be limited. Disturbing effects such as sound, stench and emissions are isolated and safety risks for people living or working nearby the function can be diminished.
- To achieve more efficient use of space. More building volume can be realized on the same ground area. In addition, the use of underground space makes combination (piling) of several functions possible.
- To strengthen the spatial-functional structure. By constructing cer-
tain facilities underground, valuable areas and functions can be spared. The character of historical centres or natural areas, for instance, can be saved by underground construction of infrastructure and barriers can be prevented. Furthermore, underground construction offers possibilities to combine mutually reinforcing functions into a more effective functional structure (for example, the combination of retail, storage and parking).

2. SPATIAL EFFICIENCY ASPECTS OF GOING UNDERGROUND

Use of the underground space can lead to

- Proportional gain in space. The case of an environment where there are no special quality demands (with regards to green areas, open space etc.), so that the space directly above the underground construction can be used for other buildings.

- More-than-proportional gain in space. Functions that normally cause considerable disturbance in their environment, e.g., highways or storage facilities for dangerous substances. Normally, either there would be no building in large noisy zones and/or there would be safety zones around these functions. Constructing the function underground therefore not only releases the space that such a function would take in itself, but also (a part of) the space of those disturbance zones.

- Less than proportional gain in space, on behalf of spatial quality. In certain cases, the use of the underground can be aimed mainly at achieving more spatial quality. The space above ground thus released is then not wholly used for building again, but is left (partially) free, to create, for example, more green, light and space in an area that is densely built up.

Starting from the possibilities for using the underground for the different functions and the three forms of gaining space described above, an estimation was made of the maximum possible gain in space per type of area, when leaving the quality of the inner and outer space still at an acceptable level. This leads to estimates of possible gains in space ranging from 5 to 15% for city environments, to up to 100% for infrastructure areas.

3. GROUNDWATER ASPECTS OF GOING UNDERGROUND

Because building structures underground can have large and lasting effects on groundwater, these effects were taken into consid-
Groundwater has a number of essential functions, related to:

- Ecology. Groundwater determines the water balance in the soil on which natural environment strongly depends. Quality and quantity of groundwater perform an important role in this.
- Public water supply. Two-thirds of the groundwater in the Netherlands is used for drinking water and industrial uses. Therefore, a high quality of ground water is necessary.
- Feeding of agricultural crops. For every type of crop, there is an optimal ground water level. Changes in the ground water level can lead to losses in yield.
- Recreation. Changes in the watermark influences vegetation and access to recreational areas, and the possibilities for using recreational waters.
- Building and infrastructure. For buildings on wooden pile foundations and for roads, dikes and networks of pipes, a more or less constant level of groundwater is desirable to avoid damage through subsidence.

To preserve these essential functions, the original ground water situation should be left intact as much as possible. However, some smaller or larger changes in the ground water situation will always occur if an underground structure is built. For a general understanding of these effects, the following ground water aspects are important:

- Infiltration: vertical downward flow of ground water, for example the entry of rainwater from the surface into the soil.
- Upward seepage vertical upward flow of ground water.
- Groundwater system: a (more or less) closed circuit of ground water flows within a defined area where (rain) water infiltrates, flows horizontally and wells upward again.

Underground construction will not cause too many problems for the groundwater situation if these conditions are taken care of.

4. COST ASPECTS OF GOING UNDERGROUND

The costs of buildings are determined by construction costs, prices of land and exploitation costs. Exploitation costs are made up of costs for maintenance and
use of energy. They are made during the whole duration of life of a building, in contrast to the construction costs and costs of land that have to be covered directly at construction. Very precise tables included in the study show that underground construction has consequences for costs. In all cases, higher investments are needed for construction, but these can be (sometimes partially) recovered by savings on the costs of land and exploitation. Less surface is needed for the same amount of building and less maintenance is needed for outer walls and roofs. In addition, the use of energy for heating and cooling is lower (but the use of energy for lighting is higher). Underground construction can also be favourable for security and other reasons, but these were not included in the calculations.

5. CONCLUSIONS OF THE FEASIBILITY STUDY

The conclusion of the study has an extremely optimistic tone towards the use of the underground as a base for future expansion in the Netherlands. The study showed some remarkable results. For one thing, gains in available space up to 50% in specific areas of the Randstad seem possible (even 100% for infrastructure areas). For another, when costs of energy and maintenance were taken into account, underground construction for offices, hospitals and parts of houses was no more expensive than above-ground construction, which contradicts a widely held belief in the Netherlands. Especially for commercial services, underground construction seems a viable option. Finally, once again the high potential of putting the distribution (and circulation) function underground was confirmed (MONNIKHOF, EDELENBOS, VAN DER HOEVEN and VAN DER KROGT, 1999).

As a result of these studies, even with the super high groundwater, The Netherlands has been building a huge amount of structures in the underground. One famous example is the preservation of the Museum square of Amsterdam by using the space underneath it to build archives of the museums around, a supermarket and parking places. A similar solution was used for the preservation of the so-called Green heart of the country by building a high-speed rail system to connect its biggest cities (Amsterdam and Rotterdam) to the airport underneath the preserved area.
RIVER AND CANAL BANKS

The height difference between the water surface and the street level in cities with canals or rivers represent one particular way of exploring a high quality part of the underground: the banks of rivers and canals. Those potential volumes hidden behind canal (and river) walls have been successfully explored through the last centuries.

In Turin, Italy, the huge difference between the Po River and the street level hosts bars and restaurants, while in Paris the banks of the River Seine host a reserved walkway, some meters away from the cosmopolitanism of the city that helped to shape the romantic character of the French capital.

Images 10, 10.1: Paris and Turin, each one with a different use of the space between street and water level. Credit: Paris: picture by the authors; Torino: wesite “Cità di Torino - Night life”.
In Utrecht, a canal system designed for transportation and distribution of goods used to have an efficiency problem related to this difference of levels between water and street. The employees of canal-front warehouses needed to bring the goods one level up, in order to get inside the warehouses and only then go back one level down to store the goods in the cellar. A spontaneous initiative from an owner of opening doors and windows connecting the cellar and the canal level was quickly reapplied throughout the whole city. Nowadays, most of these cellars have become restaurants, bars and galleries, exploring the new main use of the canals: the touristic potential of historical centres.

In Delft, a number of small stairs lead to compact public spaces dedicated to relaxing and enjoying the relation with the canals. In most of the cases, these spaces fit no more than a seat, and they are shared between the inhabitants of the city and those of the canals, like ducks and swans. Facing the Oude Kerk, a little door under the sidewalk that leads to the Prince of Orange’s “war-times residence” suggests an alternative escape route.

Another example is the old prison of Amsterdam, built inside the banks, behind the higher canal walls around a wide bridge over the Singel. Recently, the space has been used as a museum and at this moment hosts sporadic cultural events opened to the public. The access is made descending some stairs aside the canal walls and through a door entering the bank. Once inside, the interior space shows that the height needed to bridge over the boats provide a volume with extreme potential for utilization. That kind of potential volume is spread all over the Grachtengordel (the canals district in the city centre of Amsterdam), in one of the most restricted urban environments, where the densification seems impossible to be hosted in the traditional layer of the city.

UNDERNEATH AMSTERDAM

The specific space of Amsterdam constituted by the Grachtengordel, as a matter of fact, has been inspiration for a number of projects that gather the potential of the Dutch underground (dissected in the last pages) with a very special position, the heart of the inner-city of Amsterdam. In an attempt to improve the efficiency of this symbol of Dutch traditional architecture, the police department, for instance,
made a proposal in 1903 to transform the space under the canals into a special high-speed lane for emergency use. That potential volume in the middle of the city-center is hidden under a very thin layer of water and offers huge possibilities, like the potential of circulation. In fact, the network of canals above them was designed exactly with the goal of “circulation efficiency” when the main mean of transportation was naval. The proposal never materialized, but the potential of the idea keeps producing proposals that explore the same logic until today.

The most notable recent one is a study from Zwarts en Jansma called AMFORA\textsuperscript{14}. The main goal of the project is to create a new layer for cars, “giving back the streets of the city to the pedestrians, as it used to be centuries ago”. But the project also intends to use the underground to host many other functions that, throughout time, ended up banned from the expensive city center, like sports facilities, big supermarkets and parking places, one of the biggest problems of the area.

Besides proposing this solution for the central issue of space scarcity, the authors of the project also list possible environmental advantages: “The water in the canals becomes cleaner, the underground spaces offer possibilities for the storage of heat and cold and the air quality is considerably improved, because particulate matter, CO\textsubscript{2}, NOx and other hazardous particles can be filtered from the air.” About the other big controversy of the project, the cost issue, they use a very simple calculation to defend the plausibility: “Less than €30,000 per parking space. AMFORA is, therefore, not a utopian plan”, they conclude.
OVER THE ROOFS OF NETHERLANDS

Just like the underground, the space over Amsterdam’s inner city have also inspired space-research projects and small-scale interventions. Recently, a group of neighbors from the surroundings of the Eenhoornsluis, in Korte Prinsengracht began to collect a list of signatures to support the proposal of a common rooftop park. According to the project of the Argentinian architect Georgia Alaniz, who lives in one of the penthouses, the green surface would be developed over flat rooftops of a group of 20th-century buildings, including a supermarket that would benefit from the insulation provided by the rooftop park.

But bigger and more utopian proposals over houses are also part of the city cultural heritage. In the early 1950’s, the Dutch artist Constant Nieuwenhuijs, after reading “Gay Ludens” (HUIZINGA, 1938), developed the idea of a utopian city, his New Babylon. Conceived to be a place where men are free from physical labor in order to become exclusively devoted to the development of creative ideas living in an aerial structure over the existing city.

For almost 20 years Constant worked with the help of assistants on drawings that cover the whole map of the Netherlands. In addition, paintings, models (of plexiglass, wire and wood), collages, lithographs texts and even movies were part of the exhibitions and lectures about the New Babylon. He considered the project as “the design of a new culture”.

According to the official website of the movement to which he was engaged, Situationist International, New Babylon envisages a society of total automation in which the need to work is replaced with a nomadic life of creative play, where traditional architecture has disintegrated along with the social institutions that it propped up. The website recovers a text by Mark Wigley extracted from an old website (not online anymore, called: ‘New Babylon - The Hyper-architecture of Desire’). Wigley explains in his text the architectural aspect of the project, that raised a lot of discussion in Dutch architecture then:

A vast network of enormous multilevel interior spaces propagates to eventually cover the planet. These interconnected ‘sectors’ float above the ground on tall colum-
ns. While vehicular traffic rushes underneath and air traffic lands on the roof, the inhabitants drift by foot through the huge labyrinthine interiors, endlessly reconstructing the atmospheres of the spaces. Every aspect of the environment can be controlled and reconfigured spontaneously. Social life becomes architectural play. Architecture becomes a flickering display of interacting desires.¹⁷

Constant always saw New Babylon as a realizable project, which provoked intense debates at schools of architecture and fine arts about the future role of the architect. Rem Koolhaas, among the enthusiasts of the project, considers that New Babylon made many architects think and refers to Constant as “an example of courage”.

Constant insisted that the traditional arts would be, in future, displaced by a collective form of creativity. The project had a major influence on the work of subsequent generations of architects. It was published widely in the international press in the 1960s and Constant quickly attained a prominent position in the world of experimental architecture.

PUBLIC ROOFS OF JERUSALEM

The Old City of Jerusalem is surrounded by the impressive 16th century Ottoman city walls and, with a history that stretches back more than 3,000 years, represents the heart of the city both historically and spiritually. There, it is possible to admire the spectacular setting from the roofs, which are largely publicly accessible and offer
an astonishing point of view towards the old city. The roof of the Austrian Hospice, the top of the tower of the multicultural YMCA, or the Tower of David are other good view points, but none is quite like the Old City walls themselves. This freely pervious level provides to tourists a unique chance to experience the city, and to locals a fast way for crossing the crowded and tangled city.

**VILLE SPATIALE**

During the 1950s and 60s, architects and planners investigated alternative ways through which design could respond to the cultural and technological era, and developed new urban visions that were able to offer more freedom and greater opportunities for individual expression. In this scenario, and pushed by the French housing shortage of the late 1950s, Yona Friedman created new urban concepts such as the Ville Spatiale and Mobile Architecture, based on the free organization of a city by citizens, using low-cost materials and reusable modules.

![Image 13: Public circulation over the roofscape of Jerusalem. Credit: website “Manube”](image)

Ville Spatiale is an architectural mean of the democratization of urban design built up by the citizen themselves. It advocates an architecture without plans that adapts to people’s desire and implement a negotiation between neighbours. Friedman embraces the unpredictability of future behaviour and insists that planners should rather lay a framework within which the inhabitants can structure their surroundings however they like. In addition, this kind of architecture was
meant to be able to be expressed in a large number of ways through prefabricated elements that could be arranged, altered and modified at a later stage according to the occupants’ preferences. The architect, then, becomes only a mere consultant, only in charge of designing the (infra)structure that will provide space and necessary resources for the city to grow.

His vision was conceived of an urban structure on piles, appropriate for spaces where building is not possible or permitted (like water or wetlands, or above existing used areas such as farmlands or cities). That could leave untouched the level below. Basically, a second city was raised upon the existing one, fifteen to twenty meters above. This project was designed to be built anywhere, and meant to be adapted to any climate. The framework was the primary fixed structure, while the residences were conceived and built by the inhabitants and inserted into the framework’s voids. On each level, half of the space should be left free in order to provide air and light to each residence, as well as to the city below. Several layers could be stacked on top of each other so that, for instance, the lower level could be utilized for public life, community services and pedestrian areas, while vertical transport was inserted inside the structure piles. Finally, the superposition of many levels would make possible the creation of completely new cities.

**FINAL CONSIDERATIONS**

The urban mobility issue, just like the city itself, cannot be addressed with frozen approaches and old recipes. Just like a living organism, the City adapts quickly to new situations that modify its metabolism – in this case, population trends, density and rearrangements of its urban tissue. For that reason, the search for solutions to keep the efficiency in transporting people, goods and waste through the city needs to be constantly updated. Nevertheless, that does not mean that researchers should not look back, because on the other hand, many urban patterns follow a cyclic logic and utopian ideas from the past can give very important clues for the development of new solutions, based on new technology that was not available before.

In that sense, the collection of examples here presented should not be seen as a set of rules, but also not a set of innoc-
uous adventures. The goal of assembling these experiences is to create a kind of catalogue of inspirational utopias. Facing current challenges, one can revisit them from the privileged point of view of those who now live among the future realities envisioned by those avant-garde Urbanists, Architects, thinkers and communities.

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NOTES

1. Igor de Vetyemy is a Professor in Estácio de Sá University since 2006. Since 2014, he is the General Coordinator for the Course of Architecture and Urbanism and Area Coordinator for all the courses of the Creative Industry in the same University. Graduated in Architecture and Urbanism cum laude in UFRJ in 2005, specialist in Architectural History in University of Oxford and Master in Architecture and Building Sciences, also cum laude, in the Technical University of Delft, in The Netherlands, in 2012.

2. Currently in a second master at the ESCP Europe Business School, in the United Kingdom and France, Virginia Scapinelli graduated as an Architect and Urban Planner in Politécnico di Milano. In Milan, she also worked as a tutor in “Your Trainers Group in profissional development seminars. Her first master was held in Delft University of Technology, in The Netherlands, where she also attended to the Entrepreneurial Program and joined the research groups “The Why Factory” and “Explore Lab”.


9. https://niels85.wordpress.com/2012/02/02/architecture-and-film/

10. https://cuoredimilano.wordpress.com/


12. CNN article from 2011 accessible at: https://www.youtube.com/watch?v=jXNyEiw28D0 (visited in 29/04/2012 and 05/05/2016).


17. Link for the article in the official website of Situationist international: http://members.chello.nl/j.seegers1/situationist/constant.html (visited in 02/05/2012 and 05/05/2016)
