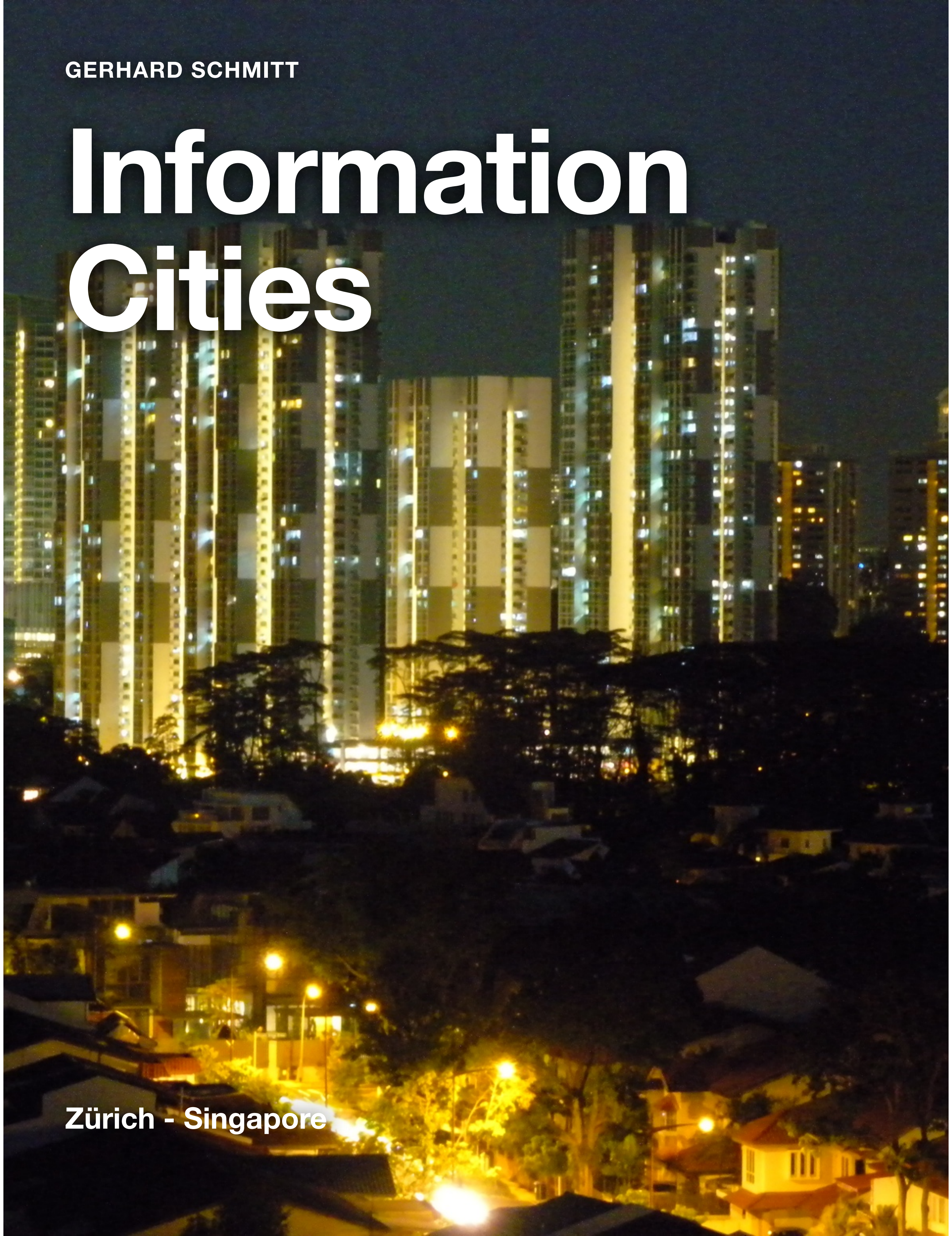
GERHARD SCHMITT

Information Cities



Zürich - Singapore

Future Cities Preface

Abstract

What is a city? What is an urban system? Do we understand these most complex man-made artefacts in their entirety? Do cities need skyscrapers? Are there cities without density or are there dense settlements without being a city? Some are liveable for most, others just for a few. As we enter the first urban century, we start to realise that today‘s cities are not sustainable, no matter from which side we look at them. In order to transform them towards livability, sustainability and resilience, better knowledge and the power to change are needed. Understanding the city and knowledge about the city should be the base for change. As we begin to see that cities are not neutral objects, but that people define the city, the citizen takes the central role in the definition of the future city.

With the regard to cities, the development in different parts of the world is moving in radically different directions. Cities in the tropics will grow strongly in the coming decades: overall, the number of new inhabitants will increase by 3 times the population of Europe today in the next 30 years. But who is planning those cities? To enable people to do so, it is necessary to develop new University programmes which in an integrated and holistic way transmit the knowledge to understand the city, to transform it, to plan it, to design it, to build it, to manage it and to constantly adapt it. The Future Cities Laboratory in Singapore and Zürich is conducting fundamental research into this area and also prepares concrete proposals to change existing urban structures towards higher sustainability.

A new understanding of the city: The Future Cities Laboratory

At the end of the 1st decade of the 21st century, networks of urbanised centres are the predominant framework of life in Europe, the United States, South America and Oceania. While in Africa and Asia a majority of the population still lives in the non-urbanised countryside, the urban population is growing much faster through higher birth rates and internal migration and will exceed the rural population by 2050. Thus, the urban framework of living will dominate the coming centuries. As a consequence, the urban theme has moved to the top of the agenda of elite universities, industries, and agencies. Governments such as the one of Singapore have made the future of the city, in particular the future of the liveable city, one of the national central themes.

The urbanisation of the rapidly emerging countries of the 21st-century as a societal and as a scientific phenomenon needs fundamental research quickly. This is the main reason, why ETH Zürich has founded in 2010 the Future Cities Laboratory as an integrated and multidisciplinary design and research centre in

Singapore and Zürich. The Future Cities Laboratory is looking for realistic approaches, techniques and methods to increase the sustainability of cities. It integrates research results from fields of science which are crucial to know about by the next generation of city planners, city builders and city managers.

In order to better understand the city, theory, experiment, and simulation need to work hand-in-hand. *Theory* entails research on the reality, the planning, and the implementation of the city; *Experiment* includes the conduction of Design Research Studios with the city as a living laboratory; **Simulation** is needed to make the invisible visible and to test and to visualise future scenarios.

In the beginning of 2013, the Future Cities Laboratory in Singapore and Zürich works with 50 Ph.D. students, 20 Postdoctoral Researchers, 13 Principal Investigators, 35 Design Research Studio Master Students and 5 management persons from 31 nations, as well as with the academic partners of the National University of Singapore (NUS) and the Nanyang Technological University (NTU). Together, these researchers are beginning the development of a new city science by the combination of theory, experiment and simulation.

Building on the model of the urban metabolism, on the stocks and flows approach and on complex systems theory, the Future Cities Laboratory in addition explores experimental possibilities, such as pre-specific modelling and the quantum city. The research operates on 3 integrated scales: small – building and building technology; medium – quarter and city; and large – hinterland and territory. 10 research modules and 3 assistant professors work on the influential and decisive parameters water, material, energy, design, capital, landscape, density and information.

Context versus universality

throughout the entire book, there will be a distinction between universally accepted facts and context-based information and facts. Universally accepted facts and methods can be transported without causing confusion or damage between cultures, countries, and climates, they apply to all cities and urban systems. Context-based information and facts refer to a specific location in a specific climate and should be used with great care as a base for design decisions in other places. Cities and buildings are not context free objects and therefore should not be copied. The boundary between those two types is not rigid, and as our knowledge about cities increases, we will be able to expand both the set of universally accepted design support facts as well as the locally important information and knowledge. The universally applicable information is depicted by the global symbol.

New ways to plan the city

City planning means different things in different parts of the world. While the development in Europe and United States is stagnating, the cities north and south of the equator are expanding as rapidly as European and North American cities did 150 years ago. Yet in the meantime, the world‘s population has grown by a factor of 6, and the global networking amongst the urban centres has increased significantly. The interactions between cities are massive as compared to the development in Europe and North America in the 19th and 20th century. Asian centres such as Singapore have recognised and developed city planning as a crucial part of the development of the entire nation. The idea is to become the leading centre in Southeast Asia with the highest satisfaction of the inhabitants. **Lee Yi Shyan**, the Singaporean Minister of Trade and Industry asks in 2012: “How can we urbanise while maintaining harmony – socially, economically and environmentally? How do we balance short-term needs with long-term demands? How do we ensure that we can go on building cities, while retaining a healthy environment for our children and grandchildren?“

The Future Cities Laboratory looks at city planning from different perspectives. On the territorial scale, the architects and urban designers **Marc Angélil and Franz Oswald** conduct research on the symbiotic relation between cities and their regional and global Hinterland in Brazil and Ethiopia. Territorial Designer **Milica Topalovic** concentrates on the interconnections between Singapore and its Hinterland, which includes Malaysia and Indonesia, but which is global in reality. Also on a territorial scale, transportation planner **Kay Axhausen** simulates the effects of mobility and the increasing number of cars and other vehicles. In the neighbouring Jakarta and along the Ciliwung River, the landscape architect **Christoph Girot and Paolo Burlando**, a hydrologist, try to understand and plan for the territorial importance and the local functions of water as natural and development elements. The urban sociologist **Christian Schmid** works with comparative methods in the rapidly growing urban centres north and south of the equator to discover common phenomena and solutions for the densification of cities.

New ways to build the city

Cities seen as physical expressions of urban systems consist of people, buildings, infrastructure, and moving parts. The urban system extends above ground and below ground. Above ground, buildings are the objects that we associate with cities most. Every single building in a city contributes to its future success or failure with regard to sustainability, and therefore building physicist **Hans-Jürg Leibundgut and Arno Schlüter**, an architect, concentrate on **Low Exergy** housing and office buildings for the tropics. Architect and building technologist **Sacha Menz** compares housing typologies in Switzerland, Singapore, and China. To construct these buildings in the future with high precision and longer life cycles, **Fabio Gramazio and Matthias Kohler** teach their students to program robots for the automatic, non-standardised digital production of high-rises. Building scientist and preservation specialist **Uta Hassler** and her group focus in Singapore on material flows and the historic aspects of quarters originating from different times and development of the city. Expanding on this team, the urban planner and architect **Kees Christiaanse** leads a team that deals with the revitalisation of city quarters and is also exploring the new role of the airport as an integrated part of the new city. With the explicit goal of saving valuable resources and reducing CO2 output in the production of building materials, **Dirk Hebel** introduces regional material such as bamboo which in specific parts of the world could partially become under certain conditions a replacement for concrete in construction.

New ways to manage the city

Cities consist of more continuous parts and more dynamic parts. In the constant development between continuity and change it is necessary to build innovative methods and instruments for a dynamic city management. Already the master plans for a city and the resulting buildings should be seen through the eyes of the city life-cycle management, and the city administration has to be composed in a way that it can implement well-founded requests from the population. Rules and building regulations will play an important role in the future to manage the city. **Alex Lehnerer** is planning a centre for urban rules, that could formulate planning guidelines for the new city. As interaction environment for those who are participating in the building and the management of the city, as well as for the safe deposit of all information related to a city, the **Simulation Platform** of the Future Cities Laboratory with the Value Lab Asia represents the technical foundation. Information originates from data. This data stems from historical records, but increasingly from real-time and online sources, crowd sourcing and social media. Integrating them carefully in the Simulation Platform will lead to context sensitive knowledge databases for the management of future cities.

Future cities

It is clear ready now, that the future city will not be designed and built based on hierarchies, formalisms, or mathematics, but will originate from a dynamic system you including global relations and the local force fields. This view of the future city is already reflected in the organisation of the Future Cities Laboratory, which closely networks on the one hand in-depth disciplinary research and on the other hand disciplines like design or sciences. Depending on the topic, the leadership of emerging synergy projects will rest with the research module that has the highest competence in this field of interest and might change throughout the project. The first example is the common work on the historic Rochor quarter in Singapore, where tradition and future are at stake. A second example is the Jakarta Ciliwung project, in which several research modules of the Future Cities Laboratory cooperate with the University of Jakarta on the concrete redevelopment of a Kampung in order to improve the situation of the slums in a sustainable way. A third example is the design and construction of the city of Nestown in Northern Ethiopia. All examples having common that research, development and implementation are closely working together in the rapidly growing regions around the equator with the common goal to achieve urban sustainability.

The cities of the future will differ from each other much more than those of the presence, because they emerge in a globally networked consciousness and with the knowledge of the importance of sustainability. They increasingly will take into account the participation of people as well as the climatic and economic context. This requires that the teaching of city planning and urban design needs to be revisited and renovated fundamentally, and must be adjusted to the degree of knowledge that has been created in city related research. To this end, the Future Cities Laboratory develops a new curriculum for those students in different parts of the world, who will lead the planning, construction, and the redevelopment and the management of future cities. The new curricula will influence education in the West but possibly even more the education in Asia and in Africa, because these curricula will hopefully end the discrepancy between the needs of cities in those continents and the solutions that were traditionally offered in the West.

At the beginning of the 21st century, the majority of the fastest-growing cities are in Asia and Africa. In the very near future, the majority of the population in the world will not only be housed in cities, but in Asian and African cities. As a result, the knowledge of the development of the cities is crucial for students worldwide. The patterns and recipes of the past will be replaced by new patterns and blueprints that are under development in the Future Cities Laboratory in Singapore and Zürich.If

Review Future Cities Preface.1 Urban population

How many people in Asia will need new living and working places in the coming 30 years?

- **A.** 500 million
- **B.** 2 billion
- **C.** 5 billion
- **D.** 1,5 billion

Check Answer

Section 1

How to navigate

QUICK GUIDE

You are interacting not really with a „book“, but with a multi-dimensional „information space“ that you can access from different perspectives and levels of knowledge.

1. **If you are interested in an overview, read the short summaries on the first page of the chapters**
2. **If you are interested in the definitions underlying the chapter topics, read the page following the chapter summary**
3. **If you want to know why this chapter is relevant for designing, planning or managing cities, read the section on „Relevance for the city“ in each chapter**
4. **If you know more or read incorrect statements, please use the feedback section to improve the book for all future readers.**

Overview

All Chapters in the book are relevant for the understanding of cities, and if you are in the position of or have interest in designing, building or managing a city or its parts, these chapter overviews will give you a brief introduction. Do not worry about expressions you might not know - if they are highlighted and you click on them, they will be explained.

Definitions

The first page after the chapter introduction contains the definitions and gives access to the next level of understanding. The more formal approach is meant to establish access to the relevant literature and reports in the particular field of urban design, construction or management knowledge. Here you will also meet the persons who are most prominently working in and defining the cutting edge research in the area.

Relevance

In some cases you may wonder why a particular chapter or section is relevant for city design, construction and management. The relevance section should give the reasons in situations where it is not obvious and establish the correct links to the related chapters.

Chapter 1

Information Architecture

In the realm of the built environment, Information **ARCHITECTURE** visualises the information inherent in a building and thus makes the invisible visible. In the realm of the virtual, **INFORMATION** Architecture serves as a metaphor to structure the vast amount of data produced in modern society. We define **INFORMATION ARCHITECTURE** as the necessary framework to understand architecture, urban systems and territories in the knowledge society.

Section 1

Data, information, knowledge

INFORMATION ARCHITECTURE COMPONENTS

For physical architecture, we use physical materials. For information architecture, new types of material are needed. Data, information, and knowledge could be those materials. Abstract in nature, they need structure, space, and interfaces so that we can use them for design support purposes. Other disciplines, such as medicine, are constructing their body of knowledge with the same elements to come to a better understanding of the functioning of the human system.

Three important words

Data and information are often used interchangeable, but as they are at the core of information architecture, they deserve a special consideration. Wikipedia, for example, suggests that “**Data** is another word for information“. We see data as the smallest entity of information and as a necessary foundation for building knowledge.

The transformation from data to information to knowledge is one of the most important activities in every society. End might appear that this activity applies only to the post-industrial societies, yet it was and is as important for the preindustrial and the industrial societies. With regard to the city as hubs for the collection, storage, and transformation of data into information, knowledge, and finally built architecture and other physical and intellectual structures, this activity is crucial. It requires the capacity to abstract, to order, to give structure, and to design. Therefore, the architectural curriculum is a good foundation for information architecture.

Since the middle of the 20th century, a development in computer science, with roots even more than 100 years before, laid the foundation to represent and work with data in a standardised format. This standardisation of data and information has had the most important impact on human society until today.

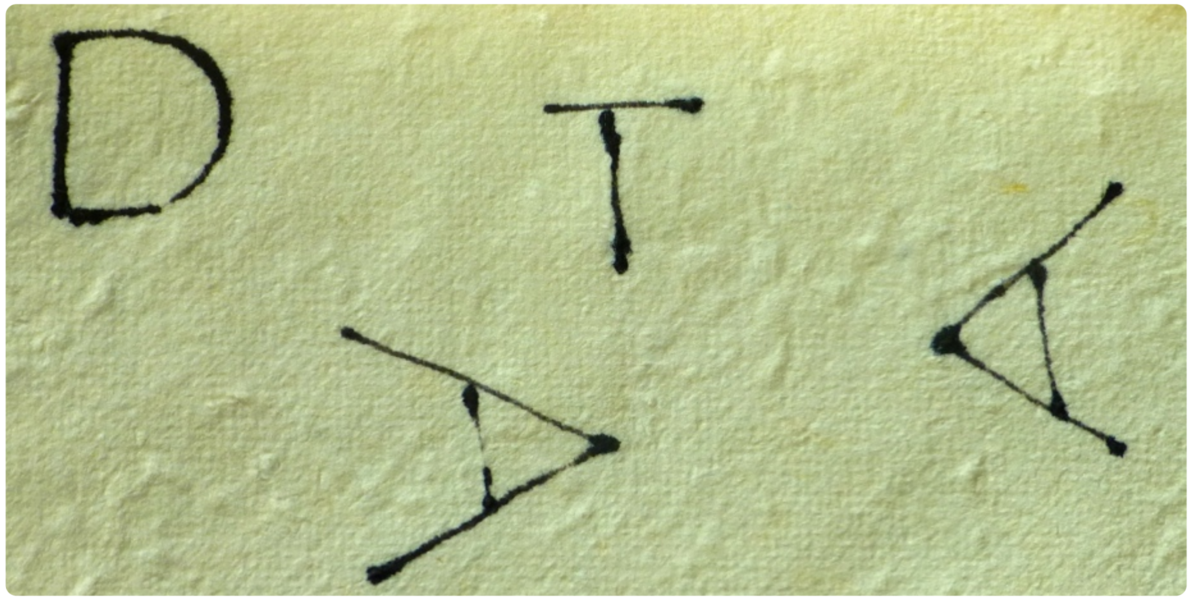
Data

The Romans used the word **datum** to express „that is given“. In the context of the city, we refer to **data** as the smallest entities of information, as values given to objects, expressions, functions or properties. Examples for data are numbers, colors or other simple descriptions. To better describe objects, expressions, functions or properties we need data and connections or relations - we call the result information. Important to remember: Data do not completely describe objects, expressions, functions or properties, but they are an indispensable ingredient.

Information

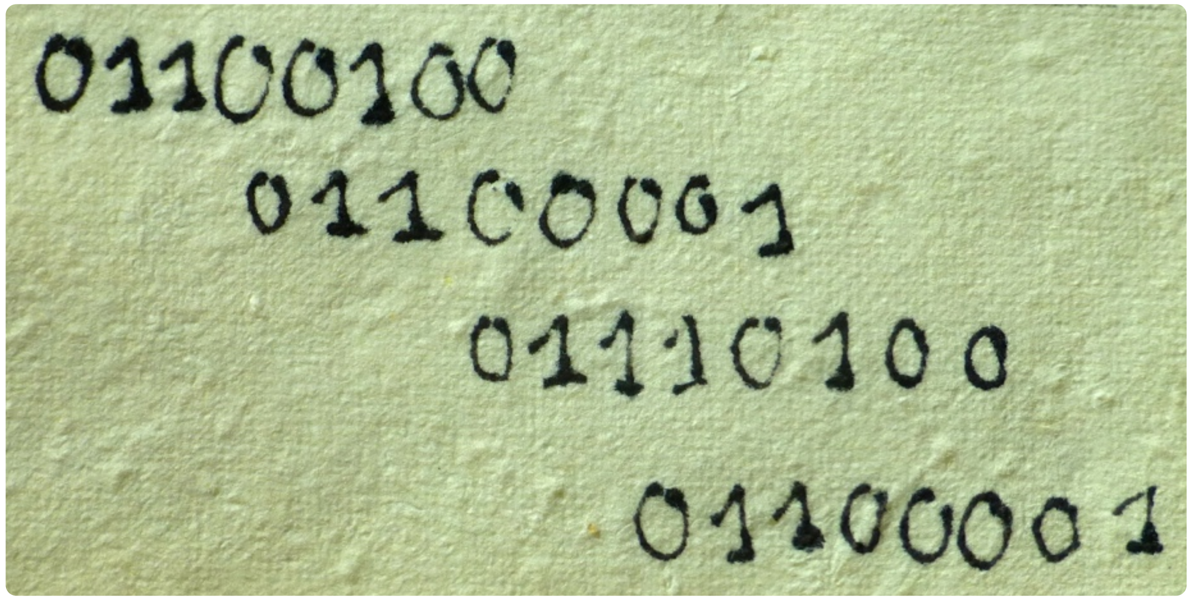
Information sets data in relation to each other, it consists of data and connections. The word has also Latin roots: informatio. There was the stone age, the bronze age, the iron age, or the nuclear age. We consider information as a virtual material, and one of the most important ones for the information age and for the information society. Important to remember: Information does not completely describe society, but it is an important abstraction.

Gallery 1.1 Examples for data



Letters of the alphabet as data. Ink on paper, Johanna Schmitt, January 27, 2013

Gallery 1.2 Examples for information

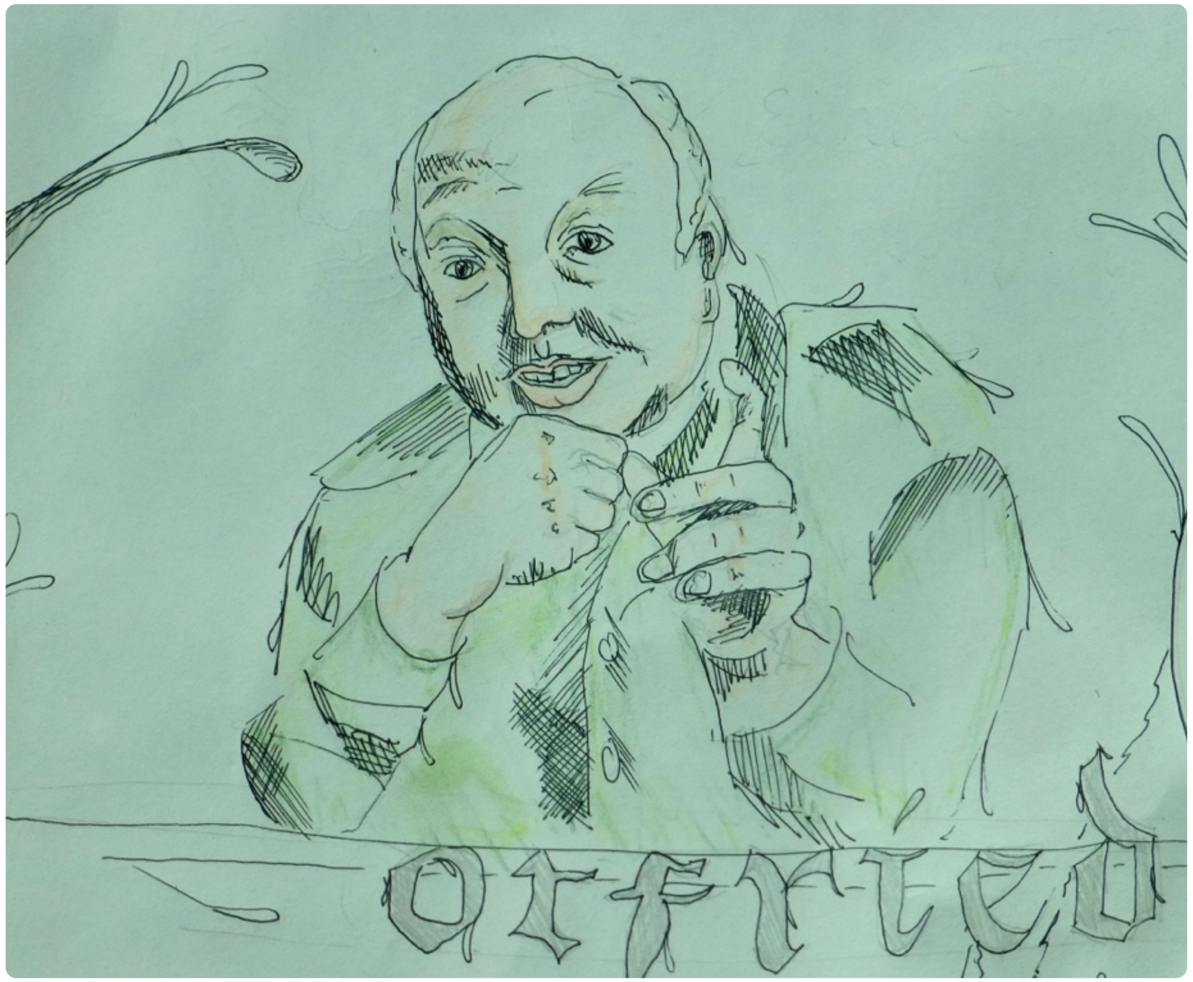


Binary code of the word «data». Ink on paper, Johanna Schmitt, January 27, 2013

Knowledge

Knowledge is a result of connecting data and information. It is not entirely clear how data and information are combined in the cognitive process into knowledge, but in any case domain knowledge and domain independent knowledge build on data and information.

Gallery 1.3 Containers of knowledge



The knowledge of the writer Otfried Preußler, author of the book Krabat. Pen on paper, Johanna Schmitt, January 20, 2013

Section 2

Information ARCHITECTURE

DEFINITION

Information ARCHITECTURE stands for making the invisible visible in the form of digital information extracted from and applied to physical architecture to better understand and design physical architecture.

Information is a central property of architecture, as it is defined by data and their relation and at the same time is a crucial ingredient to build and maintain architectural knowledge. We can think of information as the building blocks of future architecture. Looking at such a building block, we can decompose it into its facts (data) and into the relations connecting the different facts. Looking at knowledge, we can decompose into information and into the relations connecting the different sets of information. But it is much more difficult to reverse this process.

Information ARCHITECTURE describes the information IN architecture.

Architecture and information

Far too often, we take built architecture for granted. We are satisfied by looking at the surface of a building, of a city, or of a landscape. For those who want to merely enjoy and experience architecture, this may suffice. But for those who want to design buildings, urban quarters or territorial structures, this is not enough. We need information to understand and design architecture, and as we shall see later, we need the architectural metaphor to understand and design information. But what is information? And what is the relation between data, information, and knowledge?

Think of a simple brick wall: in the distant past, it was sufficient to know about the bricks ability to protect and to bear loads. In the information age, the brick wall can tell us an entire story: the origins of its materials, the process of their transportation to the production site, the production of the bricks and the mortar, the transportation to the building site, the construction process, the position of each brick in three-dimensional space, the thermal properties of the wall, its colour, its acoustic properties, its health related qualification, and many other invisible, yet existing properties. In fact, the wall tells us an entire history about its life-cycle. If we know all these properties and also how to handle them, it should be possible in the future to design and build new architecture, which fulfils its specifications much better than today.

Data in ARCHITECTURE

All scientists need data, and all architects need data. Often, we see the value of data only then when we have no access to them. As history is an important aspect of architecture, historic data of valuable and the precondition for many design decisions. Future data–which by definition cannot exist–come from architectural simulation and design exploration.

Information in ARCHITECTURE

Looking at architecture, we see the obvious. But there is more invisible information in architecture than meets the eye.Think, for example, of the past, present, or future temperature of the room; the weight of the wall resting on a floor; the age of the wooden beams in the ceiling; the hidden pipes and cables behind the plaster; the acoustic properties of materials surrounding you; the cost per square metre or per cubic metre of the space you look at; or the CO_2 embedded in the material and the energy needed to heat and cool the space.

Gallery 1.4 Data in ARCHITECTURE

What do these numbers mean? This data might be important, but make no sense without knowing the context. Science Park 2, Singapore, April 1, 2011. Photo: Kevin Lim

Gallery 1.5 Information in ARCHITECTURE

Old or new? Original or reconstructed? We need historical information to decide. In the vicinity of Riyadh, January 28, 2010. Photo: Gerhard Schmitt

Knowledge in ARCHITECTURE

Combining information, experience and insights can lead to architectural knowledge. This knowledge is necessary to design new buildings that fulfil certain properties; and it is necessary to understand the function and meaning of buildings in the first place. Knowledge is associated with people, in this case with architects. Knowledge increases with the experience of architects in their practical and theoretical work.

Gallery 1.6 Knowledge in ARCHITECTURE

The Architect Franz Oswald in Singapore as Leader of the Future Cities Laboratory on September 8, 2011. Photo Gerhard Schmitt

Data, information, knowledge, architecture

The design of architecture is built on knowledge, knowledge is built on information, and information is derived from data. Yet there is no straight and automatic way from data to information to knowledge to architecture. The structures, frameworks, hierarchies, ontologies and mechanisms that relate those entities are most interesting for research. One of these structures we refer to as models. Models in architecture, urban design and territorial planning are an abstraction of the real object with its functions and behaviours. Models are also the base for simulation, an activity and abstraction that includes the important parameter of time.

Information ARCHITECTURE uses simulation for more than creating images or artefacts based on geometric constraints, rules, or cases. Rather, non–geometric factors such as light, energy, structure, behaviour or systems knowledge become available for integrated direct modeling. Information Architecture helps to formalise and generalise design principles.

Few design principles in architecture, urban systems or territorial planning are context-free. Those are the ones based on known constraints, such as gravity, temperature ranges, or material properties. Most other design considerations depend on the context.

Modeling in ARCHITECTURE

When we think of architectural models, physical models of proposed designs or existing buildings come to mind. Yet in the context of information ARCHITECTURE, **modeling** builds on abstractions of physical architecture that explicitly show the connections between the parts and the whole. This normally involves simplification and formalization. To simulate a building‘s cooling demand, for example, we apply a formalised physics model to a specific, yet simplified geometric model.

Simulation in ARCHITECTURE

Simulation in Architecture requires the existence of a model, representing the most important characteristics of the proposed solution. In the past, the words «model» and «simulation» were often used interchangeably in architecture, i.e., an architectural model was seen as a design scenario for a given time in the future. Increasingly, the factor time and with it the dynamic aspects of design proposals become important parts of simulation in architecture.

Gallery 1.7 Modeling in Architecture

Physical models of buildings in Singapore. URA Gallery, August 25, 2010. Photo: Gerhard Schmitt

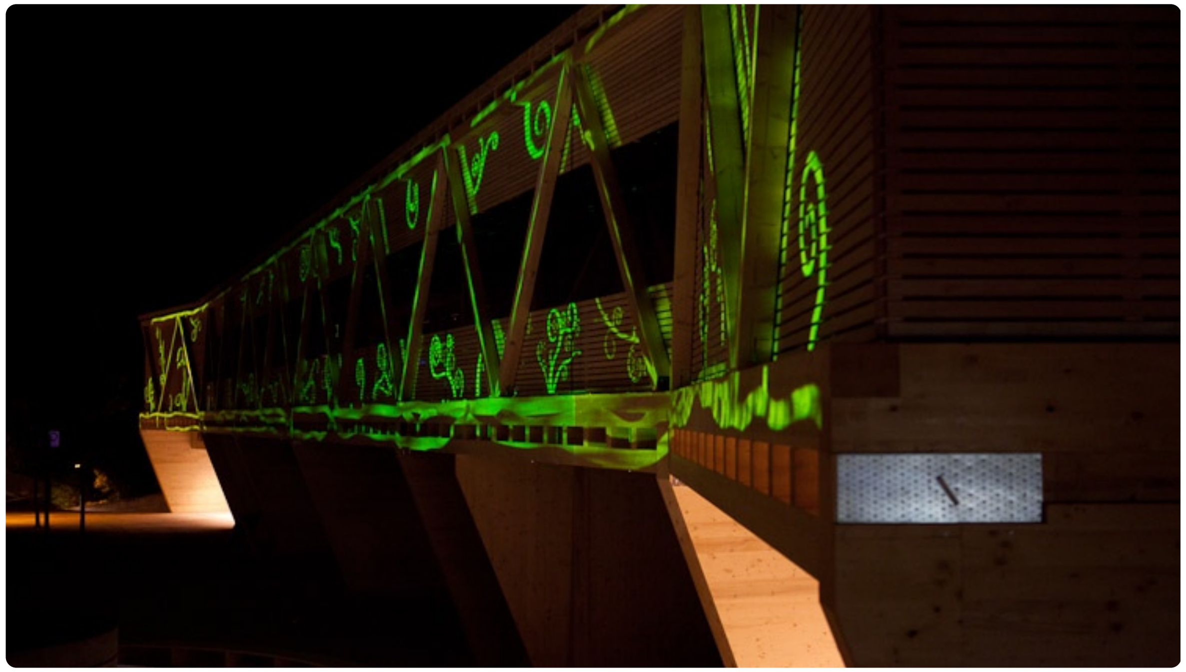
Gallery 1.8 Simulation in Architecture

Simulation of future buildings and land use in the Value Lab Zürich. Antje Kunze and Jan Halatsch, 2009. Photo: Chair of Information Architecture

Projection in ARCHITECTURE

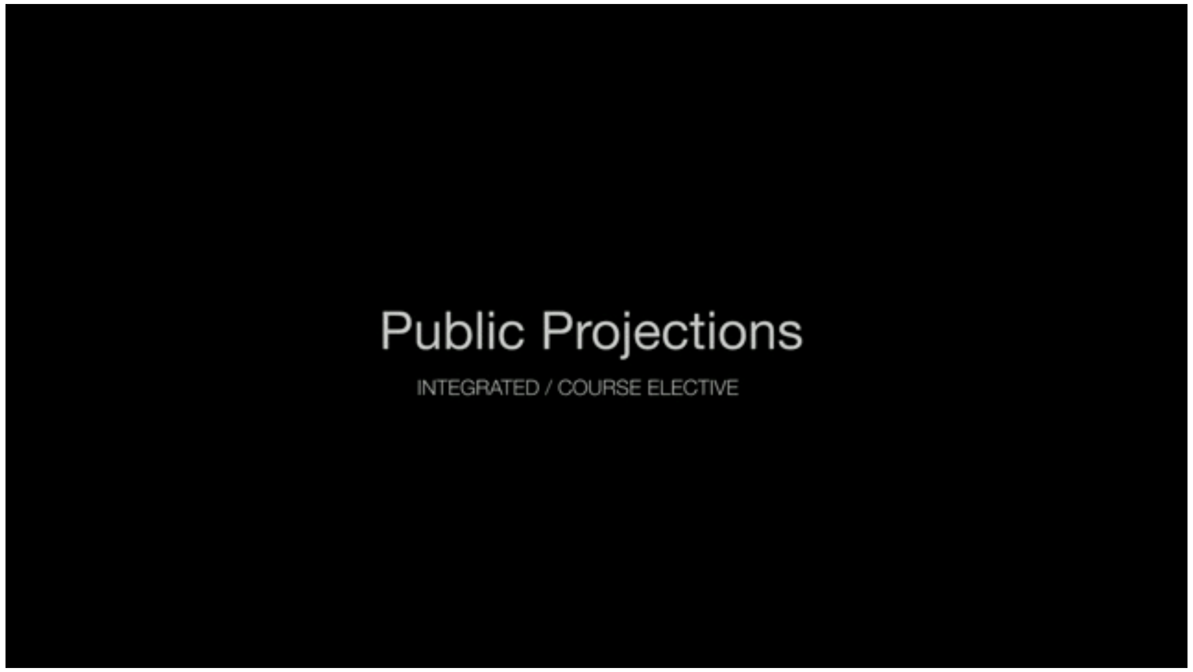
Projections are a special type of information ARCHITECTURE. They either project images that have nothing to do with the content of the projection area. Or – more interesting – they project abstractions of information of functions or events that occur behind, in, or in front of the projection surface. This way, facades can become large information displays. The chair of information architecture has established a tradition of projection exercises with Christian Schneider. He started with projecting complex adaptive code generated geometries onto facades, respecting the particular qualities of each facade in terms of openings and proportions. He then began using infrared cameras to detect people and heat emitting objects as they were moving in front of the building, resulting in dynamic changes in the projections.This was a convincing example for making the invisible – in this case sources of heat – visible. Lukas Treyer extended the experimental exercises towards dynamic design projected on more complex geometry. Students learned programming and at the same time gained experience in visualising information in previously unthinkable ways.

Gallery 1.9 Projection in Architecture



Architectural projection by Lukas Treyer on the facade of a parking garage. Stadtfest Baden, Switzerland, November 2012. Photo: Lukas Treyer, iA, ETH Zürich

Movie 1.1 Projection in architecture

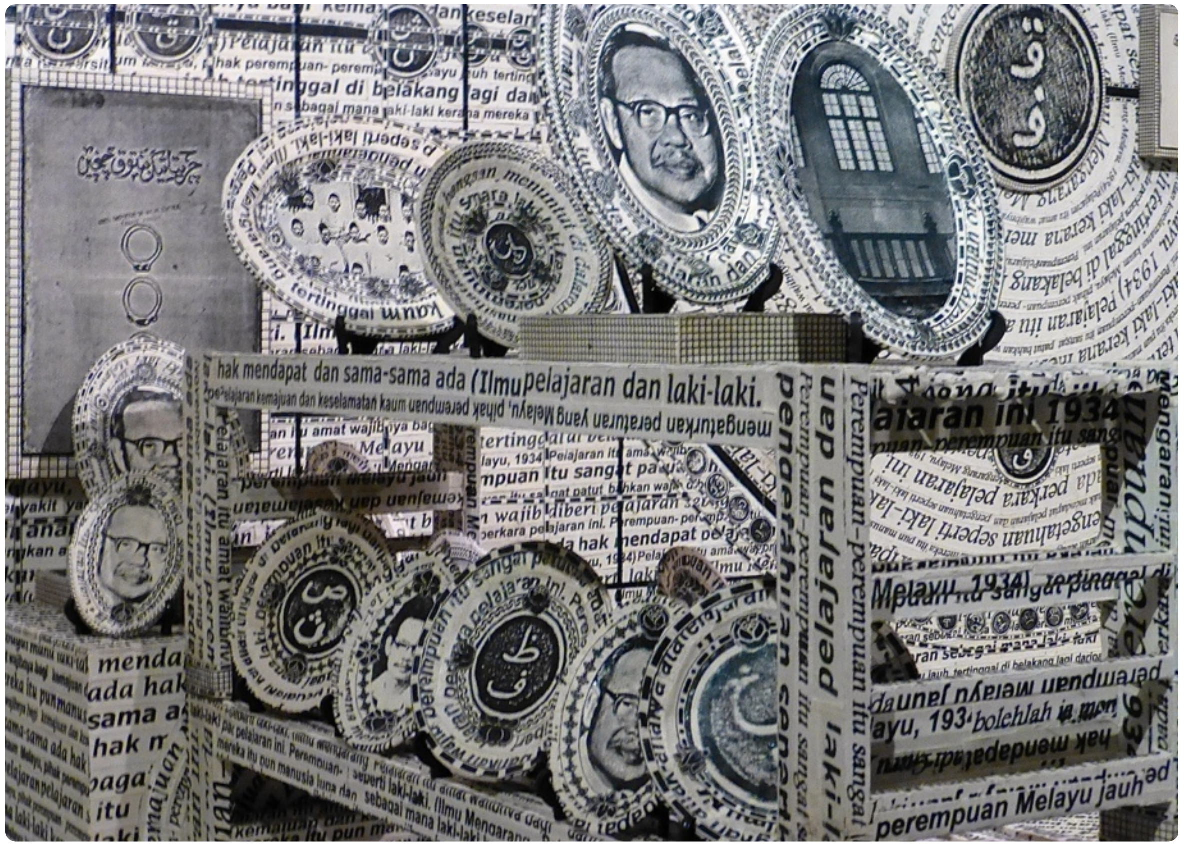


Video of the architectural projection by Lukas Treyer for the Stadtfest Baden, Switzerland, November 2012. Video Lukas Treyer, iA, ETH Zürich

Art Information ARCHITECTURE

In art, architectural spaces and furniture can be used as information carriers. Most of the time spaces are used as an empty shell in the background, to allow art to be perceived separately. Information can also be displayed from furniture and other surfaces, giving the impression of interaction between the viewer or user of the space and the art installation.

Gallery 1.10 Art information space



The shaping of cultural memory by historical texts. Zulkifli Yusoff, collage embossed dye printed on canvas, 2011. Exhibition in the Singapore Art Museum. Photo: Gerhard Schmitt, February 11, 2013.

Curricula in ARCHITECTURE

Architectural education is about integrating data, information and knowledge with the ability to design and to arrive at buildable, affordable, and sustainable architecture. The same applies to urban design education and territorial planning education. Each architectural curriculum represents the present view of the institution in charge of what it considers to be necessary for the education of architects, urban designers and planners. Over the years, courses covering topics from other disciplines and sciences are added to and dropped from the curriculum, with the ultimate goal to improve the final product, be it architecture, urban design or territorial planning. Every addition of a new topic and every elimination of an existing topic cause heated discussions in faculties and among students. Yet as the total time for education is limited, and as the body of knowledge of architecture is growing exponentially, this process is necessary and unavoidable. Rather than merely dropping and adding courses, it is worth looking at a higher level of abstraction to find out if some topics could be combined into one, and if there is an underlying structure, grammar and language to these topics. Data, information, and knowledge might be a first step in this direction.

Section 3

INFORMATION Architecture

DEFINITION

INFORMATION Architecture describes metaphors and principles of physical architecture applied to digital data and information to create an architecture of information, using information as raw material.

INFORMATION architecture describes the architecture OF information.

In the Internet, **INFORMATION architecture** describes the organisation and the labeling of websites, online communities, and intranets. But there is the potential to organise and structure not only the obvious, but the entire information space. The key to these possibilities is the understanding of the architectural metaphor.

The architectural metaphor is an abstraction that is used in various fields. Think of words such as computer architecture, financial architecture, security architecture, or political architecture. In each case, the word architecture is meant to describe a structure and order, and not the physical construct. These expressions and descriptions use the abstract power of architecture and apply it to other fields.

Richard Saul Wurman is the person who originally used the term information architecture. As an architect and graphic designer he clearly broad architectural concepts into the world of information with the intention to make it better understandable for everybody. He also invented the Technology, Entertainment and Design (**TED**) conferences.

INFORMATION architecture is very powerful in placing emphasis on certain information by using the architectural metaphor. It is, at the same time, also a dangerous instrument as it might lead to overlooking other, less structural prominent pieces of information that might be essential, but go unnoticed.

Architectural and planning metaphors shaping the structuring of data

Even in the digital age, everybody knows a stack of books, or a stack of dishes. Placing a book on top of the stack or taking a plate from the top of the stack our activities in a building that we perform almost daily. In computer science, a **stack** is described as a abstract datatype or collection with with one main operation: to add an entity to the collection, described as push, or to remove one entity, described as pop. With the stack,The connection between the physical world and the abstract world of computation is still visible: the most recent item is pushed on top, and it will also be the first to be retrieved. One can almost feel the effect of gravity in this description, although it is a completely virtual analogy in information space, were the metaphor of the physical stack is helpful to describe a particular ordering principle.

Moving closer to the building, computer science uses the expression of **barriers** and **fences**. Fences are used as metaphors and stand for guaranteeing that storage and cache have the same state. In analogy to an animal herd, fencing in computer science can also describe the process of separating entities from the rest. In computer science, this is necessary when nodes or sense of nodes in large computational clusters feel and need to be isolated to protect the overall performance of the system.

Sounding similar, but not necessarily related is the expression of computer farms. In an analogy to physical farms, usually in the hinterland of urban systems and supplying them with food, computer farms have specialised meanings. There are the **server farms** or server clusters, tying together logically and physically dozens, hundreds, thousands or even millions of individual computers. These server farms around the core of most operations in the Internet today. The analogy to farming does not stop here: the individual servers are usually stacked on top of each other in metal racks, which evokes the analogy to vertical farming. They also generate large amounts of heat as a result of the significant electricity consumption. As a matter of fact, server farms and the associated storage devices become so significant in terms of electricity requirements and cooling loads, that in temperate climates they can be used to heat entire buildings, and in hot climates need to be faraway from the city – in previous farmland – to avoid the overheating of the urban environment. In some cases, the analogy goes even further, in that gigantic server farms are placed directly in the vicinity of huge cattle farms, to make use of the electricity generated by burning biogas. A special type of computer farms are render farms in which several thousand CPUs are connected to produce the animations for the movie industry.

The function of a **firewall** in architecture is well known: its main purpose is to protect from a threat, specifically to prevent the spread of fire. In computer science, firewalls will most likely not protect from the spread of fire, but they are designed to prevent un-authorised access to information. Today, this software concept is installed on almost every computer we carry around, but nobody seems to be aware of this particular irony. It does however clarify the absolutely virtual character of the expression firewall.

Further expressions in computer science, using the architectural metaphor are: Roof-line model, Data vaults, Data warehouse, Data highway, Data mining, Portal, Software architecture (Mary Shaw, CMU), Windows, Control plane, Back pressure, Pipeline, Staging, Tiling (so that data fit in the cache), B-trees, quad trees, oct-trees, grids.

Section 4

INFORMATION ARCHITECTURE

DEFINITION

INFORMATION ARCHITECTURE describes objects and buildings that are both expressions of information and at the same time use the architectural metaphor or the architectural object itself to bring structure and order into information.

INFORMATION ARCHITECTURE is architecture built for data and information gathering, storage, display, access, and experience.

A good example for this type of information architecture is the **Jantar Mantar** in New Delhi. The structures are not only architecturally attractive, but serve a specific scientific purpose. They are a perfect merger off form and function. Although construction started in 1724, they still form an impressive information architecture park in the centre of the capital.

Certain cathedrals and temples could also be considered INFORMATION ARCHITECTURE. The condition would be that the physical architecture rationally supports and enhances the information to be conveyed. This applies particularly to the use of orientation and windows to guarantee particular lighting effects at given times of the year. Sound enhancing interior space quality, achieved by geometry, surfaces and material, enable the transmission of sound information to the listeners with emotional effects in mind. Text integrated in the wall, on the floor, or on the ceiling, as well as sculptures conveying messages, are additional pointers. As such, the precalculated effect of light, sound, written, painted and sculptural information is a indication for INFORMATION ARCHITECTURE.

In general, buildings that successfully convey messages (intended, not by accident) and were designed for this purpose, can be considered as INFORMATION ARCHITECTURE. Examples are light towers, old bank buildings, hospitals, skyscrapers or Apple stores.

Example Atacama telescopes

INFORMATION ARCHITECTURE is probably the easiest way to explain the relation between information and architecture in a practical sense. There are structures with the only purpose to collect data. Those could be telescopes in Atacama desert, displaying fixed and dynamic parts. The fixed parts are the outer shells of the building, the dynamic parts follow the instructions given by scientists around the world.

Gallery 1.11 Architecture built for gathering information

One of the 1.8m diameter auxiliary telescopes, mobile on tracks, working in synchronization with the large telescopes. Paranal, Chile, August 12, 2007. Photo: Gerhard Schmitt.

Example libraries

Libraries have the purpose to store, protect, display, and give access to data and information, mostly in printed form.They have developed over centuries in all cultures and form, if successful, communal and social centres in urban systems. Their status and media content is changing constantly in society, especially in the digital society, yet the inexplicable connection between architecture and information remains.

Gallery 1.12 INFORMATION ARCHITECTURE

A place to store and access information. Library in the Collegium Maius, Krakow. Photo: Gerhard Schmitt, December 9, 2008.

Example stores

It appears unusual that digital companies need physical stores. Yet it has become a successful business model to build attractive stores selling digital and information technology equipment directly to consumers in prominent locations in the city. The desire of clients to explore the product together with well-trained personnel makes those stories commercially most successful.

Gallery 1.13 INFORMATION ARCHITECTURE

Store that sells digital instruments for accessing digital information. Apple Store in Sydney. Photo: Gerhard Schmitt,October 24, 2012.

Example churches

Churches are good examples for information architecture. The structure is optimised for light and sound impact to support both contemplation and festive celebrations. Strong symmetries and spatial hierarchies in plan and spatial realisation suggest analogies to the organisation of the church. Walls and windows are additional places to display data and information – or leave free space for projections.

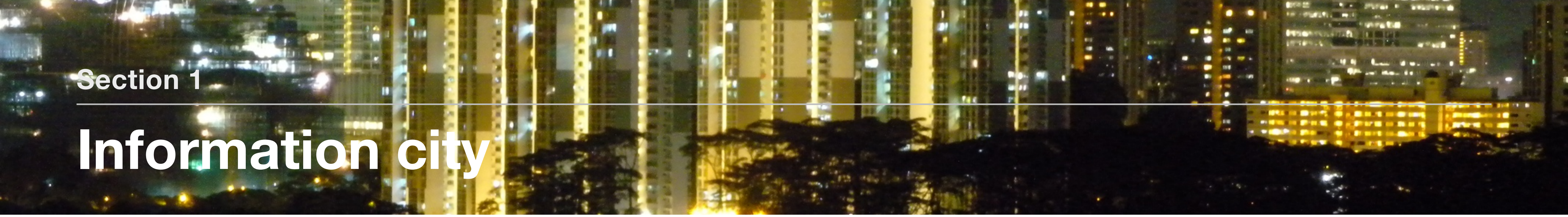
Gallery 1.14 INFORMATION ARCHITECTURE

The Catholic Cathedral in Ho Chi Minh City, Vietnam. Photo: Eva Schmitt, December 25, 2012.

Chapter 2

Information City

Information in digital representation will be a major component of the future city. We propose the term Information City to differentiate it from the present city and to emphasize the importance of information, its creation, handling, storage, mining and refinement into knowledge for the city of the future.



Section 1

Information city

DEFINITION

Information city describes the extension of information architecture to the urban scale. In analogy to information architecture, information city has two main meanings: (1) making the invisible visible on the scale of a city and thus helping to understand the functioning of an interaction between components of the city and to design new cities; (2) information city might become a metaphor for the structuring and ordering of vast amounts of data, created increasingly by the city's inhabitants and its infrastructure.

With information citiy we do not mean the various InfoCities projects that focus on the seamless integration of information and communication technologies. We also do not mean completely virtual cities.

Increasingly, cities seem to take on personalities of their own. They are labelled as megacities, industrial cities, green cities, liveable cities, rich cities, smart cities, innovative cities, tele cities, info cities, or future cities. These properties of the city are sometimes related to the society they are positioned in. It is therefore surprising that the information society or the knowledge society has not produced an equivalent adjective with regard to the city.

We therefore put forward the suggestion that the information society is increasingly living in **information cities**. Cities and urban systems have for a long time been the place where societies accumulated and stored their information. More important, they made this information available to the general public in the form of libraries and exhibitions. Yet the information displayed in libraries was mostly static and describing the past.

New today is the ability of any person using computational devices to generate large amounts of data, and in particular of real-time data. The storage and display of this information cannot occur in traditional libraries any more. Instead the entire city becomes an information organism that at the same time generates data, turns it into information, and displays information in real-time. The visualisation of this information creates new knowledge about the city and is fundamentally different from previous knowledge, as it is able to make the invisible visible.

City information, visible

Like in buildings, much city information is visible, but not all. Coming to a city, we take photos of the obvious information: people, buildings, traffic, parks. At night, other information becomes visible: Lights in buildings, streets, and parks. It may give less 3D information, but more activity and occupancy information.

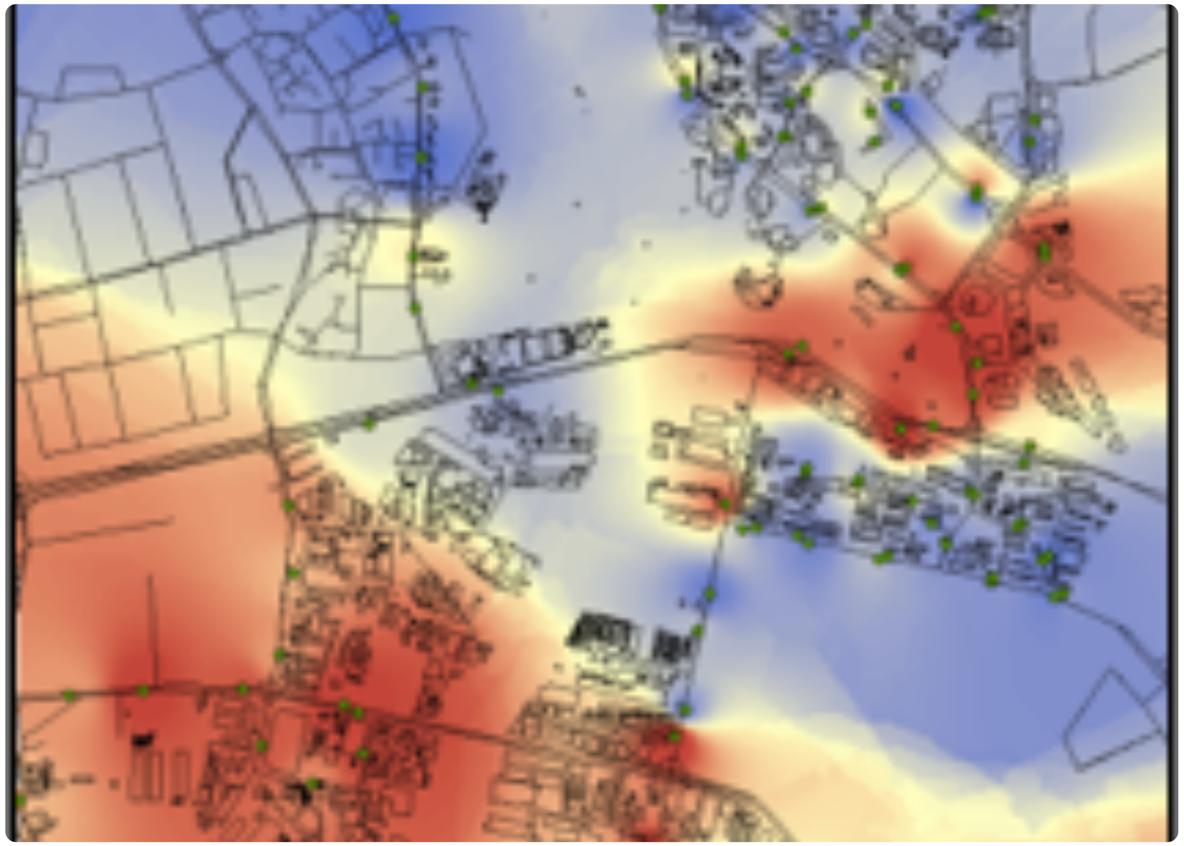
City information, invisible

The inhabitants of the city produce a constant flow of data. They can be visualised, admired, and taken as a basis for observation or future decisions. The first step is to derive a connection between data, activities, and locations in a meaningful sense by deducting relations between data. **Chen ZHONG** has performed pioneer work in this area, in that she is able to clearly relate use of buildings and travel behaviour.

Gallery 2.1 City information

Lights in buildings and cities as indicators for activities. Marina Bay Sands in Singapore. Photo: Matthias Bettschart, December 23, 2010.

Gallery 2.2 City information



Interpolated probability of working places - red: highly probable, blue: less likely. Chen Zhong, January 2013.

City information, invisible

Coming to a city, we may sense the areas where poor, middle class or rich people live. This information is normally invisible, the building and streets are not labelled this way. This information is normally contained in the census data of a city. But how do we sense it? It is a combination of observations that leads to the categorization. **Comparative urbanism** is developing tools to gather and visualize this information.

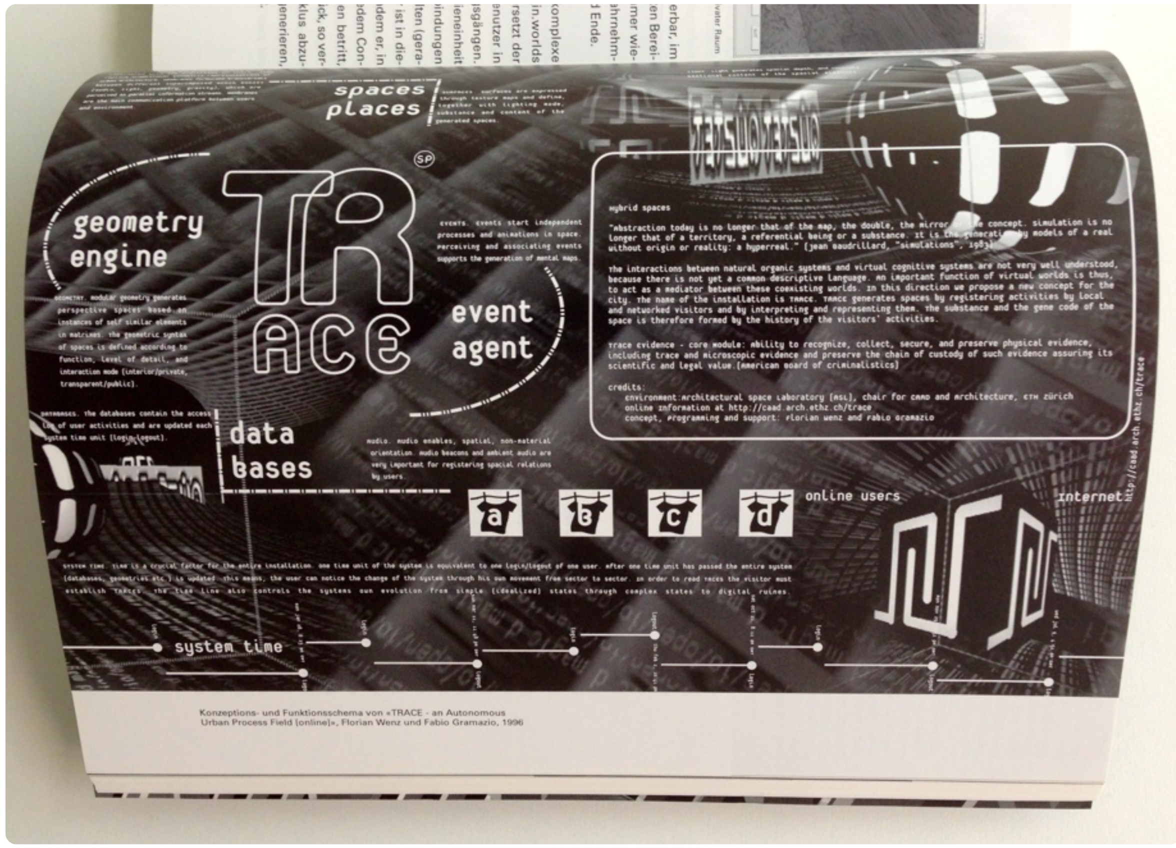
Archaeology of the future city

The plans of today, using information Architecture to depict a possible future, are the historic documents of tomorrow. Seen from the future, they are archaeological items. This view produced the title of an exhibition in Tokyo in 1996, the «Archaeology of the Future City» by **Takashi Uzawa**. It demonstrated the power of combining Architecture and information in the sense of information as the new building material.

Gallery 2.4 Information city

Making invisible information visible: comparing cities. Meeting of the comparative urbanisms group at the Future Cities Laboratory on February 8, 2013. Photo: Gerhard Schmitt

Gallery 2.5 Archaeology of the Future City



«TRACE» installation by Florian Wenz in the exhibition «Archaeology of the Future City» by Takashi Uzawa. Florian Wenz, 1996

Senseable city lab

The research group focuses on the visualisation of real time data.

The **Senseable City Lab** at MIT

Chapter 3

City Models

City models are structural abstractions of cities. The purpose of these models is to simplify the components, the properties, the functions, and the structure of the city to a degree that projections into the future become possible with acceptable effort. City models are increasingly mirrored in computational representations which opens the path towards rapid generation of alternatives. City models are also precondition for urban simulation.

Section 1

City Models

DEFINITION

Models describe an abstraction of the real. The are not the real object and should never be confused with it. But they can extract and describe important features of the real object. Good models also described the interaction between those features and functions of the real object.

Cities in their entirety are the most complex objects humankind has created and is constantly expanding. The city changes with and through its observation by the people living in it. Therefore, any model of a city must respect the dynamics of the habitat.

In this chapter, we shall look at historical, present and potential future models of the city. This is an open ended search for definition, yet necessary in a similar way as medicine needs a model of the human being, even if it is not perfectly describing the entirety of human.

During the sixth decade of the last century, a young scientist wrote an influential book with the title „ A City is not a Tree“. Christopher Alexander, the author, had previously published his „Notes on the Synthesis of Form“. While the first book could be seen more into edition of „form follows function“, „A City is not a Tree“ is a strong hint that modelling a city might not be that easy.

The two books are interesting, because they describe positions that were extended to the extremes in both directions. On the one hand, the perception of the city as a mechanism that can easily be explained, measured, and extended, resulting perhaps in the single number describing the essence of the city. On the other hand, the city as the uncontrollable, messy, constantly changing, unpredictable and in its entirety undescribable organism made up of people, infrastructure, thoughts, money, water and sewage.

Neither the search for the ideal city nor the virtualisation of the city have led to tangible results that would increase the sustainability of a city. Reduced to plans and spreadsheets as their only instruments, many city governments in developing and emerging countries are struggling to provide for the growing number of people streaming into the cities. On the other hand, the emergence of instruments to take advantage of big data and the increasing capacity of information technology to simulate complex systems, there is a clear need for city models.

Overview

„Early architecture and urban design examples are based on fundamental geometric shapes: point, line, circle, square and rectangle. Besides the purity of these forms, they have the advantage that they can be constructed easily with simple tools. They could straightforwardly be assembled into grids, thus providing the footprint for the basic organization of urban services and separating public from private areas. For the arrangement of these shapes and infrastructure networks, city planners defined simple rules and instruction sets which, in combination with the shapes, would form a design description that could be easily taught to others.

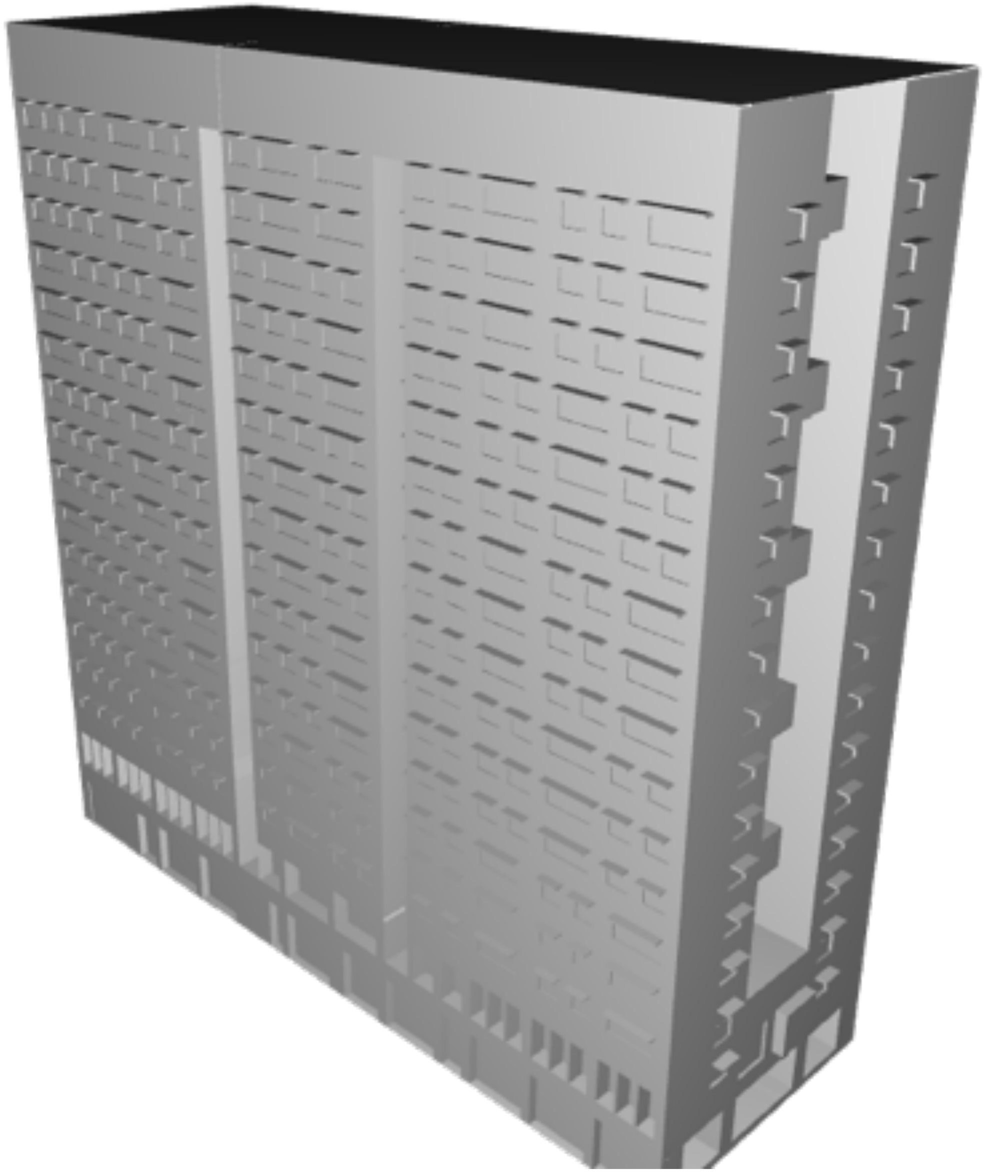
The rule-based approach. With the growing complexity of settlements into urban centers and denser cities, the simple instruction sets became less effective and could in fact diminish the overall performance of the city or hinder it from achieving its defined goals. The definition of those functional goals became priority, geometry had to follow. The geometric pattern of the city was brutally altered accordingly, as the example of the redesign and reconstruction of Paris in the 19th century demonstrates. In this and other cases, geometry was put into the service of other, for example military goals, rather than being the generative driver of city form. Yet the planning intentions and the results of interactions between basic geometry and political or private goals were still visible.

The stocks and flows approach. With growing sophistication of societies and politics, technology and economy, cities changed their geometry again. Linear transportation systems such as freeways, train tracks and suburban private roads gained in importance and reshaped the design of cities. Economics, transportation and the separation between living and working areas became dominant factors. With less limitations in materials and increased freedom in design, driven by a temporary abundance of cheap energy in the 20th century, the geometric expression of the city became increasingly a result of the various stocks and flows that determined city life, leading to sometimes ordered, but sometimes seemingly chaotic conditions of a city's geometry.

The complex system and quantum city approach. With the beginning of the 21st-century and the globalization of city stocks and flows, the dependence of the city on its direct hinterland decreases, and even national networks of cities for the exchange of goods and services lose their dominance. The forces that cities are exposed to start to shift rapidly, thus making them in their development increasingly the result of changing force fields – force fields in the sense of rules governing the balance of the complex system of the city. This leads to metaphorical analogies with quantum theory and thus to the proclamation of the quantum city, as proposed by Ayssar Arida (1) or Ludger Hovestadt (2). At this stage, geometry takes on a new role, but it still is and will be decisive for the positioning of any physical manifestation of city stocks and flows and force fields.“

From: „The role of geometry and space in the continuum of city modeling“.

Interactive 3.1 interactive 3-D model derived from UAV data



Graduate student residences at the University Town in Singapore. 3-D model by Wei Fang, March 21, 2013, ETH CREATE.

Geometric Models

Stocks and Flows Models

As the stocks and flows models are such an important description of possible material, energy, water and other stocks and flows in cities, a separate chapter will be dedicated to this topic.

Land use models

Dynamic models

Complex models

Chapter 4

Stocks and Flows

The concept of stocks and flows helps to bring some order into the complexity of a city. While the concept of stocks and flows was not invented in for architecture, but in economics, it constitutes a useful way of looking at and abstracting of parts of the urban system. The chapter on city models will place it in its historical context.

Section 1

Stocks and flows

DEFINITION

The stocks and flows **concept originated in economy in the 1960s, and best known today are the stocks and flows of finances. Stocks are quantities that do not move, whereas flows are quantities that move. Flows of measured quantities per time. This simple differentiation makes the principle applicable architecture, urban design and territorial planning. The stocks and flows via most interested in are those of people, water, material, energy, density, and information. Stocks and flows are also basic building blocks of system dynamics.**

This chapter is merely an overview, in-depth description of the individual stocks and flows is given towards the end of the book.

The Irrawaddy river in Myanmar and the ecosystem it creates is a good example for stocks and flows in architecture, urban design, and territorial planning. The river changes its volume drastically twice a year. The water it brings from the mountains carries sand and other sediments that settle in the areas it floods. Once the water level recedes, the river has deposited a small stock of material in the form of fertile earth on its banks that can then be used for a few months. People move in and erect temporary housing and shelter: a stock of material and low-density emerges for a few months. Animals accompany the peasants and deposit fertiliser, becoming another contributor to the stocks and flows of the land. Information on the usability of the land and of the best places to settle is transferred via mobile telephones, creating a flow of information. Peasants grow vegetables and bring them to market, thus creating a small flow and possibly stock of finances. The entire landscape is changing over the years, and as a result creates a stock and flow of landscape elements such as land, bodies of water, trees, and other vegetation.

Yet the example also shows how a single stock and flow cannot be isolated from the others. The water mixes with the material and the sand deposits. Later people use the clay to burn pots, and they harvest the send and ship it to the city to construct buildings.

Stock stocks and flows of energy

Every country and every city has the specific way to acquire, transform and distribute energy. The chapter on infrastructure will describe the physical necessities to transform and transport energy. In this chapter, we are interested in the different sources and uses of energy.

A comparison between Switzerland and Singapore reveals significant differences. While Switzerland has a broad mix of different energy sources or supplies, ranging from hydropower to gas, crude oil, nuclear and biomass, Singapore is relying mostly on natural gas and on crude oil. As a result, Switzerland‘s electricity production is almost carbon free, whereas in Singapore there is almost no carbon free electricity production.

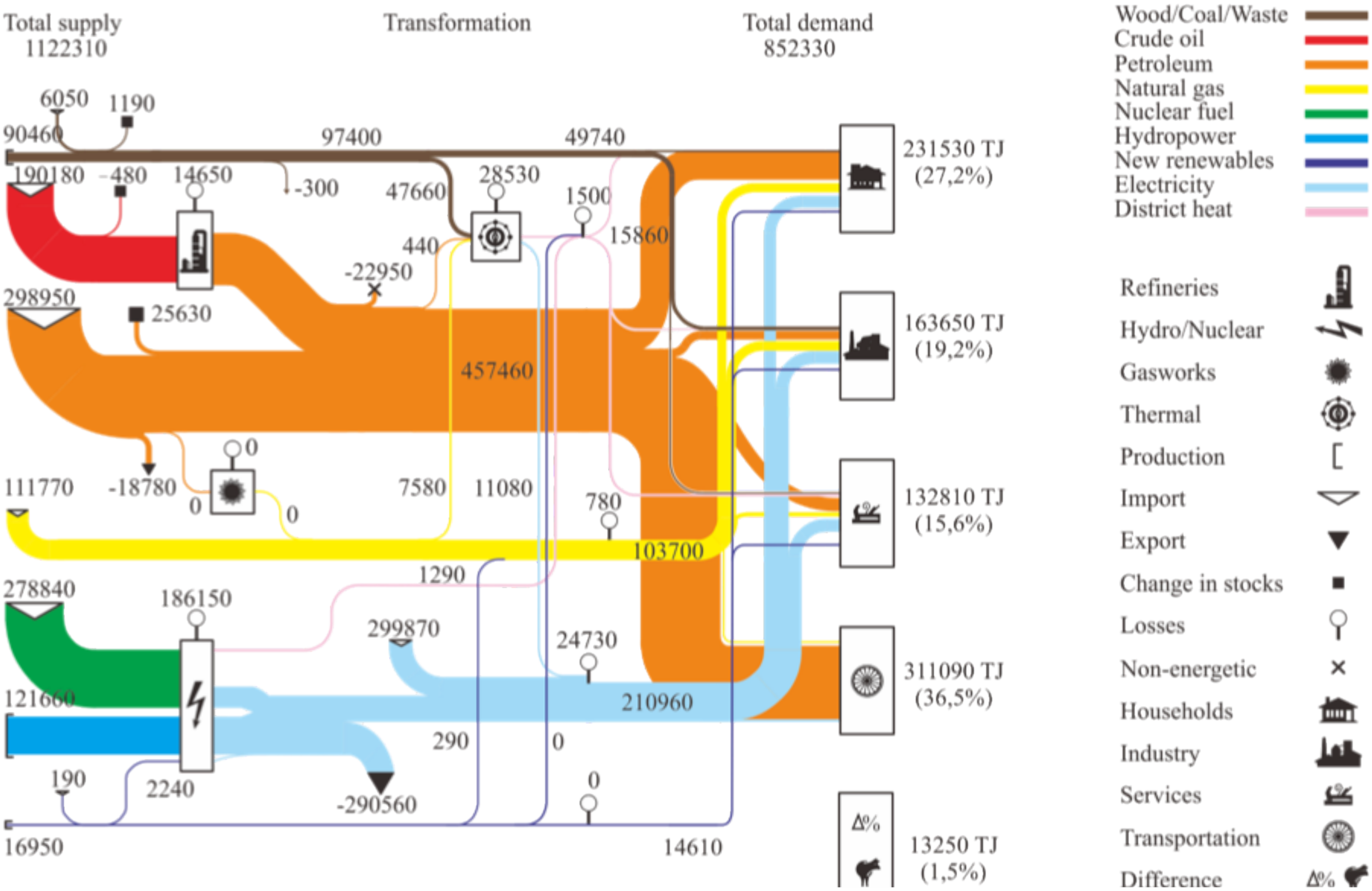
The uses of or demands for energy are also different in the two countries. Whereas in Switzerland a large percentage of the energy is used to heat residential buildings, offices and factories, the need for heating fuel in Singapore is zero. Instead, electricity is needed to cool factories, residential buildings and offices. Large differences are also visible in transportation. Whereas Switzerland is a mountainous country with a multitude of centres, Singapore is a small island with short paths and no mountains. As a consequence, the per capita energy use for transportation is smaller than that of Switzerland.

The storage of energy is also different. In Switzerland, artificial lakes with dams in high altitude serve as energy reservoirs and energy buffers during times when excess energy can be generated. This water can later be used to generate electricity that can be produced exactly then when it is needed. The water in the reservoir is at the same time a stock of water for drinking purposes, but also for energy storage purposes. The flow of water for drinking purposes is normally from higher areas into the lakes, whereas the flow of water for energy storage purposes can be reversed, and large amounts of water are pumped from lower situated lakes into higher situated ones.

For example, Lake XXX is situated at the height of 2500 m above sea level. The water pipes descend through the mountain to a height of 1300 m above sea level. The resulting water pressure drives turbines that are as powerful as an entire nuclear power plant. The artificial lake is used mainly for storage purposes and to respond to peak demands in times when not enough natural inflow of water is available.

The stocks and flows of other energy sources are not as spectacular, but also interesting. For example, the stock of wood is growing in forests. After harvesting, it turns into a stock of heating materials. The stock and flow of oil begins its cycle as a stock in the subterranean caverns of Saudi Arabia, flows into tankers or pipelines, ends up as temporary stock in oil tanks, and is finally transported as a flow into the individual heating appliances.

Gallery 4.1 Stocks and flows of energy



Energy supplies, energy transformation, and energy demand in Switzerland 2012. Matthias Berger, ETH Singapore, Future Cities Laboratory.

Stocks and flows of material in the city

Concrete is a good example to explain the concept of stocks and flows of materials in a city. The components of concrete are mixed with water, concrete is then poured, hardens and becomes a stock. This is almost a literal translation of the stocks and flows principle. What happens with concrete after the lifetime of the structures in which it is used has expired? In an era when recycling was neither an ecological nor an economical necessity, it was exploded, torn down, crashed, and dumped in the city itself or, more often, in its hinterland.

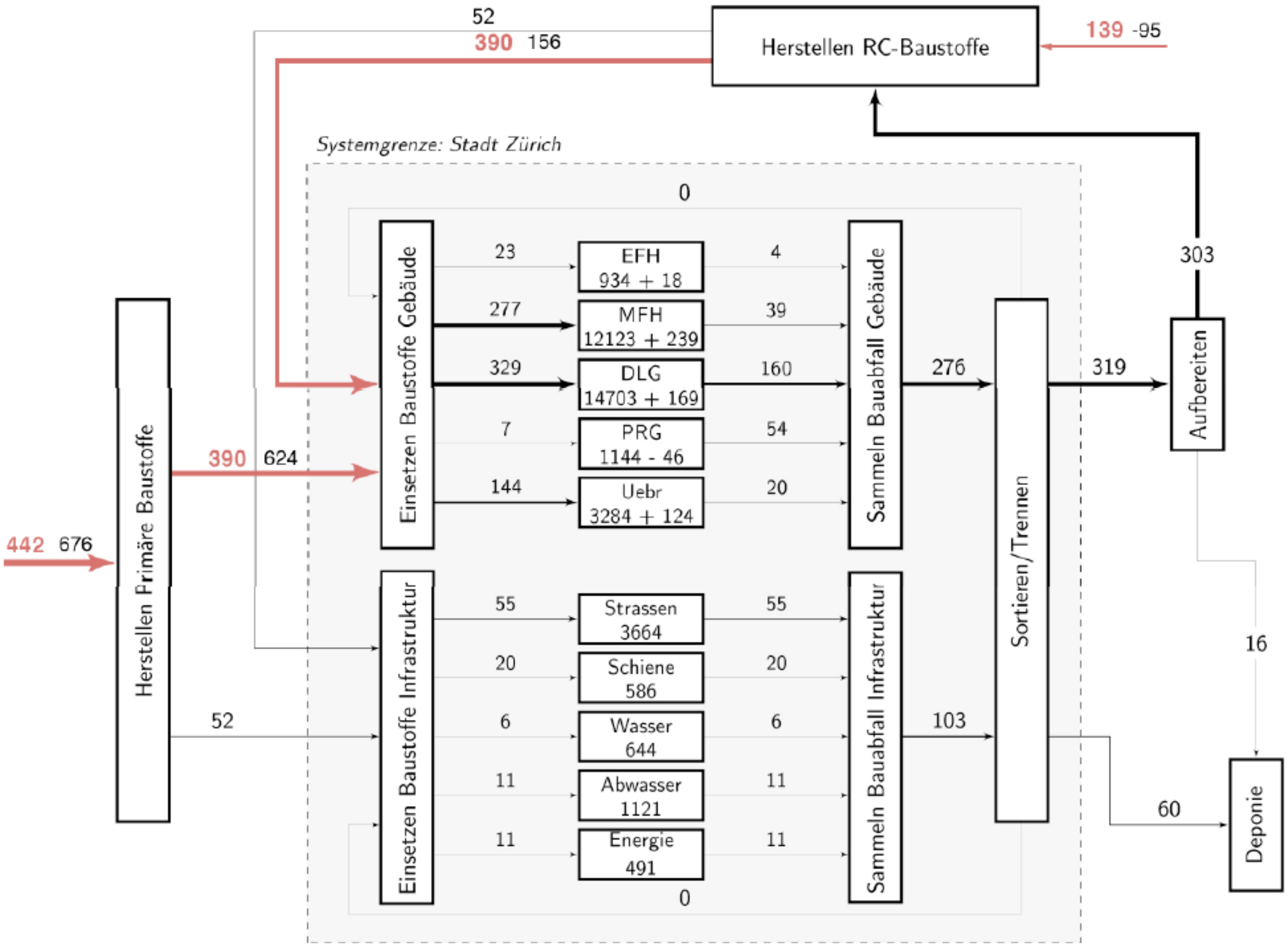
But concrete is a very valuable material with high energy embodiment and thus a major cause for greenhouse gas emission during the production of its components. When a city is built or expanded, they need for concrete is immense. Every emerging economy and country shows this extensive need. At the beginning of the 21st-century, this is the case in Asia, Africa, and South America, while in Europe and North America the need for concrete has decreased.

Recycling of concrete is a relatively new concept and describes the decomposition and crushing of a stock of concrete to prepare its parts for reuse in another context. If a city is not growing very much any more, such as in Europe, the recycling of concrete makes very much sense for ecological and also economic reasons. In the new emerging cities in China that grow from a few hundred thousand to several millions inhabitants within a few decades, there is no possibility to recycle, because the stock of material does not exist beforehand. In other cities, such as in Singapore, where there is a consistent scarcity of building materials, especially sand, there is a high economic incentive to recycle every tonne of concrete when a building is torn down or broken infrastructure is renewed.

A concrete example might show dimension of the stocks and flows of concrete in a city. The first step is to define the system boundary within the observation and the measurements are to be made. In Zürich, for example, this would be the city boundary. Looking at the particular year, in this case 2005, researchers from ETH Zürich have analysed the stocks of flow and flows of concrete precisely. They found that 676,000 t of concrete gravel flow into the city and that 379,000 t of concrete material left the city boundaries. Almost half of the inflow – 329,000 t – went into new office buildings, which at the same time produced with 160,000 t also the highest outflow. The present increase of population into Zürich is reflected in 277,000 tons of concrete flowing into the city for apartment buildings, and only 39,000 t from demolished apartment buildings leaving the city. Only 7000 t of concrete went into the construction of the new factory buildings, while 54,000 t of demolished factory buildings left the city.

This glimpse of material flow in and out of the city shows how closely related it is to the history of the city.

Gallery 4.2 Flows and stocks of concrete material in Zürich in 2005



From: „Entwicklung einer Ressourcenstrategie für mineralische Baustoffe für die Stadt Zürich“, Martin Schneider, Stefan Rubli, Heinrich Gugerli, 16. Status-Seminar «Forschen und Bauen im Kontext von Energie und Umwelt», 2010, http://www.stadt-zuerich.ch/nachhaltiges-bauen

Stocks and flows of water in the city

There is no city without water. Water decides on the survival of the city, and always has. In ancient times, water was transported in aqueducts over large distances, when the city internal water resources dried up or were not sufficient any more. In the city, water is used as a stock in lakes, drinking water reservoirs or in individual water tanks on, in and below buildings. Water is a technical, an artistic, an architectural, and a landscape architecture element.

Gallery 4.3 Stocks and flows of water in the city

The Marina Bay Singapore, previously open sea, now a freshwater reservoir. Photo: Eva Schmitt, January 4, 2013.

Stocks and flows of wood in the city

Would used to be a crucial stock and flow contributor in early cities. It was at the same time construction material and heating resource. Its overuse around cities might have caused climate changes in the cities and in some cases led to the demise of the city. Wood is prone to fire and was therefore replaced, if possible, by more fire resistant materials. It has a comeback today in terms of construction and heating material. It stores CO_2 in large quantities.

Gallery 4.4 Stocks and flows of wood in the city

Krakow: stock of wood as a building material in the ceiling, in the stairs, and for the furniture. Photo: Gerhard Schmitt, December 9, 2008.

Stocks and flows of food in the city

Food used to be grown directly around buildings. With the growth of cities, its production moved further away from the centre. Today, food in almost any city comes from global sources. This causes high levels of CO_2 during its production, its processing, and its transportation. In Singapore, more than 96% of the food needs to be imported. As „Urban Farming“, food in the city is making an important comeback in cities that had completely lost the direct relation with food production.

Gallery 4.5 Stocks and flows of food in the city

On the way to the market in the morning, Mandalay, Myanmar. Photo: Gerhard Schmitt, April 4, 2011.

Stocks and flows of capital in the city

There is no city without capital, and the stocks and flows of capital are a decisive factor in the development of the urban system. As capital is a virtual entity, it has a different effect on the shape, size, and livability of a city than material stocks and flows, such as concrete or water. Yet there is a strong relation between the location and the spatial quality of the city and the flows and stocks of capital.

Gallery 4.6 Stocks and flows of capital in the city

World exhibition Shanghai, June 1, 2010. Photo: Gerhard Schmitt

Stocks and flows of land in the city

Land appears to be a stable stock at first sight, with little flow possible. Yet if we take a closer look at any of the ancient or newer cities, we will find significant flow of land, either to increase the buildable area into the sea or into a lake, or buy natural accumulation of material which leads to vertical growth of land. Singapore, for example, has increased its land area by several hundred square kilometres, but also in Zürich has claimed land from the lake of Zürich.

Gallery 4.7 Stocks and flows of land in the city

Artificial land made in Singapore. The entire Marina Bay area is reclaimed from the sea. Photo: Felicia Bettschart, November 9, 2012.

Stocks and flows of people in the city

It is not correct to place people in the same category as other stocks and flows in the city, but there are similarities. Areas of the city, for example, which have been inhabited for a long time by generations of people from similar backgrounds could be called to represent a stock of people. The flow of people is characterised by by those newly coming to the city from the outside and by those who leave the city or die in the city.

Gallery 4.8 Stocks and flows of people in the city

People, cars and motor scooters mixing as a stock and flow in the street. Ho Chi Minh City, December 25, 2012. Photo: Felicia Bettschart is

Stocks and flows of density in the city

It appears surprising at first to list density or space under the stocks and flows characteristics of the city. Yet the concept becomes immediately clear if we imagine the difference between a mediaeval Italian city, such as Siena, and that of a suburban sprawl area in Phoenix Arizona. The example of Detroit in the beginning of the 21st century demonstrates that density does not remain a stock for ever, but that there can be rapid changes of density within few years.This

Gallery 4.9 Stocks and flows of density in the city

From low-density to high density: Riyadh, Saudi Arabia, January 27, 2010. Photo: Gerhard Schmitt

Stocks and flows of information in the city

In the information city, stocks and flows of information are almost as important as water or material. A stock of information is any library or data warehouse, the flow of information is ubiquitous and continuously increasing in all cities of the world. In many places, the storage of information has led to its own infrastructure, which is increasingly consuming space and energy and thus influences the other stocks and flows of the city, as the chapters on information architecture and information city show. I

Gallery 4.10 Stocks and flows of information in the city

Enabling the flow of information in the city: communication tower in São Paulo, Brazil. Photo: Gerhard Schmitt, June 30, 2012.

Chapter 5

System: Urban Sociology

Urban sociology is a field of growing importance for the design and redesign of urban systems. While some fundamental observations are consistently true for all cities around the globe, each city displays considerable specialties.

Section 1

Urban sociology

URBAN SOCIOLOGY

Urban sociology describes the study of human life and interaction with urban systems from a sociological standpoint. Urban sociology is sometimes used to provide input for city planning and urban design. While the analytical findings of urban sociology are necessary to understand the functioning of urban systems, the inverse use of these findings as drivers of design are rarely possible.

While urban sociology is an active research field in Europe, the United States and the Anglo-Saxon language space, it has started later as a locally grounded and locally driven science in those countries were most of the cities are emerging in the 21st-century. It is almost non-existent in the poorest countries of the world.

The history of urban sociology goes back to the early 20th century and to the Chicago School of Sociology. More recent research areas are gentrification, globalisation and global cities.

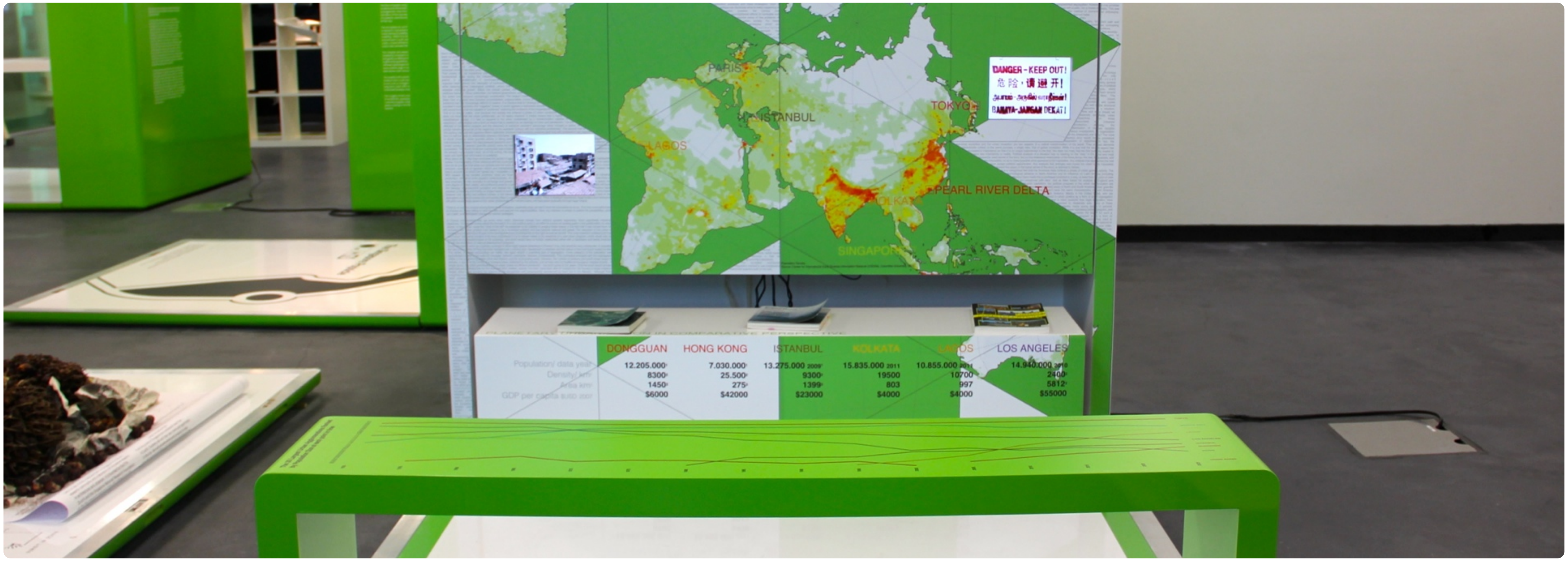
At the ETH Future Cities Laboratory, Professor Christian Schmid and his group lead the research on sociology and comparative urban studies. They describe the topic of their research as „global urbanisation in a comparative perspective“:

„Building a comparative typology of global urbanisation processes, analysing the mechanisms that generate urban uniformity and difference, and proposing appropriate urban development model

The last two decades have seen a sharp increase in the speed, scale and scope of urbanisation that has fundamentally changed the character of urban areas. Transcending physical borders, political jurisdictions and social spheres, urbanisation has become a truly planetary phenomenon. While it is often assumed that this phenomenon leads inexorably to uniform and undifferentiated cities, evidence shows that it also gives rise to surprising forms of difference, diversity and variation within and between urban areas. This simultaneous proliferation and diversification of urban forms has important implications for urban planning and design. In the first instance, it demands a more supple conceptual framework that can both hold the processes of planetary urbanisation and remain sensitive to the diversifying local manifestations. While many urban studies have examined particular cases in this emerging situation, a comparative and synoptic approach that captures both global and local dimensions is still lacking.

This module aims to redress this lack. It not only analyses the emergence of new urban forms, but elaborates the processes of urbanisation to explain how general tendencies are materialised in specific places. Methodologically, the module is structured around comparative analyses of patterns and pathways of urbanization. Nine metropolitan areas are examined as case studies: Tokyo, Hong Kong / Pearl River Delta, Singapore, Kolkata, Istanbul, Lagos, Paris, Mexico City, and Los Angeles. It will do so by: first, developing a methodological framework for comparative analysis; second, analysing the mechanisms and differences of planetary urbanisation and establishing a typology of contemporary urbanisation processes; and, third, examining the range of possible urban development models and exploring their practical implications. Special attention will be given to the analysis of urban potentials and the framing of possible strategies for a sustainable urban development.“ http://www.futurecities.ethz.ch/research-modules/urban-sociology/

Gallery 5.1 Urban sociology



The display booth of the Urban Sociology research module at the Future Systems Laboratory on February 8, 2013. Photo: Gerhard Schmitt

Extraction and inequality

While this book is about designing, planning, and managing cities, it is nevertheless important to be clear about the most destructive influences on the development of cities. Independent from the time or geography, from the culture or the country, societal inequality and extractive institutions have been identified of two of the most dangerous developments.

Inequality, especially social inequality means that large portions of the population are treated differently from those who are in charge of running the country, the economy, the city, or the social systems. In a wider sense, it also means that minorities are not part of the political and social systems, that they have no voice, and cannot express their opinion for fear of repression of personal safety.

Extraction describes the situation that a ruling party or a portion of the population render such power over the rest of the population that they can force them to work for them at very low cost. History is full of such examples: South America before and after the arrival of the Spanish, Africa before and after the advent of the Europeans, parts of Asia before the advent of the colonial powers. Extraction occurred in the process of colonisation, but could also be observed in the Republic of Venice, which changed from an inclusive society towards an extractive society. As observed before in the Roman Empire, this change started the final decline.

Inclusion and equality

While extraction and inequality are the situations to avoid under all circumstances in a country and in a city, inclusiveness and equality are qualities necessary for long-term success. They are no guarantee for the sustainability or for the longevity of an urban system, they might even cause misunderstandings, complaints about inefficiency, and prolonged discussions about seemingly unimportant details.

Social equality describes the situation, when the difference in income and political influence between the richest and the poorest sections of the urban population are small. A low **Gini coefficient** is a positive measurement and its rise signifies that inequalities in society are increasing.

Inclusion is perhaps the most important factor to guarantee the longevity, sustainability and resilience of urban systems and cities. It implies that all members of the population, including minorities, migrants, and those who might be unwilling to participate in the normal democratic process are invited, respected and encouraged to participate in the definition of urban life and development.

Urban systems and countries which are built on inclusion and equality have consistently shown a higher quality of life, income, and resilience. Good examples today are Denmark, Norway, inor Switzerland.

Growth in extractive systems

Acemoglu and Robinson claim that growth can occur both in inclusive and in extractive systems, and just by observing the effects, it is not easy to detect the underlying system and motivation. As the example of the Roman Empire after the end of the Roman Republic demonstrates, the gradual shift from an inclusive to an extractive system led to a loss of political influence of the majority of the population, the forming of the elite, but also in the beginning to an unprecedented expansion of the Roman Empire and and Brussels and lousyits economic power.

However, Acemoglu and Robinson, among many others, claim that there was, is, and will be no sustainable growth based on extractive systems. They use the example of the Soviet Union, which after the death of Lenin in 1924 established an extremely extractive system, accompanied by an impressive industrial growth until the 1970s - from which observers drew the conclusion that the Soviet Union would surpass the United States before the end of the 20th century. Yet it collapsed in 1991.

The city state of Venice was at one point the richest city in the world, supposedly as a result of an inclusive political system that switched to an extractive system that for a few years could reap the results of the previously positive inclusive system. Yet after the characteristics of the extractive system took root, the decline was inevitable. „La Serrata“ of February 28, 1297 is seen as the decisive switch from an inclusive to an extractive system.

Growth in inclusive systems

We often hear that inclusive systems are boring and cannot lead to advancement because too many people need to be listened to and decisions cannot be taken in due time to get ahead of the competition. Yet looking at historical evidence, this judgement is incorrect. Swiss cities, Vienna, Munich, Vancouver, or Copenhagen are consistently rated as those cities with the highest quality of life. All of those cities show a high level of inclusiveness in making decisions. Not a single city that does not have a decision making and planning process based on an inclusive system appears in the top 10 of the most liveable cities worldwide. No business hub, no gigantic tax generator, no top-down planned cities in dictatorships have ever won the title as the most liveable city.

It is therefore a fact, that inclusive systems can lead to growing, prosperous, and liveable cities. This also means, that cities with inclusive systems are potentially sustainable and resilient, that all of them have survived and prospered for many years. It can therefore be argued that inclusiveness is perhaps the most important ingredient when planning a new city or redeveloping an existing city, if sustainability and resilience of the long-term plans. It is therefore important to focus on how inclusiveness and equality can be guaranteed already in the design and implementation of new cities. The chapter on Urban System Design provides practical hints.

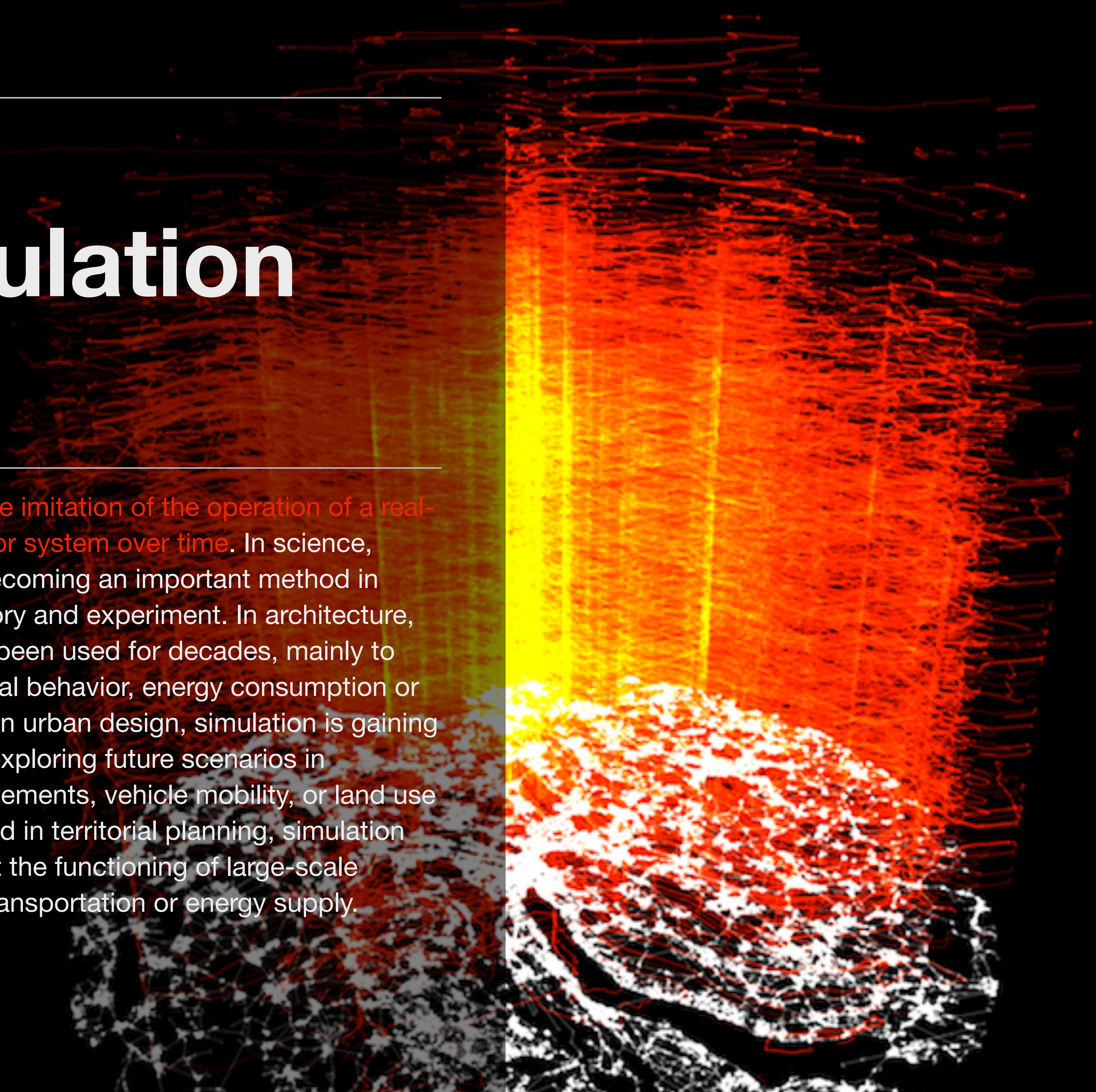
Name	City	Country	Reason	World Bank Gini	Criteria
Abigail Stoner	Berlin	Germany	Connectivity	28,3	Safety, transport, activity, commerce, culture
	Florence	Italy	Simplicity	36	
	Burlington, VT	USA	Comfort	45	
Elena Haddad	Zürich	Switzerland	Clean and beautiful	33,7	Infrastructure, culture, sustainability, internationality, climate
	Amsterdam	Netherlands	No cars	30,9	
	Boston	USA	Good education	45	
	Copenhagen	Denmark	Innovative designs	24	
	London	Great Britain	Public transport	34	
Erasmo Valeria	Barcelona	Spain		34,7	Climate/environment, cost of living, recreation/cultural, safety, transportation
	Zürich	Switzerland		33,7	
	Cagliari	Italy		36	
	New York	USA		45	
	Rio de Janeiro	Brazil		54,7	
Haitao Pang	Kyoto	Japan		38,1	Humanity, culture, comfort and health, economy, information
	Zürich	Switzerland		33,7	
	Vienna	Austria		26	
	Singapore	Singapore		48,1	
	Munich	Germany		28,3	
Hubert Holewik					History/identity, points of growth/ transformation, spaces of cultural exchange/art, access/integration, way of perception
Jan Alvfors	Stockholm	Sweden		25	Private physical conditions, social life, inclusion, ethics, of the physical conditions, congruence
	Zürich	Switzerland		33,7	

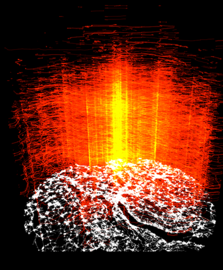
Name	City	Country	Reason	World Bank Gini	Criteria
Merchant Mehek	Zürich	Switzerland		33,7	Safety, quality of life, healthcare, infrastructure, education
	New York	USA		45	
	Dubai	UAE		???	
Pablo Acebillo	Barcelona	Spain		34,7	Infrastructure, culture, sustainability, internationality, climate
	Manhattan	USA		45	
	Zürich	Switzerland		33,7	
	Copenhagen	Denmark		24	
	Lugano	Switzerland		33,7	
Shoichiro Hashimoto	Zürich	Switzerland		33,7	Business condition, recreation space, urban design, access to nature, balance of the before
	Helsinki	Finland		26,9	
	Copenhagen	Denmark		24	
	Vienna	Austria		26	
	Munich	Germany		28,3	
Nishta Banker	Zürich	Switzerland		33,7	Safety and stability, people and environment, living costs versus earnings, infrastructure, resources
	Vienna	Austria		26	
	Stockholm	Sweden		25	
	Auckland	New Zealand		36,2	
	Bern	Switzerland		33,7	
Pietro Del Vecchio	Berlin	Germany		28,3	Political and social organisation, infrastructure, public transportation, medical and health services as well as culture, schools and higher Institutes of education
	Zürich	Switzerland		33,7	
	Copenhagen	Denmark		24	
	Hamburg	Germany		28,3	
	Rome	Italy		36	
Tom Doan	Copenhagen	Denmark		24	People, information and culture, economic and capital, food, climate and energy
	New York	USA		45	
	Kyoto	Japan		38,1	
	Hong Kong	Hong Kong		53,3	
	Sevilla	Spain		34,7	
Nikol Marincic	Bangkok	Thailand		40	Heterotopia, cost of living, quality of infrastructure‘s, diversity of cultures in relation to services, diversity of built environment
	Hong Kong	Hong Kong		53,3	
	Berlin	Germany		28,3	
	London	United Kingdom		34	
	Belgrade	Serbia		27,8	

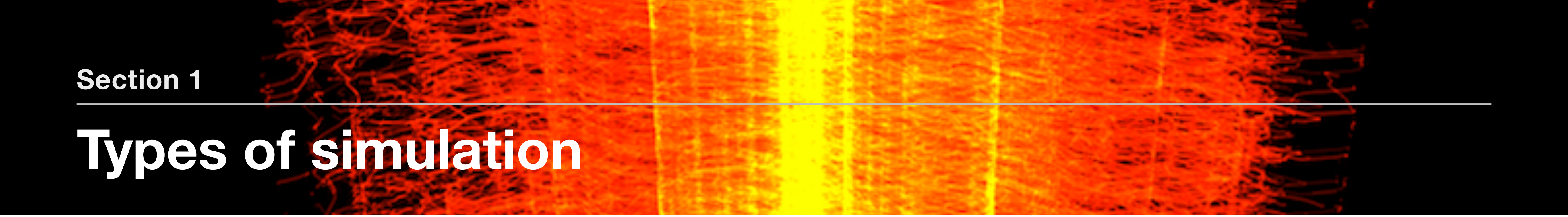
Chapter 6

City Simulation

Simulation is the imitation of the operation of a real-world process or system over time. In science, simulation is becoming an important method in addition to theory and experiment. In architecture, simulation has been used for decades, mainly to predict structural behavior, energy consumption or life cycle cost. In urban design, simulation is gaining importance in exploring future scenarios in pedestrian movements, vehicle mobility, or land use alternatives. And in territorial planning, simulation helps to predict the functioning of large-scale operations in transportation or energy supply.







Section 1

Types of simulation

SIMULATION

Simulation in Architecture, urban design, and territorial planning is evolving rapidly. In Architecture, it is often used synonymously with visualization. In more technical terms, it includes energy use simulation of buildings, evacuation simulation, or interactive exploration of a virtual model of a building. The factor time, important in simulation, becomes more apparent on the urban scale: simulation of transportation and mobility, of land value changes, of densification, or any other changes over time. On the territorial scale, simulation is used to depict the growth of city networks, migration of people, or flows of material and information across continents.

Students study Architecture or urban design to design buildings and cities. Design is at the centre of their attention, to design they devote most of their time in education. Technology, information technology and other technical fields may appear as unwelcome constraints to the freedom of design. Thus design and simulation are in constant competition. They compete for the student‘s attention and time, and in the end, design wins. Who wants a building that performs well on quantifiable criteria but is ugly or has no appeal, except for being efficient with regard to low-dimensional criteria?

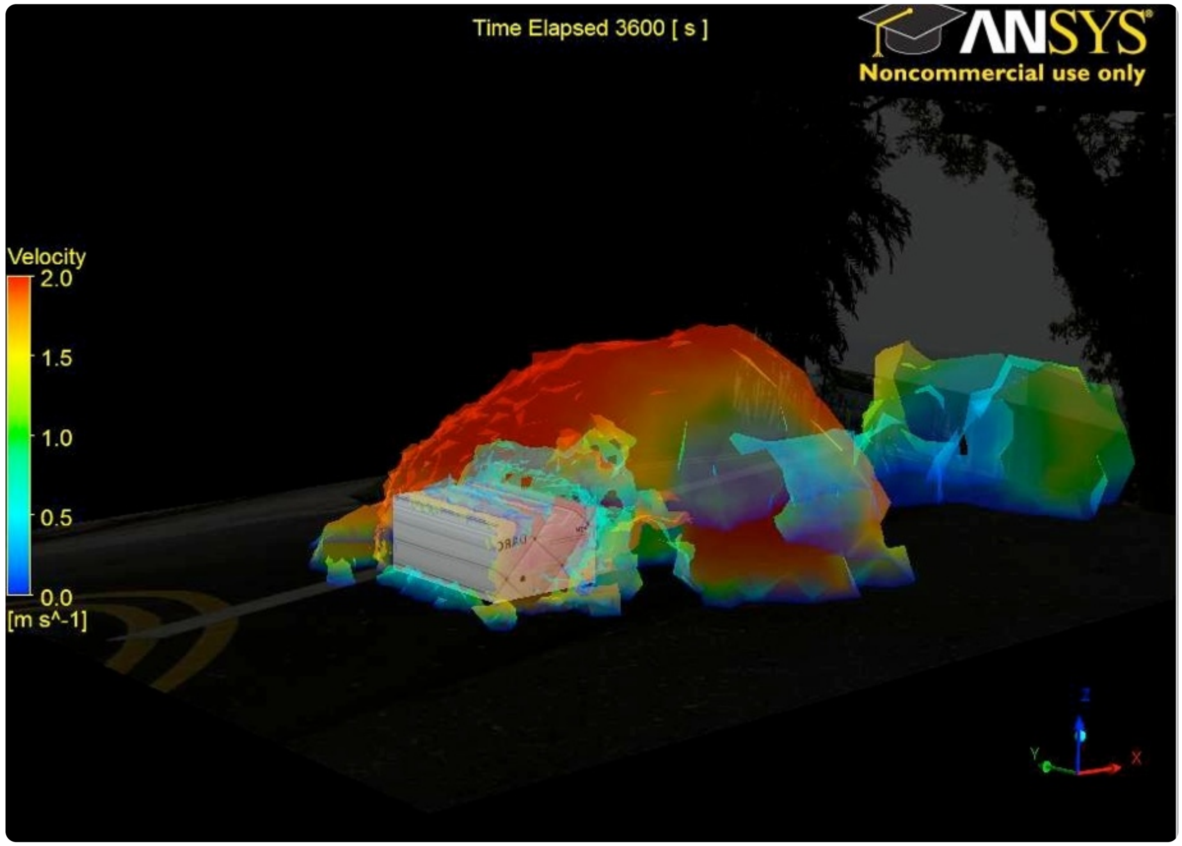
In the practice of building buildings and cities, especially in the design and decision making phase, institutional clients require simulation more often than private clients, mostly because they are investing in high-tech buildings with significant maintenance cost. For this purpose, simulation seems to make sense. Sometimes during this phase, simulation is used to confirm wishes or anticipated results, which can be questionable.

In the construction and maintenance phase of a building or part of a city, simulation becomes more popular - perhaps because there are less undefined parameters to observe and the accuracy and reliability of the simulation result increases. In this phase, the role of the architect is much reduced as compared to the early phases. Yet these phases in the life cycle of buildings and cities are highly interesting as they have produced highly valuable data and information.

Building simulation - wind

Simulation is only possible form phenomena that we are able to quantify and to understand. The same is true for building simulation. Examples are wind flows around the exterior of the building or air movement inside the building, the stream of occupants entering or exiting buildings, or the flow of energy and temperature, light and sound inside the building.

Gallery 6.1 Building simulation



Simulation of wind velocity surrounding the Future Cities Laboratory BubbleZero experimental installation. Maria Papadopoulou and Didier Vernier, November 24, 2011.

Building simulation – energy

The projected use of energy of a building was one of the first quantities to be simulated. Early simulation programs go back to the 1960s. The University of California at Berkeley and the Lawrence Berkeley Laboratory where eminent research locations that developed computer programs such as **DOE-2** which are still the basis for todays energy simulation programs, such as **Ecotect**.

Building visualisation

The visualisation of 3D models of planned buildings is often called building simulation. As the parameter time is often missing in these visualisations, it is not entirely correct to label them as simulation. However, virtual walks through and around these buildings could be accepted as visual simulation of future designs. This will change soon with the dynamic aspects of architectural design gaining rapidly in importance.

Gallery 6.2 Building visualisation

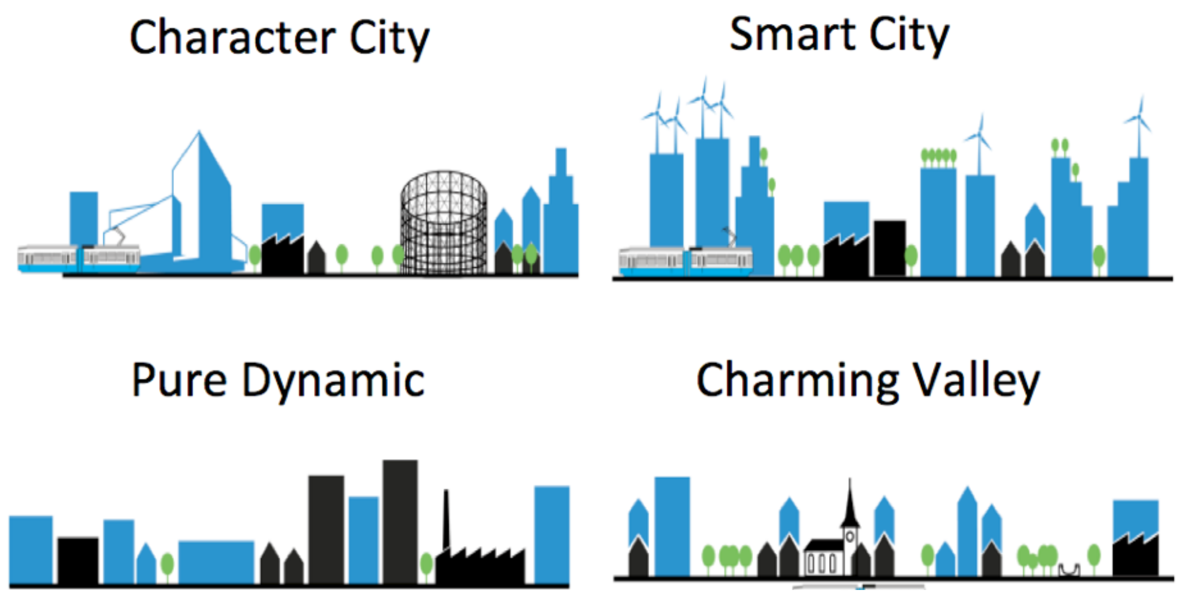
Procedural model of a street in Masdar, the planned carbon-free city in Abu Dhabi. Simulation-visualisation Jan Halatsch, April 6, 2010.

Urban simulation - patterns

Urban patterns are the physical expression of specific settlement characteristics. They differ widely throughout the world, determined by climate, culture, history and purpose of the city. They can be decided and designed top-down, or they can develop and change over time according to the forces that shape the city. The reason for looking at urban patterns is often a situation that has become difficult - be it growth or decline of population, changes of the settlement‘s economic base and connections, or transportation issues.

The conscious search for a sustainable future for urban patterns is relatively new, and here Information Architecture and simulation can play a major role. The Swiss National Science Foundation, SNSF, launched a special program on New Urban Quality in 2009. One of the winning projects is focusing on Sustainable Urban Patterns - **SUPat**: „SUPat scenarios describe four perspectives focusing on design, technological, economical and ecological aspects of urban development in the Limmattal region. The scenario "City with Character" presents the Limmattal as a valley with a strong identity, created by a clear sequence of centres and a good mix of land use and architecture. In the scenario "Smart City", the valley positions itself as a cleantech pioneer; it boasts the greatest possible energy efficiency, a high density of services and an optimum modal-split-infrastructure design.

Gallery 6.3 Urban simulation - patterns



The 4 scenaria for the SUPat project in the area North of Zürich in the Limmattal. Antje Kunze, 2012.

The scenario "Pure Dynamics" does without a joint regional development concept. The valley is shaped by a vaguely defined mix of industrial areas, housing developments, green sites and transport infrastructures with no character of their own. The scenario "Charming Valley" presents the valley as a human ecological system with a strong mix of concentrated developments (informed by modern small-town values) and a productive and resource-rich agriculture. The research project defines new urban quality as the interaction between human behaviour and the built and non-built environment. The needs and objectives of the population are linked to urban structures (e.g. sufficient open spaces) and their functions (e.g. recreation).“

Urban simulation - sociology

Territorial scale

RK Vienna, segregation model Schelling 1971. Singapore case different? URA used it? Central places and segregation. Rules and segregation. Segregation and rent dynamics

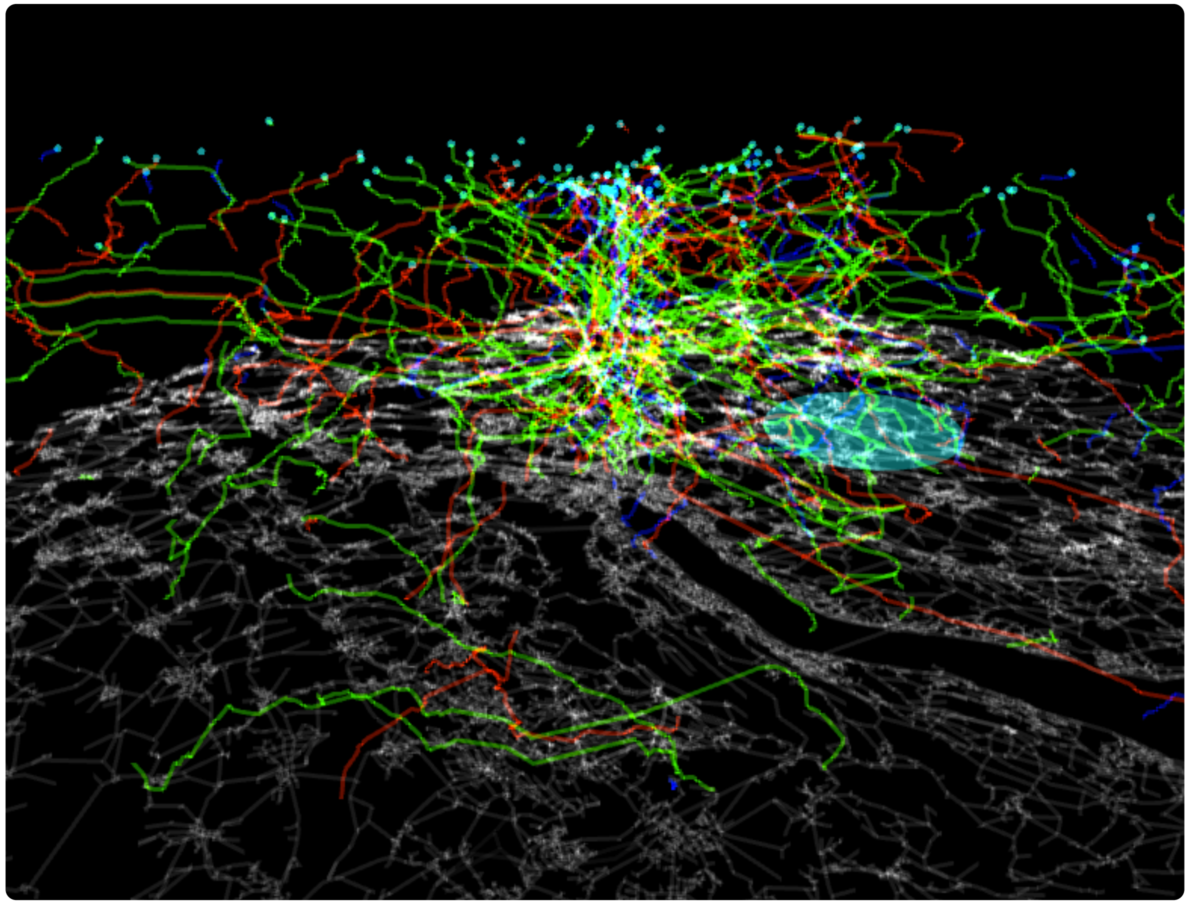
SMA Springer

Inverse planning RK benedict 1979 not by initial specification of real surfaces

Urban simulation - land use

Aliaga et al

Gallery 6.4 Territorial simulation



MatSim simulation of individual transportation and mobility in the Zürich region. Zeng Wei and Stephan Müller-Arisona, SEC FCL, 2011.

Territorial simulation - mobility and transportation

	Office s	Hotel s	Institution al Buildings	Residentia l	Lab intensive	Schools	Malls
Residential							
Building Envelope + Facade Systems							
Building Management Systems							
Integrated Design approach and tools							

Roadmaps versus Simulation

Design versus Simulation

In offices, hotels, Institutional buildings, lab intensive, schools, Malls

Discussion, whether the future would develop as predicted, if specific technologies would be available in the years to come. Indicators and sub-indicators may change.

Challenges: retrofit, risk aversion, easy to use software and design analysis tools, hybrid cooling, maintenance, data transparency, bridging gap between research and poicy, heat island, procurement, accountability of consultants, risk, lack of motivation and fear of data sharing, lack of actual performance of test cases.

Needed are data, greater integration within tools and between disciplines, and reliable cases and test bedding. Result of the Needs Assessment Workshop on February 4th and 5th, 2013.

Simulation Platform

DEFINITION

„As citizens, we want to enjoy and contribute to the life of the city. As architects, designers, and planners, we want to understand the city and propose exciting choices considering effects and side effects. In the past, architects and designers could project their visions into the future and hope that citizens would support the design results by adaptation. The growing knowledge of components and their interaction, the increasing wealth of data generated by the city and the rapid progress of computational instruments and computational power have opened new possibilities for the design and management of the city. We call the combination and deployment of this knowledge, information, data and computation *simulation*. To support the urban design process with this activity, we need a *Simulation Platform*.“ (from: Schmitt, Gerhard, Module Leader Reflection, mid-term evaluation report, Future Cities Laboratory, Singapore – ETH Centre, May 2013)

Simulation of the city: scenarios

Sometimes, there is the opportunity to design a new city or to redesign an existing city, because unusual situations have made it possible. If such an opportunity arose, why would simulation be important? And why would one need a simulation platform to put together all aspects of the planned city?

Simply put, the simulation platform allows to collect, store, assemble, process, and visualise all information that is available or can be gathered about a city. Take, for example, the situation of Yangon, the largest city in Myanmar, at the beginning of 2013. Major political changes lead to the expectation that the city will develop into a mega city in the coming decades. It is obvious to the decision-makers and to the external observers, that the city cannot just continue to grow as it did in the past. Major strategic decisions are necessary, but must be based on sound evidence. In other words, city planners, citizens, and stakeholders need to know what the result of their decisions will be.

This is the point where the Simulation Platform becShiftsomes an indispensable instrument. It will be able to display the historic stock and the infrastructure of the existing city, and it will be able to depict the results and the side-effects of each decision taken with regard to the placement of housing, industry, mixed-use areas, or subways. It will show the carbon footprint of the city, its value creation and prosperity. The Simulation Platform cannot predict, but show scenarios.

The Simulation Platform

„Simulation, as we see it, describes integrated future urban scenarios based on the most up-to-date knowledge, information and data. Simulation includes scales within space, time, economic, ecologic and social dimensions. It allows the incorporation of new real-time data from sensors crowd sourcing, and it creates opportunities to move from limited top-down specific and exclusive models towards pre-specific and inclusive models.

The body of knowledge in urban design and planning accumulated over the last centuries is immense and too large to be remembered by a single person or by a team. Not using this knowledge because of naiveté would be irresponsible. Design using integrated simulation is therefore becoming essential.

The Simulation Platform increasingly helps to identify and quantify the components of a city, their functions and their connections. For the first time in history, it is possible to directly and interactively visualise stocks and flows of people, energy, water, finances and information in Singapore, a city of more than 5 million people. For this, the Simulation Platform accesses Big Data, explores the role of individual data and discrete populations versus statistics on the urban level, and searches for innovative models of the city. While progress is incremental in each field, researchers in the Simulation Platform continue to question the role and the future of the underlying models and abstractions. At the same time, they are able to support other research modules in the Future Cities Laboratory with the newest in hardware, software and data interpretation strategies, thereby keeping the Simulation Platform's modelling capabilities at the forefront of the global state-of-the-art.

Advanced urban design and modelling environment: the Value Lab Asia

Gallery 6.5 The Value Lab Asia

Members of the Simulation Platform conceived, designed, and implemented the Value Lab Asia, a physical visualisation, simulation and interaction space in the CREATE campus. With more than 35 million pixels it offered South East Asia's highest resolution display and interactive touch panels for urban planning.

It is by now a major asset of the Future Cities Laboratory. The Value Lab Asia supports more than 80% of all external and internal presentations to the Future Cities Laboratory and is at the same time a visual programming environment for researchers. The Value Lab Asia has set the standard for interactive urban planning environments and is a role model for Australia (Perth) and Switzerland (Value Lab Zürich). The Value Lab Asia is open to Singaporean educational and research institutions as well as to government agencies. It is also the platform for presentations to industry and host to the Digital Art Weeks in Singapore.

Teaching and Massive Open Online Courses

The Value Lab Asia has developed into a successful teaching environment with weekly courses between the Value Lab Zürich and Singapore. Classes are interactive and students from Singapore and Zürich participate in both locations. The unique visualisation and sound system of the Value Lab Asia creates an immersive classroom atmosphere, where the participants from Zürich appear in 1:1 scale on the large display in Singapore. The sharing of presentations, drawings, videos, and other media functions seamlessly. The Value Lab Asia is the test bed platform for the emerging Massive Open Online Courses on Future Cities prepared by faculty of the Future Cities Laboratory.

Computing and visualising stocks and flows

The Simulation Platform successfully enables visualisation of urban stocks and flows. It displays historic maps of Singapore in high resolution, impressively showing the change of material stock. It allows research into the change of land use over time with associated physical transformations of areas.

Visualisation of stocks and flows of material also illustrates the increase of the land size of Singapore since 1965. This extensive dynamics in stocks and flows of material is unique worldwide. Also unique is the rapid flow of material within the city by reusing the material from demolished buildings for new structures with the result of increased density. Innovative algorithms by Simulation Platform researchers can automatically detect this physical change over time by comparing satellite images and other sources.

The Simulation Platform is capable of visualising the energy stocks and flows of Singapore or any other city, as far as official data are available. In this case, it is able to break down the energy stocks and flows to the individual building level. The resulting map of the island of Singapore provides an impressive differentiation between areas of comparably low energy consumption, such as housing and office areas, and the highly industrialised areas around Jurong and the airport. The energy intensity indicates origins of the heat island effect. The Simulation Platform is also able to depict the emerging electricity grid of Ethiopia. Planners, decision makers and observers interactively model and manipulate existing and new energy sources on the large touch screens of the Value Lab, allowing a previously unreached level of interaction and precision.

In cooperation with the transportation and mobility specialists of the Future Cities Laboratory, the Simulation Platform simulates the stocks and flows of people, cars and buses in the street network of the entire island of Singapore. Theoretically, every Singaporean can be modelled and displayed as an individual agent. The location and movement of these agents can be displayed on the high-resolution screen in the Value Lab Asia that provides a qualitative jump of analytic capacity over individual screens that can only display a fraction of the information.

A unique feature of the Value Lab Asia Large Display is the realistic visualisation of mobility in the city. On the urban design scale, programs developed by Simulation Platform researchers show the individual movement of people walking through parts of the city. The programs help designers to recognise what people will see, how they make their navigation choices and which parts of the urban area will be most populated. A different programme developed by Simulation Platform researchers visualises the incredibly diverse streams of passengers in Singapore MRT stations at different times of the day. A further interactive visualisation demonstrates whether or not citizens can reach destinations Singapore in a given time using public transportation only.

The computational fluid dynamics work of the Simulation Platform produces promising results in defining the best locations to gain the most information with a minimum number of sensors. It generates better knowledge of airflow around buildings in Singapore, which can lead to better design and refurbishment of buildings by increasing the effectiveness of natural ventilation. The use of sensors can also improve the accuracy of other simulations, such as those for temperature. The practical benefits of intelligent sensed cities include more reliably reaching important design goals, such as sustainability, under changing environmental conditions.

Finally, the architectural effects of urban planning, depicted by three-dimensional visualisations of buildings, are further refined by the use of the procedural modelling tool CityEngine. The CityEngine software has been enhanced by members of the ETH team to rapidly display geometry originating from design decisions, including energy-related information and the effects of design decisions on embodied CO_2 or CO_2 produced by the heating or cooling of buildings.

Collecting, storing, mining: Big Data

The Simulation Platform has accumulated a most impressive dataset of historic, current and emerging data about Singapore.

This dataset is available to all researchers of the Future Cities Laboratory, as well as to outside parties. The Simulation Platform thus enables the collection, the storage and the mining of the ever-increasing amount of data about the city. The structure of the database is generalizable, while the content is specific for each city. The Simulation Platform is set up to receive and then take advantage of the major onslaught of Big Data, generated by thousands and soon by millions of sensors and smartphones in use and shared by citizens. It uniquely connects this data to a GIS model of the city.

In this context, it is important to build up trust and to take full advantage of the data that citizens are willing to share. For this purpose, the Simulation Platform offers a safe and attractive environment for depositing and extracting data. The data is then formed and visualised in advanced ways. Big Data visualisation has become one of the major assets of the Future Cities Laboratory, not only for the researchers, but also for the stakeholders of Singapore and for any other city that chooses to employ this concept.

UAV: Dimensions of Singapore

There is no 3-D publicly accessible model of all buildings and topologies of Singapore for civil use. The Simulation Platform closes this gap and proposes several innovations on the way. Firstly, the difficulty to achieve high altitude flyover rights in Singapore led to the acquisition of a small and versatile Unmanned Aerial Vehicle (UAV) platform that can take high-resolution images from predefined positions at low altitudes. Flying the UAV at 120 meters above ground, Simulation Platform researchers took more than 800 aerial photographs of the campus of the National University of Singapore, thus acquiring the basis for a full three-dimensional reconstruction. The extensive tree cover on the ground on the NUS campus obstructed the aerial view of the natural topography and to the facades of most of the buildings. This led to the necessity for ground-based Lidar data acquisition by a Mobile Mapping System, mounted on a car. The combination of the point clouds with image analysis techniques, resulting from both data acquisition methods to arrive at a precise three-dimensional and texture model of the buildings, is a major innovation. The combination of satellite image based 3-D reconstruction and point clouds acquired from ground-based Lidar led to precise models of the Rochor area which is now the basis for integrated design studios between ETH, and the Singapore University of Technology and Design, SUTD. In Jakarta, finally, the use of fixed wing UAVs lead to crucial point cloud models of Ciliwung River settlements, which can now be transformed into 3-D models as the necessary basis for new designs for the purpose of flood mitigation in the area.

Cooler calmer Singapore

The knowledge accumulated in the Future Cities Laboratory and in the Simulation Platform has led to the recognition of the interdependencies between climate, urban design, energy demand in the city, the heat island effect, the intensity of downpours and flooding in Singapore, population density, and the planned increase of the populace to possibly 6.9 million in 2030 from 5.3 million in 2013. The question is: will it be possible to decrease or at least keep the average temperature in the coming years, decrease the noise level, reduce the intensity of downpours while increasing the population density and guarantee and even improve the liveability of the city at the same time? Simulation is the only possibility to generate, evaluate and propose realistic answers to such questions, which are crucial for the future of Singapore. As a consequence, the interest in this topic is high among the population, as well as among city planners and decision-makers. In this case, the Simulation Platform could become a key instrument to improve the quality-of-life, not only in Singapore, but also in many other emerging tropical cities.

The first step is to collect and confirm relevant data, either from the database of the Simulation Platform, or from other research institutes in the CREATE campus. This collective effort is unique worldwide and has not been tested before and thus the potential for innovation is high. The advanced research institutes from TU Munich and MIT contribute to the Simulation Platform with data and information to make the most realistic assessment about the future of cities. Data are climatic, geographic, energy related, urban design related, geometric, political, economic, and health-related.

The results of the simulation are open ended. First estimations suggest interesting and far-reaching consequences. For example, Singapore could become the first country in the world that would completely switch to non-fossil individual transportation and thus reduce the heat and noise output. Singapore could become the first country to function with non-fossil and non-nuclear electricity generated in neighbouring countries with high efficiency photovoltaic and energy storage areas. Singapore could become the first country that reverses man-made health and commercial risks such as air pollution and flooding. Singapore could also become the first country in the world to export this knowledge to other countries and emerging cities.

The Simulation Platform is the only instrument at present that allows the realistic observation, implementation, and long term monitoring of such far-reaching plans. As such, the Simulation Platform would move from an academic, fundamental research driven instrument into the reality of planning, implementation and monitoring. Implementation and monitoring are necessary subsequent steps for the Simulation Platform, because they will guarantee a constant flow of data and information to verify, or falsify, assumptions, models, abstractions, and proposals derived from the results of simulations.

Alternative City Models: Quantum City

The basic research group at FCL is dealing with a known problem: more data and more computing power will not solve the old questions regarding cities, because each level of more analytical accuracy is increasing the computation costs exponentially. Therefore we need new questions to cope with the extraordinary political, economical and cultural dynamics most explicitly demonstrated by the rise of social media today. The basic research group therefore follows the concept of pre-specific modelling as a next level in computer aided design and decision-making. In case of urban development the concept of A Quantum City was developed. The basic technical question is how to establish a coexistence of citizens within infinite data streams. To get a better understanding, a principle implementation could be developed which illustrates technological questions deriving from these concepts. Pre-specific modelling is not only of theoretical interest, it has direct practical implications: We demonstrated a prototype of pre-specific modelling on urban topologies, which illustrates that the costs for setting up city models can be reduced by at least the factor 100. With a second prototype we focussed on topographies and had been able to show that we can generate online datasets with minimal costs that can substitutes expensive simulations for most of the questions today. The next step in this line of new tools for modelling will be on text analysis of websites, blogs and news feeds as a source to map abstract parameters like cultural identities, moods, political and economical activity or even city styles. In summary, pre-specific modelling promises, apparently paradoxically, to run a city beyond it‘s optimum.

Dissemination

The Value Lab Asia has developed into a strong instrument of dissemination. An average of more than 200 weekly internal researchers and external visitors make use of the unique modelling and visualisation capacities of this laboratory. There are now more than 65,000 specific entries under "Value Lab" on the Internet, referring to the ETH Value Labs in Zürich and Singapore. Students from the National University of Singapore, from the Nanyang Technological University, and from six different Singapore based primary and high schools have interacted with information displayed on the touch panels and on the large display, or seen the UAV in action. They spread this experience to their classmates and parents, and it results in follow-ups.

In Asia and beyond, the Simulation Platform is also becoming known for its quality as an interactive teaching environment. Every semester, students from ETH Zürich and from other universities, registered as guest students at ETH Zürich, participate in the interactive seminars on information architecture and information cities. These courses are increasingly used to disseminate results from all research modules of the Future Cities Laboratory.

Dissemination of results from the stocks and flows research also works through presentations to high-level government delegations from Singapore, Switzerland, Germany and other countries. They result in follow-up visits and research proposals. The Cooler Calmer Singapore project, for example, originates in part from feedback by Singaporeans visiting the Value Lab Asia and seeing representations of the stocks and flows of energy in the city.

The reputation of the Value Lab Asia as an interactive digital library of the most complete geographic and historical data about Singapore is increasing. It has led to the plan to make available data to researchers in the entire CREATE campus and beyond under the title "Data Alliance".

One of the most prominent modes of dissemination of the results originates from the flights with the UAV across the NUS campus and the follow-up reconstruction of many of the buildings in high detail. This has led to a follow-up project with NEA to detect small water puddles in difficult situations in order to eliminate the breeding grounds of insects that spread Dengue fever. With its very high accuracy Digital Terrain Model, the Simulation Platform also supports the work of a NUS hydrology group, which maintains a hydrology testfield on campus.

Regarding alternative city models, such as quantum city, there are several recorded lectures available, as well as papers on conferences and an upcoming summarizing book at Springer in Wien.

Synergies

Strong synergies have emerged with the research module on transportation and mobility. This module provides data and the MatSim simulation programme, and the Simulation Platform provides the know-how to visualise and interpret the results. The use of the visualisation environment of the Value Lab Asia has led to new qualitative findings regarding transportation processes for two reasons: the size of the large high-resolution display allows the discovery of integrative aspects that cannot be seen on smaller displays, and the interactivity of the touch panel displays is the best environment for exploring time-based and dynamic simulation results.

Strong synergies also exist with the Rochor+ project. In this case, three-dimensional information necessary for the analysis of different building types was attained by 3-D reconstruction from satellite images, and from point clouds created by Lidar data acquired from the street level. Other synergies include the development of programs that directly and interactively depict what people would see by walking on the streets of Rochor. This program is agent-based and computationally innovative, while at the same time very practical and easy to use.

The Jakarta+ project benefits from the collaboration with the Simulation Platform. In this case, it is the reconstruction of 3-D building roofs and flooding prone topography derived from point clouds that were generated by flyovers of a model helicopter, UAV, by the Geomatics group in cooperation with the landscape ecology research module.

Synergies with ETH Zürich and Singapore Agencies are strong. With the Urban Redevelopment Authority URA, a first talent exchange has been agreed on. It means that one person from the Simulation Platform will be directly working with a URA planning group. With the National Environment Agency NEA, a first joint project on detection of Dengue breeding grounds has been completed.

The potential for synergies based on the direct and striking first results of pre-specific modelling is large. Yet it is necessary to integrate them into the mostly applied research context at FCL. This is especially the case in the design studios and the research on simulations, climate and economy. The basic research group therefore decided to slow down the conceptional and technological development and concentrate more on the mediation of the theory and technology of pre-specificity into the urban disciplinary discourses, by writing the book A Quantum City.

Impact

Simulation Platform members advanced the field with publications on technical innovation, visualization and user interfaces, design research, and city models. Technical innovation papers focus on reality-based reconstruction (Gruen 2013; Huang et al. 2013; Müller Arisona et al. 2013; Qin et al. 2012) and on the future role of sensors in the city (Vernay et al. 2013; Papadopoulou et al. 2013). Visualization, simulation, interaction, as well as data acquisition and management publications (Zhong et al. 2012; Wei et al. 2013; Aschwanden et al 2012; Shin et al. 2012; Dai et al. 2012; Wang 2013) will have impact on the emerging Big Data analysis field. Design research publications integrate technical and design aspects (Schmitt 2013; Schmitt 2013a). City models publications range from urban heat island topics (Berger 2012) to alternative models (Miro 2013, Moosavi 2013). Two book publications cover the fields of engineering informatics (Raphael and Smith, 2013) and digital urban modelling and simulation (Müller Arisona et al 2012) broadly.

The work of the Future Cities Laboratory and Simulation Platform members is featured prominently in the 2012 Annual Report of the ETH Domain and of the ETH Zürich, as well in the Bank Vontobel’s client magazine ‘blue’ and the Swiss design journal ‘Hochparterre’.

The Value Lab Asia is a physical, built statement on the future urban design and planning environment (System Integrations Asia 2013). The fact that it is being copied in other countries is a strong sign for its impact. Researchers of the Simulation Platform have used the Value Lab Asia as a base for laboratory work and communication, and have spoken through it in front of large audiences in conferences in Asia, Oceania, the Americas, Europe and Africa. The Value Lab Asia also hosted part of the Digital Art Weeks festival in Singapore from May 6 to May 19, 2013 and displays patterns between art, architecture, planning, and computer science, nurturing a culture of sustainability.

Researchers from the Simulation Platform was active as experts in the globally leading Smartgeometry Workshop at The Bartlett / UCL, London, from 15-20 April 2013 and contributed algorithms and interactive tutorials, along with published articles.

For Singapore, visualising the heat island effect by depicting the energy use of the island has a high impact because it was not visualised before. The same is true for the visualisation of Singapore work locations derived from the transportation and mobility studies, which partially explains certain traffic conditions.

The interactive multi-touch Singapore connectivity application also has a high impact on all visitors, as it depicts the large differences between locations in Singapore with regard to accessibility by public transportation: after pointing to their area of choice, visitors immediately understand which areas in Singapore are advantaged in terms of public transportation and which are not.

The emerging Cooler Calmer Singapore Project has already drawn the attention of decision-makers and researchers in Singapore and beyond. The project shows that context specific topics can lead to scientific contributions beyond the place of application. The preparation of the Cooler Calmer Singapore Project involves stakeholders and opinion leaders from several agencies and universities. Building on the extensive knowledge accumulated in the Future Cities Laboratory, this project is becoming a strong attractor for Singaporean and foreign talent willing to look across the boundaries of their disciplines.

The Quantum city model as basic research field will unfold its impact in the future. It questions the fundamentals of the applied research projects and is obviously disturbing their well-adjusted pragmatics. In the long term, however, this kind of thinking will gain momentum. In theory, these questions exist since 120 years, in information technology this way of thinking became explicit with Google and the social media since 2000, and applications in economy can be expected soon.

Benefit

The Simulation Platform is on its way to become an interactive companion for decision-makers, urban planners, academics, as well as for the general public. The multitude of programs developed for the Simulation Platform cover an increasing area of interest for the analysis and planning of new cities and the renewal of existing cities. They allow the integration of large amounts of data and crowdsourcing with traditional top-down decision-making tools.

The Simulation Platform provides a planning and simulation environment, and therefore it also allows for alternative views and explorations of the urban planning process. Pre-specific modelling promises a way out of the global conditions described prominently by Rem Koolhaas as the generic city and junk space. It has enormous economic impacts and will nevertheless keep the cultural differentiation. But it will take time to change the mind-set of politicians, stakeholders, researches and institutions - interestingly enough, the citizens of the future cities will be faster, as we see with internet and social media.

In the long run, the Simulation Platform will be an important contributor to the resolution of the conflict between too much pragmatism and too much theory. Equipped with the interactive software and hardware arsenal it is developing, the Simulation Platform will be a major benefit for society. Distributed in a Massive Open Online Platform for teaching, the Simulation Platform will become an important instrument for dissemination of art, engineering, design and planning knowledge on a global scale.

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Section 3

City Simulation: Relevance

HOW IS CITY SIMULATION RELEVANT?

City Simulation always existed - in the designer‘s mind, in the builder‘s mind, and in the mind of the people governing a city. Now we have more powerful methods and instruments to externalise these visions, using combinations of science and visualisation:

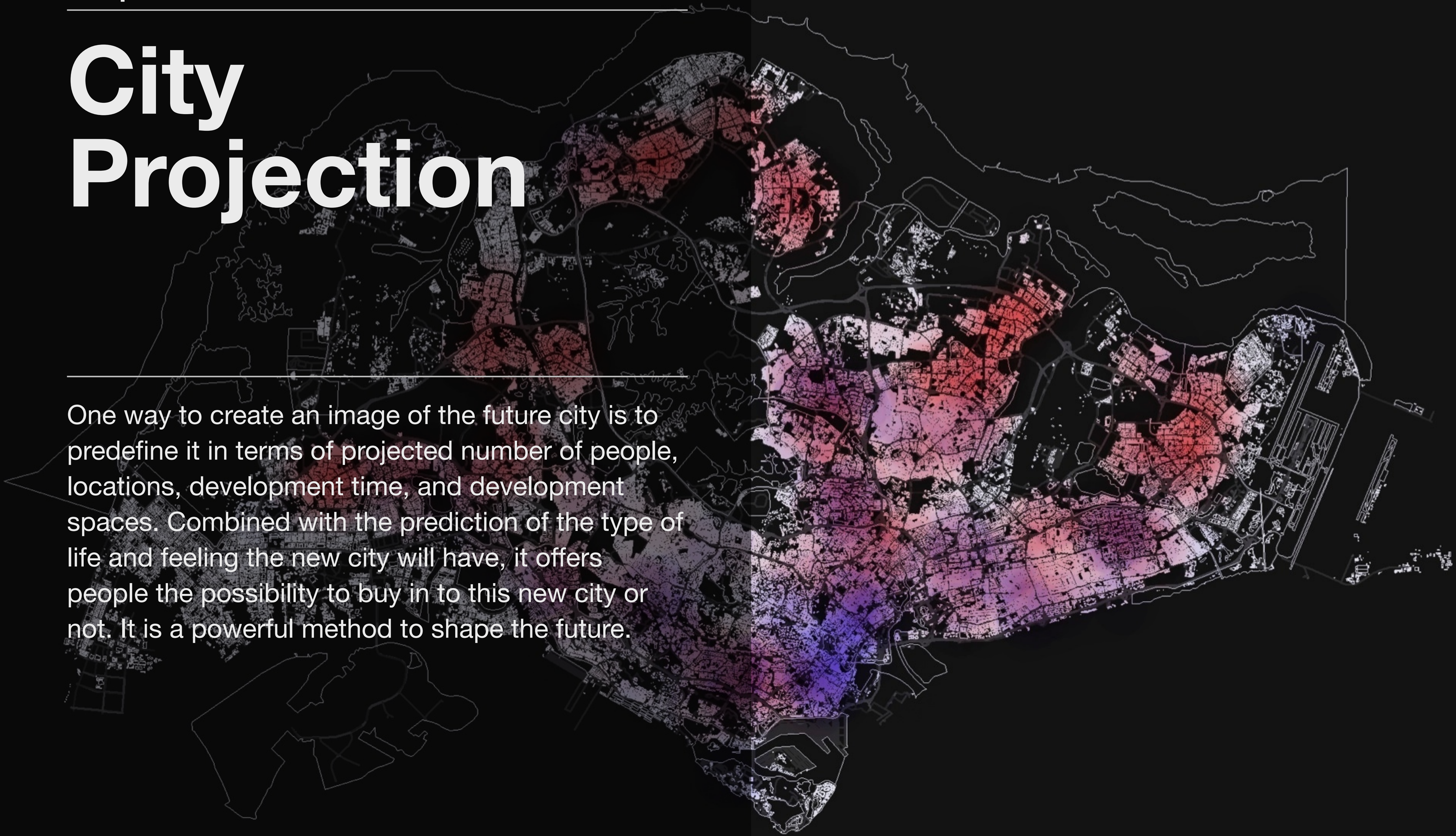
1. **Make the invisible visible: we know results of processes from experience and observation, but we cannot directly visualize it - this is where simulation helps.**
2. **Design future scenarios: We have ideas about a future building, urban, or territorial design, but it seems too complex to explain or draw - this is when simulation helps to design realistic future scenarios.**
3. **Test future scenarios: We have come up with or received a proposal for future urban design, but are not sure it will work or have the desired effects - this is when urban simulation is needed to test the assumptions and visualize the results of the design over time.**

Simulation is a powerful method and instrument. It forces us to structure our thoughts and to put things into order.

Chapter 7

City Projection

One way to create an image of the future city is to predefine it in terms of projected number of people, locations, development time, and development spaces. Combined with the prediction of the type of life and feeling the new city will have, it offers people the possibility to buy in to this new city or not. It is a powerful method to shape the future.



Section 1

City projection

A CASE STUDY

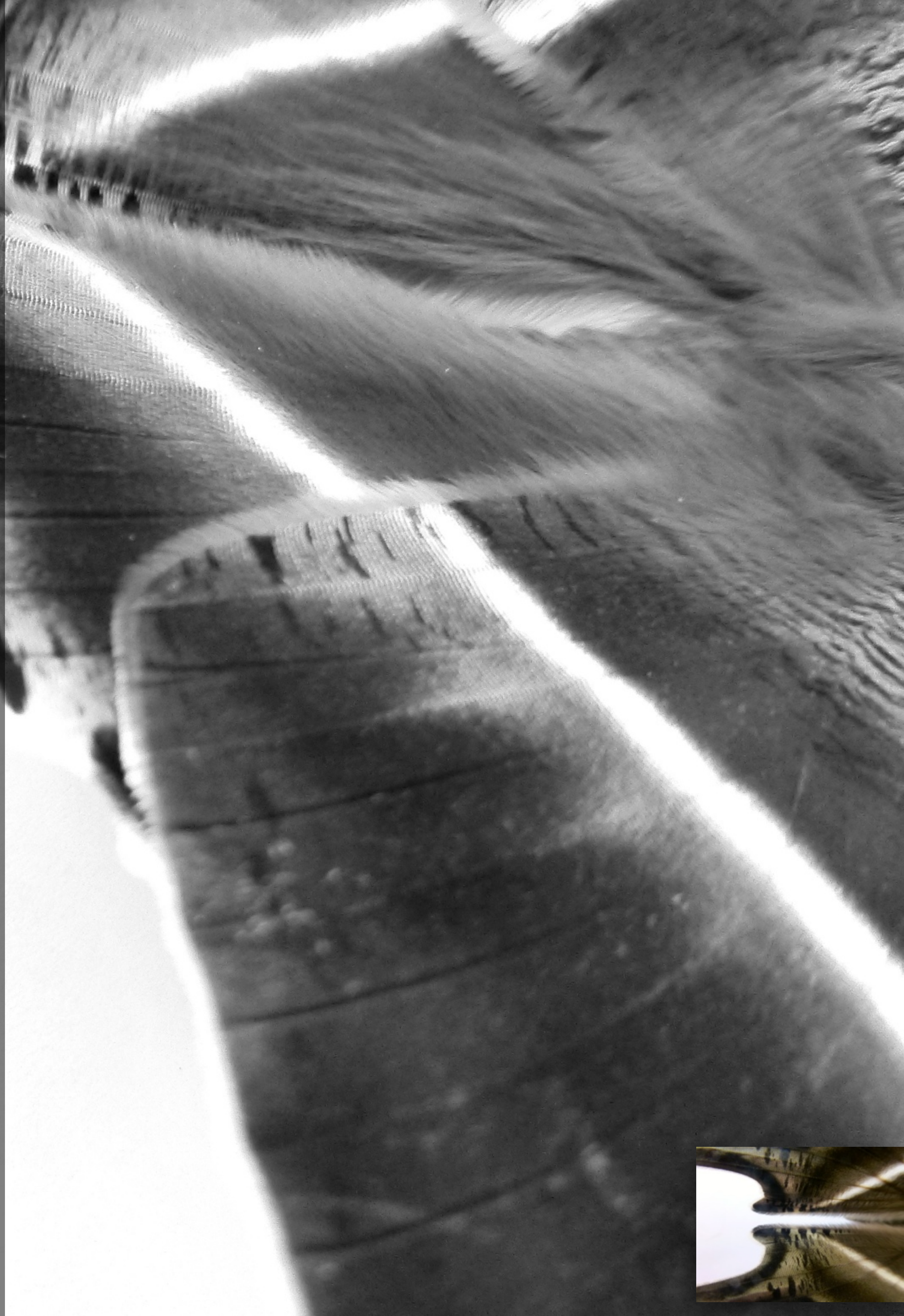
Singapore as a city state that publishes master plants for the growing city in regular time intervals. In early 2013, the city government unveiled a new plan to increase the population from 5.2 million in 2012 to 6.9 million people in 2030. The planning authorities also describe the necessary steps to reach this goal.

Just before this announcement, the Centre for Liveable Cities published a book describing 10 goals towards a liveable future city. Combined, these two documents project the future of the city for the years to come. We look at this study and projection as a case study, in particular of the components of the city deemed important for growth.

Chapter 8

Urban System Design

The ultimate goal of modelling, simulation, and projection is design. Design is situated outside of science and art, but building on discoveries in both areas. Open system design this special in that it connects architectural design and territorial design. Informed and responsible parent system design builds on information and knowledge derived from modelling, simulation and projection.



Section 1

Urban System Design

DESCRIPTION

Urban system design is a new discipline. Situated between naturally and slowly growing cities, between geometrically predefined cities, and between arbitrary growth, it is a challenging, responsible and proactive design activity.

Its foundations should be threefold: the first pillar is the ability to understand, to abstract and to model the urban system. The second pillar is the careful simulation of design ideas, based on data and information to be placed in and to interact with the urban system model. The third step is the projection of various possibilities and the creation of design scenarios to be discussed with the stakeholders and decision-makers. The design of the final artefact then results in executable plans and multidimensional models based on which the city can be built or re-built.

Urban systems are large and complex, yet most of them work because of the adaptive capabilities of humans. From the original idea through planning, competitions, commissioning, construction to management, it takes years or decades. This reduces the probability that a a single idea will be followed through the entire process and will significantly influence the final result. Yet exceptions are possible and stay in the mind of the public. Examples are Brasilia in Brazil, Chandigarh in India, or Shenzhen in China.

Chandigarh, designed by the Swiss architect Le Corbusier in the 1950s, was a social experiment in system design. Le Corbusier was a foreigner to India and the city has developed in the very different direction since then.

Brasilia, inaugurated in 1960, is directly connected to the work and memory of Oscar Niemeyer, and to the then Brazilian president Kubitschek. It could be described as one of the first system design attempts, as it tried to integrate the human, architectural, political, planning, and infrastructure needs of a then future city. Oscar Niemeyer was a native of Brazil, but still the city developed differently from what he originally intended.

Shenzhen is the newest of the three examples and there was no grand architectural urban system design scheme at the beginning. This makes it interesting, because the city of today more than 15 million people grew organically.


电脑手机超级广场

Urban systems design

Systems design describes the process to define the structure, the model, the components and the necessary data for a system to perform in a desired way. In analogy, urban systems design then is the process to define the underlying structure, the desired model, the necessary components and the data and information for an urban system to function in a sustainable way. In an abstract way, it is an extension of architectural design. Rather than buildings interacting with the urban system, the urban system will interact with the territorial system.

Specifications

High-level specifications for an urban system could be sustainability, value creation, happiness of the population, affordability for all income classes, positive environmental impact, and contribution to the functioning of the territorial system surrounding the urban system. The process of defining the specifications is most challenging and important.

Processes

In a top-down process, a process owner, for example a city mayor a city planner, assembles a transdisciplinary team of experts to address the specifications. In a bottom-up process, a community or a group of stakeholders organises itself to address the same set of specifications after formulating, ranking, expanding and discussing them carefully.

Results

The results of the process to fulfill the specifications is normally a master plan, or a master rule plan. With increasing computational capabilities, crowdsourcing and design oriented social media, the design results will be visible immediately and lead to an interactive process of improving the design and performance.

Implementation

The implementation of the design results will last for years and will continue until a equilibrium is reached, or until the urban system ceases to exist. Traces of the original design can be found today in cities that are more than 2000 years old, and this strength of the original design is a phenomenon that will persist. The **memes** of the urban system design appear like the analogy to genes in biology.

Data collection and feedback

As soon as the first buildings and infrastructures are completed, data collection must start. Data and their prudent monitoring and use are crucial for the functioning of all systems. The extensive application of data in the urban design process is a new phenomenon that was not possible only a few years ago. The data and information feedback loop helps urban systems designers to adjust their designs based on the observed performance and on the degree of fulfilment of the original specifications. This opportunity is specific to the urban systems design of the 21st-century.

Why urban systems may fail

Acemoglu and Robinson convincingly argue in their book „ Why Nations Fail“ that the most prominent reason for the failure of nations is the extractive nature of national government, in stark contrast to the inclusive nature which fosters growth and makes nations sustainable. The authors mention numerous cities and city states to which this observation also applies.

They argue that it is not geography, or culture, or ignorance which decides if a nation will be successful or will fail, but that it is the simple difference between being extractive or inclusive. They give powerful examples under the title „How Venice Became A Museum“ and described how Venice, after the decline of the Roman Empire became most likely the richest and most powerful city in the world during the Middle Ages, with several times the size of London at its time.

The description of the rise and fall of Venice, which the authors connect directly with the switch from an inclusive type of economic and political development towards an extractive type development, caused by the always inherent wish of the leadership and the elite to concentrate power in their own hands, rather than letting it go to new persons that constantly enrich the economic development. The authors claim that Venice today is a museum and only lives on tourists that come to visit the results of the time when inclusive governmental structures defined the city.

In view of the discussion of the three examples of Chandigarh, Brasilia and Chenzhen, inclusiveness and extraction also play an important role. Chandigarh, after many years of British extractive policies, was founded based on a top-down decision where the next capital should be built. A similar development could be claimed for Brasilia. Also here, the extractive nature of this part of South America is well argued by the authors of „Why Cities Fail“. In fact, the relative economic underperformance of Brazil as compared to North American countries could be one result, stemming from the extractive policies of the previous governments.

In this light, the rapid development of Chenzhen comes as no surprise, because it could be seen as an island off inclusive policies, enabled by economic development zone. The rapid growth off the city within the last 30 years, which by far surpasses the growth of Chandigarh or Brasilia in more extractive contexts could be a powerful point to support this theory. In all three cases, it seems indeed a fact that neither culture, not climate, nor geography or ignorance led to the development of the cities as they are today. The example of Shenzhen shows clearly, as does the example of the neighbouring Hong Kong, that inclusive institutions and local governance are dominating factors in the development of cities. They will also eventually decide on their long-term success or failure, and on their long-term sustainability and resilience.

Chapter 9

System: Construction

Construction used to be simple. There were 2 major approaches: subtractive construction by carving material out of existing rock or earth; or additive construction by adding material on top of each other. Today, the additive approach is dominating and most technical construction support tools are geared towards sophisticated addition of layers. Nevertheless, the construction process shows another aspect of the building as a system: material, function, and process hyperlinked as part of the building system. This system can be represented in an abstract form as information.

Section 1

Construction

TYPES OF CONSTRUCTION

Construction is the interaction with and the manipulation, partial destruction and alteration of an existing system. Construction involves the finding, processing, transporting and assembling of material. This process changes the place where the material was found, the place where it is finally used, at all the places in between to a lesser degree.

Construction used to be a localised activity, but with the advancement of construction processes and construction materials, almost every building contains components of a globalised economy. The construction process becomes more knowledge intensive and the necessity of architects, designers and territorial planners to understand construction as the alteration of the system increases.

Pick any part of a modern building, such as a chair or an open in any region of the world and try to retrace the path of all the components to their origin, and then retrace the path to the origins of the material of the components, and you will probably see a tree like structure spanning most of the globe. If in addition you calculate the energy needed and the CO_2 produced for mining, transporting, assembling, shipping, selling, and installing the chair or the oven, you will probably see unexpected and astonishing numbers and places, making the tree structure even denser. Some of the parts will be equipped with RFIDs to be able to follow them back to the place they were produced, in case something goes wrong. In other words, construction has become a global activity, and it is almost impossible, to build and equip a building from local material only.

Information technology, information architecture, and the information city concept provide for the first time the opportunity to visualise and follow the life cycle of any material, building part, building equipment or entire buildings. Construction is a typical example for material flows around the world, and probably one of the most energy and CO_2 intensive activities that can be imagined. They result of construction is a building, a material stock. Yet the building‘s life-cycle energy consumption and CO_2 production by far exceeds the amount of energy that went into its original production.

Building construction site

The construction site determines the sustainability of a building to a high degree. Given the choice, one could place buildings in locations where they produce more resources than they consume and could become sustainable structures over time. However, a system of restrictions, protecting other aspects of the human habitat, often limit this choice to positioning a building intelligently on a small site or, in high-rises, to floor level and orientation.

Gallery 9.1 Building construction site

Construction location and form follow the function of this simple building close to Einsiedeln in Switzerland. Photo: Gerhard Schmitt, October 26, 2008

Building construction material

Early construction took the material directly from the vicinity of the construction site. Clay, stone, and would in various variations were chosen in temperate climates. Protected from rain and ground moisture, even organic materials last for centuries. It was and is the knowledge about the behaviour of the material over time that determines its sustainability. This way, old timber frame buildings can have an extremely small carbon footprint. The challenges is to connect them to modern standards of living.

Gallery 9.2 Building construction material

Oak wood, with adobe and straw infill. These local materials help sustain this schoolhouse in Schönberg since 1697. Photo: Gerhard Schmitt, October 10, 2008.

Construction sites in the tropics

Choosing the right construction site in the tropics involved, like in temperate climates, protection from the elements and from the enemies, as well as access to food and transportation. The absence of snow and frost offers more possibilities than in temperate climates, and water in general plays a larger role, As it is constantly available as convenient stock and flow, providing food and mobility.

Gallery 9.3 Construction sites in the tropics

Construction site in Nampan, South end of Inle lake in Myanmar, which serves as source of food and provides mobility. Photo: Gerhard Schmitt, April 7, 2011.

Artificial construction sites

Construction sites can be created artificially, If the ideal site cannot be found otherwise. San Francisco for example, created much artificial land to house part of the city. The same is true on a large scale for Hong Kong, Shanghai, or Singapore. Given all criteria for settlement being perfect in a certain location, but no land being available, it is possible with technical means to create this land. The sustainability of this approach needs to be explored.

Gallery 9.4 Artificial construction sites

View from Marina Bay Sands Hotel on the gardens by the Bay and the Marina barrage. The entire visible land is reclaimed from the sea. Photo: Felicia Bettschart, November 9, 2012.

Building construction site protection

Construction of a building lasts between few days and several years. The construction site is in a specific state during this time. Robotics can also support the construction of fences.

Building construction process

Building sustainability

Urban construction site

The urban construction site creates a situation of disruption and danger. But it also creates increasing interest, in that by-passers can participate in the emergence of a new street, the demolition of a building, the renovation of a city block or the step-by-step buildup of an entire city quarter.

Territorial construction sites

Construction on rivers and lakes have regional, territorial, and sometimes global impact on cities, societies, and climate.

Section 2

Future Cities Laboratory: construction

THE ASSISTANT PROFESSORSHIP FOR CONSTRUCTION AT THE FUTURE CITIES LABORATORY

The Future Cities Laboratory at the Singapore–ETH Centre has established an assistant professorship for architecture and construction in 2011. Dirk Hebel, the founding assistant professor, specialises in sustainable materials and their use in the developing countries around the equator.

The following information is taken from discussions with Dirk Hebel and from the publication (SEC) Singapore-ETH Centre, (FCL) Future Cities Laboratory Booklet, 2nd edition, Zürich, revised 27 January 2012.

Given the fact that existing and future cities are less and less dependent on their immediate hinterlands, the assistant professorship of Architecture and Construction of **Dirk Hebel** takes special interest in the globalisation of the material flows in constructing and renovating cities. This development is seen as a challenge to the local identity of cities, but also to the efficient use and ownership of material resources. The chair places special emphasis on the category of waste, its possible location in the value chain of construction products and into its potential to increase the ecological and economical efficiency by reducing the global flow of construction materials.

The chair considers the intelligent re-use of material as direct contribution to the construction of buildings. It also conducts research on the process of recycling of potential building materials. A most interesting contribution will be the research of Dirk Hebel and his group to replace energy intensive materials in the existing construction materials. They have embarked on the systematic rediscovery of bamboo as a building material in conjunction with concrete. Eventually, and processed in a way that makes bamboo more resilient with regard to water and decomposition, it may be able to replace steel in concrete throughout wide areas of the world where urbanisation and high-density are not necessarily connected to high-rise construction.

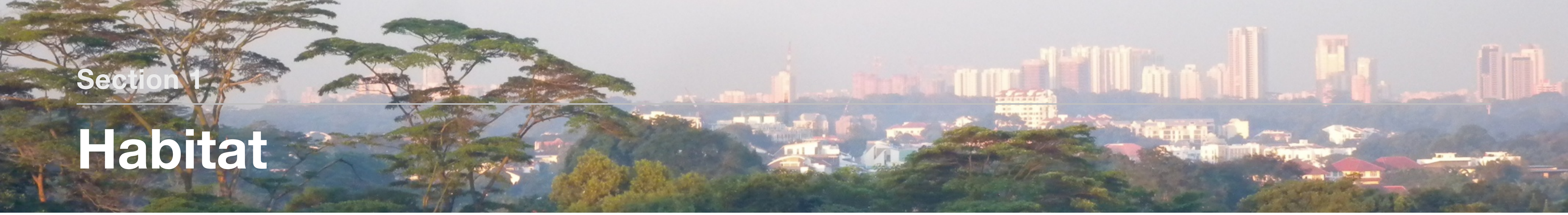
Interactive 9.1 FCL Assistant Professorship of Architecture and Construction - description

Interactive 9.2 FCL Assistant Professorship of Architecture and Construction - exhibition pod

Chapter 10

System: Habitat

Buildings made for people quickly reach a high level of complexity and as such form complex information systems. The function of providing a habitat for humans has taken on different forms over time. From the early examples of simple shelters, to sustainable and resilient structures in rough environments to multifunctional mega structures in Asian cities, humans as individuals and as collective communities have shaped their habitat. Information Systems have become an essential component of each new building.



Section 1

Habitat

DEFINITION

Habitat describes the human living and working environment. For each person, it is the centre of her or his activities. Seen from the outside, it resembles a networked environment. Seen from the inside, it appears as being in the centre of human activities.

Information increasingly influences the human habitat. Whereas in early human settlements the protection from and the fight against the elements was key, modern settlements shape the environment.

The UN Global Report on Human Settlements describe the development in regular intervals.

The **human habitat** is the place where we spend our life. Every city, village, single house or exposed research station is part of the human habitat. In broader terms, human habitat relates to human settlements and to housing in particular. The United Nations produced the first **Global Report on Human Settlements** in 1986. The titles of the following reports were „An Urbanising World“ (1996), „Cities in A Globalising World“ (2001), „The Challenge of Slums“ (2003), „Financing Urban Shelter“ (2005), „Enhancing Urban Safety and Security“ (2007), „Planning Sustainable Cities“ (2009), „Cities and Climate Change“ (2011). The reports come increasingly to the conclusion that the integration of all the factors described as chapters in this book - especially the stocks and flows - is crucial for the creation of long-term sustainable and liveable cities.

Focusing on the housing aspect of the human habitat yields the biggest differences between cultures, climates, stages in the development, social preferences and potential for adaptation.

Focusing on the relation between housing and information, information architecture, and information city reveals a very large potential for the future in each place on earth. This potential can be realised if information is used as the enabler of a better habitat, in which the individual dwelling, apartment, house, settlement, or city interacts intelligently with its environment.

Housing

Every person needs housing. In the past, housing and working were separated after the combination of living and working in polluted areas of the industrialised cities had led to deplorable health and social conditions. The total separation of the activities, however, led to the known disadvantages of suburban spread, increased need for mobility, and single purpose settlements. Information technology offered a first instrument to build a bridge between living and working, and thus to take a pragmatic approach towards combining the advantages of both situations. In Switzerland, the **Manto Report** from 1987 was a first attempt to demonstrate these possibilities.

At the Future Cities Laboratory, Prof **Sacha Menz** and his research team focus on „Strategies for optimising the spatial organisation of high density urban areas“ By Ben interdisciplinary exploration of the „relationship between density and liveability with focus on the use, and appropriation of common spaces in Singapore high-rise housing“. The group assumes, that „National economic growth combined with forward strategic planning have been instrumental in the shaping of Singapore's residential architecture since the early 1960s. As a result, Singapore's already limited land area now comes under increasing pressure. The situation demands ever-greater optimisation of land use at urban, site and building scales. This, in turn, places pressure on the balance between functional effectiveness and liveability of the everyday built fabric. Common spaces play a pivotal role in maintaining this balance. First, through their capacity to structure interaction of inhabitants, such spaces have a regulatory effect on the sense of density in the immediate dwelling environment. Second, common spaces positively impact on the liveable quality of domestic spaces, independent of standards of living of the residents.

The ETH Chair of Architecture and the Building Process, together with ETH Centre for Research on Architecture, Society & the Built Environment (CASE), aim to collaborate with relevant Singapore-based institutions to develop an interdisciplinary strategy for exploring significant housing typologies that have emerged over the past fifty years in Singapore. A set of four empirical case studies, focused on different HDB housing estates, will combine quantitative analysis of building and site characteristics with qualitative ethnographic methods. By investigating the quantitative characteristics and spatial organisation of the building and its site, and correlating this to the role of common spaces, we seek to gain greater understanding of the liveability of cities. This gives rise to a set of specific issues concerning the way of common spaces are constituted, used and appropriated, and how this impacts on the overall liveability of particular estates. The anticipated findings of this study have the potential to contribute to the design and production of housing in Singapore as well as other high density living contexts.“

Forms of animal Habitat

Animal habitat and animal housing are areas of intensive research since centuries. Obviously, animals do not have architects or city planners, but the resulting structures sometimes remind us of human settlements. The role of data and information in the construction of animal habitat is not fully explored, but definitely there must be a way to store the necessary construction instructions in a consistent way.

Gallery 10.1 An animal habitat

The hornet habitat. Germany, May 2, 2007. Photo: Gerhard Schmitt

Forms of human Habitat

The shape and form of human habitats has changed dramatically over time. Major forces are climate, landscape, transportation potential, available building material, available financial resources, and skills and knowledge of the builders. The forced or voluntary restriction to few materials and colours creates a uniform and - for the human eye - appealing settlement pattern. Yet the conditions in these settlements are often not satisfactory.

Gallery 10.2 Forms of Habitat - Sudan

A settlement from above. Sudan, March 11, 2007. Photo: Gerhard Schmitt

Low-density Habitat

Although mostly urbanised, Switzerland and Europe in general are still characterised by a low-density habitat. The majority of the population lived in low-density settlements for centuries, before an accelerated move into the industrialising cities occurred in the 19th century. The low-density habitat, reaching from solitary castles to suburbia, is often the dream for people to live in. With information technology, these habitats may gain a new life.

Gallery 10.3 Low-density human habitat

Relatively low density rural settlement in the Swiss Alps. Einsiedeln, December 24, 2008. Photo: Gerhard Schmitt.

High-density Habitat

Typically, we associate high-density with vertical cities. While Zürich reaches a density of more than 4400 people per square kilometre in its downtown area, Singapore has twice the density. This is achieved by constructing high-rises in close vicinity in the central business district and by adding residential high-rises of up to 55 floors adjacent to the CBD.

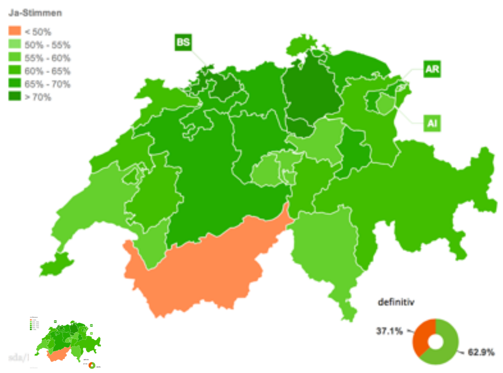
Gallery 10.4 High density human habitat

Construction of the high density Marina Bay commercial and hotel development in Singapore.

Habitat and Information Architecture

The relations between the habitat and Information Architecure are manyfold. The more people know about and their habitat, the more informed they are and can make decisions that are based on more than gut feelings. This is not to devalue the importance of intuitive decisions, if this intuition fas been built up over years and generations based on facts. Rather, it is a plea for a more complete and better informed decision-making.

On March 3, 2013, the Swiss population voted on the revision of the „Raumplanungsgesetz", the equivalent to a federal zoning law. This is a surprising fact in the first place, because the zoning law authority in Switzerland belongs to the villages, communities, and cities. Yet it became clear over time – through communicated data and information – that the communities had reserved large areas of previously undisturbed agricultural or natural areas for building activities. The population was informed, that every second one square metre of cultural land was built over in Switzerland. The population knew through data, information, and personal observation that clean water, clean air, and a pristine landscape were some of the most important assets of the country – in terms of tourism, and, more important, in terms of the high liveability standards of the country. This meant that the large „Baulandreserven" - building zones - which the communities had dedicated for development, would be detrimental to the overall and the individual appearance of the country.Although individuals had an interest in converting their previous agricultural land into building land and thus being able to make significant profits, the overall vote was overwhelmingly against a continued suburbanisation of the country. The initiative they voted for went so far as to request that sensitive natural areas that had been zoned for building activities would be de-registered for those activities and thus could cause considerable financial harm to the individuals.



Just a few months earlier, the Swiss population had also voted against the excessive percentage of „Zweitwohnungen" or second residences, mostly owned by foreigners. Again, data had informed the population that in some mountain villages the majority of the buildings were occupied only during a few weeks per year, thus ruining the community spirit of the villages. This vote was particularly interesting, as the urban population, who wanted to preserve the impeccable quality of the Swiss mountain villages and landscape for future generations - but owning most of the „Zweitwohnungen" - was in contrast to some of the mountain villages, who voted against the restriction of „Zweitwohnungen". The villages' reasoning was, that it would harm the local building industry if the restriction was accepted. Interestingly, the only Canton who voted against the „Raumplanungsgesetz" was the one that was a affected most by the „Zweitwohnungsinitiative".

Chapter 11

System: Energy

Each building is a system. A if is described as: “A system is a set of interacting or interdependent components forming an integrated whole[citation needed] or a set of elements (often called 'components') and relationships which are different from relationships of the set or its elements to other elements or sets.” Even the most primitive hut is a system, consisting of load-bearing parts, weather protecting parts, as well as light and temperature controlling parts.

Section 1

Energy and exergy

DEFINITIONS

For the inhabitant, a building has the purpose to provide for a safe and comfortable environment. The building can do so by passive and/or active components. The inhabitant or user of a building, apartment, office space or any other enclosed part of a structure perceives the inner view of a system.

Seen from the outside, a building causes a change to the environment It is constructed in with potential impacts going far beyond the direct vicinity of the building: The change of the Earth‘s surface on the building site, the addition of water and energy supplies, the production of waste in form of material and temperature directly influences the environmental system.

For the future, it will be crucial that the environmental system in which a building is placed is disrupted as little as possible. In that respect, energy and exergy become key concepts.

Energy and exergy

Most people are familiar with the concept of energy and its uses in buildings. They also increasingly understand and see the relation between their personal energy consumption and the long-term impact on the environment. But few are aware that the environmental system surrounding each building – air, earth, or water – offers many opportunities to make use of the energy contained in this environmental system for increasing the comfort inside the building. The concept of **exergy** thus presents a more appropriate measure of energy consumption.

Hansjürg Leibundgut is professor for building physics at the ETH Zürich, and besides performing fundamental research on exergy, he also teaches the subject and implements applications of it in his own practice. He describes the work and purpose of the Low Exergy Module in the Future Cities Laboratory as follows:

“The building sector places one of the heaviest, and increasingly unsustainable, burdens on the world’s energy resources and natural environment. The problems of climate change and finite stocks of fossil fuels will cause severe conflicts in the coming decades if there is no change in the technologies used to construct and run buildings. The supply of energy itself is not a problem because solar radiation exceeds the power requirements of human society by factors of more than 100 at every site of human population. Rather, current technologies inhibit our ability to capture and utilise available renewable energy without negative side effects.

This module proposes, as a consequence, that fundamental changes and innovations are necessary in the way we consider buildings and the flows of energy that they embody. This implies a rethinking of the way in which buildings are designed, constructed, operated, maintained, renovated and, if necessary, demolished. The module is focused on expanding the available range of solutions that can counter the current unsustainable demand that the built environment places on global energy resources. It does so at theoretical, methodological and empirical levels. The module will innovate theoretically around the concept of exergy as a more sophisticated measure of energy consumption in the building sector. It will develop and modify design software, building control and automation systems to optimize the use of renewable energy sources through the operation of low exergy systems. And finally, it will adapt and implement practical solutions being researched in Switzerland in the different climatic and cultural conditions of Singapore. These will take the form of models, pilot projects and at least one full-scaled building project.

The BubbleZERO is the first pilot of low exergy technologies in Singapore. The laboratory contains several technologies including radiant cooling, decentralized ventilation, and wireless sensing and control that will be tested and evaluated for high performance cooling operation in the tropical Singapore climate.

The Low Exergy module researches the development of new low exergy systems for the tropics. The work includes the adaption and performance assessment of existing low exergy systems that have been developed in Switzerland for heating and have been brought to Singapore for evaluation as part of the containers that now form the BubbleZERO laboratory. The research in Singapore is managed by the module coordinator and five PhD students have projects studying different aspects of the low exergy system implementation in the tropics. These topics are:

- radiant high temperature cooling
- decentralized ventilation and indoor air quality optimization
- wireless sensors and control
- low temperature heat rejection
- integrated system design, modeling and visualisation“

http://www.futurecities.ethz.ch/research-modules/lowex/

This example demonstrates, that by focusing on fundamental research, real-world applications can quickly emerge and contribute significantly both to value creation and to the improvement of the environment, by bringing their system back closer to its previous balance.

Chapter 12

System: Water

Water is both necessity and a threat for urban systems. It is ubiquitous, like electricity and communication. On the building scale, it is present in every single room of a structure. On the city scale, water appears in the form of rivers, lakes, and drinking water reservoirs. And on the territorial scale, it appears as oceans, rivers, storage lakes and in frozen form. Technical devices and networks transform water from a raw material to a sophisticated product. For the sustainability of the city, water is absolutely crucial, and design should account for this fact.

Stocks and flows of water

WATER

1. Building scale
2. Urban scale
3. Territorial scale

Territorial scale

Water can become life threatening quickly on the territorial scale, as frequent tsunamis demonstrate. But it also can become a slowly rising threat, as shown by the example of the Maldives.

Chapter 13

System: Economy

Are cities liveable because they are rich, or are they rich because they are particularly liveable? No matter how this question is answered, the interdependency between economic‘s and city is obvious.

Chapter 14

System: Mobility

Mobility has many meanings, but in this context we refer to it as the capacity of citizens to freely move between their living place, their working place, their education place and any other location by any mode of transportation, using the infrastructure of the urban system or the territory surrounding it. Mobility has a growing impact on the planning and management of cities.

Section

System: Mobility

DEFINITION

Mobility is essential for human life. It gives us the opportunity to move from one position to another in the physical, intellectual, economic, personal or academic space. We are used to be mobile in all of these aspects. They make societies move, they make cities thrive, they make people think and advance.

Although mobility seems a natural right for all living systems, it‘s importance might best be explained by its absence: the gradual or complete restriction of mobility can lead to desperation and immobilisation in many aspects. Imprisonment is probably the strictest punishment for humans, as it totally constraints a person‘s ability to be mobile.

In daily life, people in countries such as Switzerland, the United States or Singapore connect mobility with transportation – both public and private. Transportation has taken on an important role in modern societies and represents up to 30% of the entire energy demand of the country.

„The flow of people and goods within and through city areas is a fundamental dimension of contemporary urban design, planning and management. How these flows are accommodated and integrated into the fabric of the city impacts profoundly on the health and satisfaction of residents, and the economic prosperity and long-term sustainability of the city. The simulation of such flows, whether macroscopic or microscopic, static or dynamic, trip-based or agent-based, supports the aim of balancing travel demand (mobility needs) and travel supply (infrastructures of mobility). While the interaction between the daily flows and the built environment is well understood in theoretical terms and at larger spatial scales, a more refined understanding of the interactions between the actors who animate the built environment remains elusive.

This module will advance research into this field by addressing the complexity involved in optimising the flow of a diverse range of people and goods at different time scales. It does so by extending and implementing MATSim, an agent-based transportation simulation software (developed at ETH Zürich, TU Berlin and now in Singapore – www.matsim.org), in conjunction with the acquisition of everyday social data drawn from censuses and household interviews. The module will examine medium- and long-term time scales. The medium-term scale starts with the current situation, and addresses issues such as changes in infrastructure, regulation and pricing. The long-term scale refers to more structural kinds of change such as household location choice or the choices of service providers. The insights of this research will be used to improve the understanding of residential, workplace and daily travel and location choice, as well as customer/supplier relationships between firms, and directly inform policy-making in the field of transport planning in Singapore and beyond.“

http://www.futurecities.ethz.ch/research-modules/mobility-and-transportation-planning/

Reasons for Mobility

Mobility is a necessity. If people have a choice, their reasons range from getting from A to B, to work, to home - which could be called transportation - all the way to life style and luxury mobility. For each reason combinations of mobility are standard: Walking and riding a bus, driving and riding a train, or walking and swimming for sports. A good city will accomodate all these reasons and offer attractive solutions.

Gallery 14.1 Reasons for mobility

Studying in Cambridge, UK, as one reason for urban mobility.

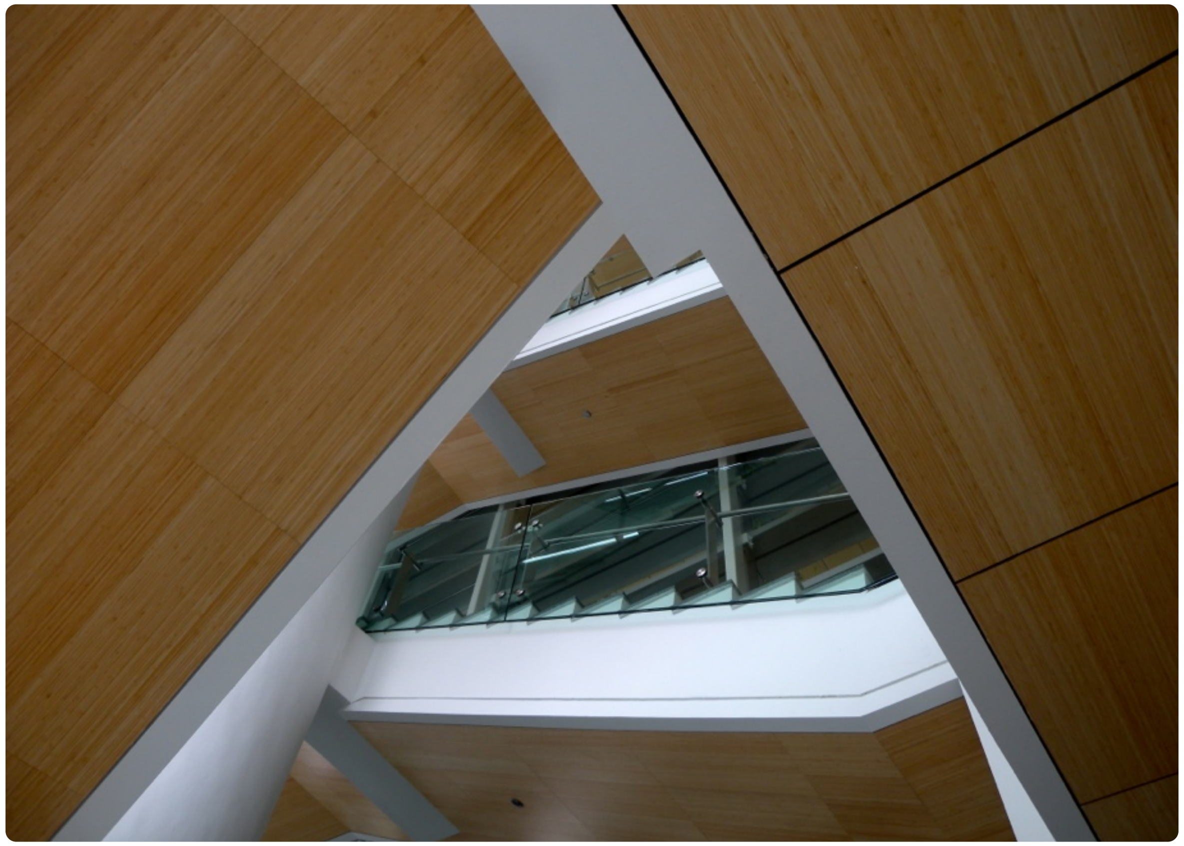
Types of Mobility

Walking, riding a bicycle, driving a motor scooter, a motorbike, a car are individual types of transportation. Taking a bus, a tram, a subway, a train, a boat or a cable car are public forms of transportation. For a single trip, we often combine different types of mobility. Depending on the choice and frequency, mobility can be detrimental or beneficial for the individual's well-being and health.

Mobility and Architecture

In buildings, mobility ranges from the small scale – to access all spaces by elderly or handicapped people – to the medium scale – to connect to outside mobility systems such as cars or public transportation – to the large-scale – such as elevator systems in tall buildings. In very large buildings that have the population of small cities between 6000 and 20,000 people, elevator systems are crucial for internal mobility.

Gallery 14.2 Types of mobility



Using stairs for the simplest form of vertical mobility. CREATE staircase, Singapore, December 11, 2011. Photo: Eva Schmitt

Gallery 14.3 Mobility and architecture

Ladders as vertical and boats as horizontal mobility elements on Inle Lake, Myanmar. April 7, 2011. Photo: Felicia Bettschart

Mobility and Planning

On the urban or planning scale, mobility is one of the dominant design factors. Walkability and the capacity to reach important locations inside and outside of the city are deciding factors.

Gallery 14.4 Mobility and planning

Mobility between campus buildings in Mumbai, India. December 8, 2011. Photo: Gerhard Schmitt, SEC FCL and ETH Zürich.

Mobility and Territory

Gallery 14.5 Mobility and territory

Airplanes connecting cities and continents for global mobility. Over the alps, March 6, 2013. Photo: Gerhard Schmitt.

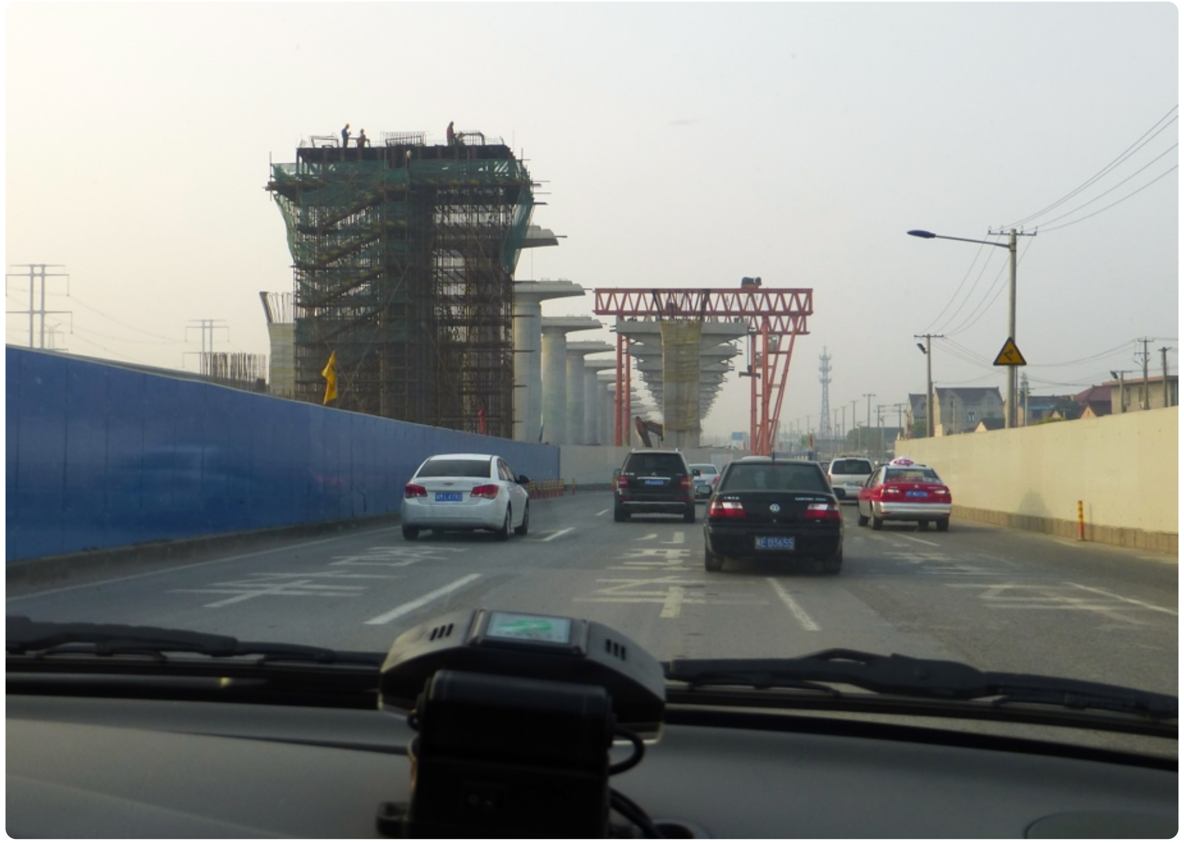
Future Mobility

Gallery 14.6 Future mobility

Electromobilty as one possible type of future mobility. Shanghai in the morning of April 25, 2013. Photo: Gerhard Schmitt, SEC FCL.

Side effects of mobility

Gallery 14.7 Side effects of mobility

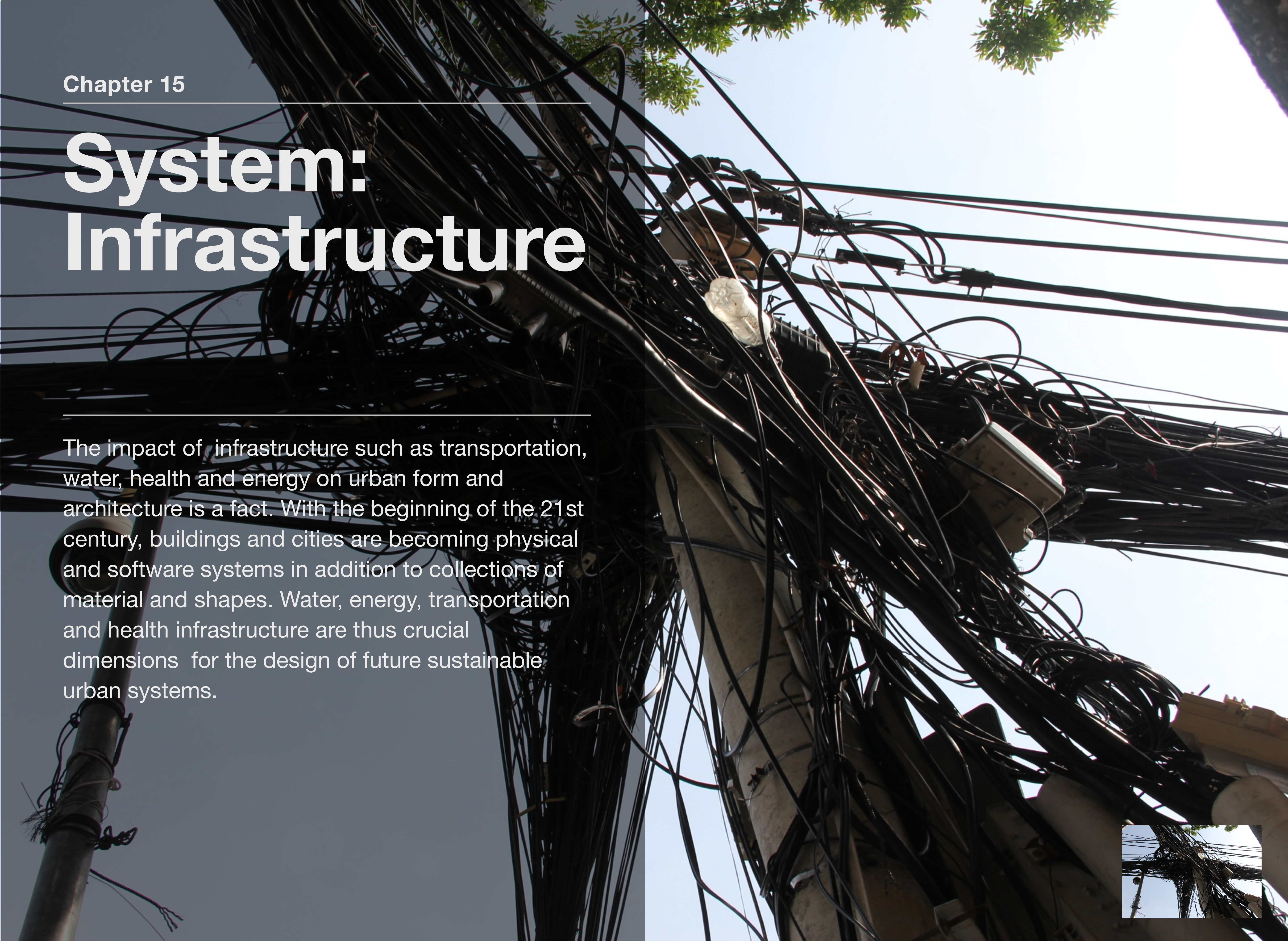


Noise, pollution, and visual pollution are some of the side effects of transportation. Shanghai, April 25, 2013. Photo: Gerhard Schmitt, SEC FCL.

Chapter 15

System: Infrastructure

The impact of infrastructure such as transportation, water, health and energy on urban form and architecture is a fact. With the beginning of the 21st century, buildings and cities are becoming physical and software systems in addition to collections of material and shapes. Water, energy, transportation and health infrastructure are thus crucial dimensions for the design of future sustainable urban systems.



Section 1

Electricity Infrastructure

VIEWS ON ELECTRICITY

In this section we look at Electricity, a specific type of energy carrier, and ask the following questions, as they all have impact on architecture, urban design, and territorial planning:

- **Where is electricity being used?**
- **How is electricity being transmitted and distributed?**
- **How is electricity produced?**
- **How is electricity stored?**

We focus on this view, as it enables the integration of electricity into the design process.

Electricity plays a special role amongst the most important energy carriers, such as crude oil, petroleum, natural gas, coal, district heat, wood, waste, gasoline for transportation, and the emerging range of alternative energies such as sun, biogas or biofuels.

Electricity

Electricity – The effects of which were known for millennia, its engineering ticking off much later - has developed into one of the planet‘s most versatile and important sources of enabling and simplifying daily life. Its uses are sheer endless, and we cannot imagine a day without it. It supports communication around the globe, mobility from electric vehicles to traffic lights, air travel from lighting to controlling and enabling the mechanical systems, moving people in elevators more than 800 m tall in a few seconds, transporting humans on people movers in extensive airports, cooling down our office spaces, melting gold, steel and aluminium. It literally surrounds us in our habitat. Think of approaching a modern residential building: a sensor (uses electricity) detects you and turns on the light (uses electricity), you ring the bell (uses electricity), the door opens (uses electricity), you take the lift (uses electricity), and before you enter the door of the apartment, you may have used half a kilowatt hour already. In the apartment, it continues with lighting (uses electricity), air conditioning (uses electricity), heating (uses electricity), the refrigerator (uses electricity), taking a shower (uses electricity), listening to music (uses electricity), using the gym (uses electricity), or the swimming pool (uses electricity). The list continues, and it is one of the main reasons why the per capita use of energy and of electricity in particular is growing continuously - in Switzerland, for example, from 2000 Watt per person in 1960 to 7000 Watt in 2010.

Building use of electricity

An average household in Switzerland uses between 3000 and 5000 kwh of electricity per year. Heating, cooling, lighting, cooking, information processing, entertainment, humidification or de-humidification: electricity provides support for all of these processes. Residents, from children to the elderly, know the universal process of turning on and off electricity with switches or dimmers. Although mishandling can lead to injury or even death, it is totally accepted today as part of our building culture.

Urban use of electricity

The electrification of cities occurred early on. Extensive streetlighting, electric escalators, trams and buses were first signs of electrification. Typically, human, animal, wood, or coal powered mechanical systems were replaced with electrically powered engines. Today, electric systems are embedded in every single component of the urban system, from surveillance cameras to above ground or below ground communication lines or power lines, to subways and cooling towers.

Gallery 15.1 Building use of electricity

Electricity as source of lighting for the interior and exterior of buildings. Singapore, December 23, 2010. Photo: Matthias Bettschart.

Gallery 15.2 Urban use of electricity

Cooling towers occupy most of the roofs of high-rise buildings in modern cities. Seoul, South Korea, May 18, 2011. Photo: Gerhard Schmitt.

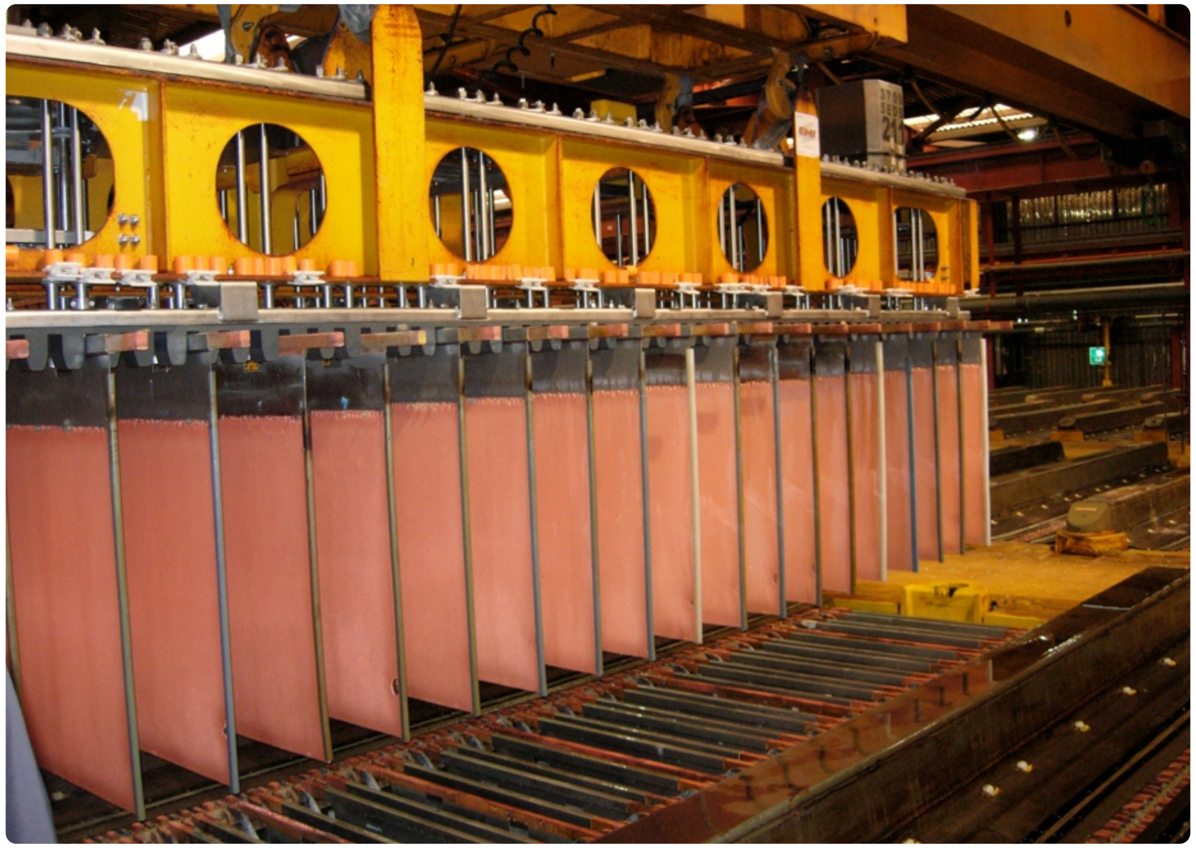
Territorial use of electricity

Electrification played a major role in connecting cities in the territories of the industrialising countries of the 19th and 20th century. Electrified high-speed trains transfer states and countries, also connecting nations. Electricity opened up new transportation possibilities in tunnels, because the source of producing electricity is remote from its use. Electrically driven hydraulic pumps regulate water gates on rivers or dams. Electricity in large quantities is needed to produce copper.

Network use of electricity

Global networks gain importance in the 21st-century. Almost all of these networks are driven or supported by electricity. Transcontinental underwater cables need repeaters to transport information to the other side. More prominent in recent years, supercomputers, data storage devices and data centres emerge close to cities or in remote areas, were cooling is not a problem, around the world. The energy use of those centres in the form of electricity begins to rival that of international air transport.

Gallery 15.3 Building electricity production



Electricity from Argentina as essential energy for the production of copper in Chile. Atacama desert, August 13, 2007. Photo: Gerhard Schmitt.

Gallery 15.4 Network use of electricity

The K supercomputer in Kobe, Japan has an installed cooling capacity of almost 30 MW. October 4, 2011. Photo: Gerhard Schmitt

Building electricity infrastructure

In old buildings, we still often find free hanging electric cables around the rooms, and in basements we can sometimes follow the electric lines to the fuse boxes. Yet increasingly, the building electricity infrastructure becomes invisible by design, to reduce the danger of accidentally becoming exposed to high voltage. They only visible elements left are switches and power plugs, secured by different standards worldwide. It takes specialists to extend or repair this infrastructure.

Urban electricity infrastructure

Electricity needs to enter the building from the distribution network on the city scale. Tall wooden poles were the first solution to this design problem. They carry the cables transporting electricity and complication next to the streets, and that from there into the building. In advanced cities, the distribution occurs underground. In the future, this network will increasingly transport the electricity back from the building into the network.

Gallery 15.5 Building electricity infrastructure

Light fixtures and sensors as visible electricity infrastructure in the Monte Rosa shelter. October 3, 2009. Photo: Gerhard Schmitt.

Gallery 15.6 Urban electricity infrastructure

Ho Chi Minh City, Vietnam, December 26, 2012. Electricity infrastructure. Multiple lines collect on concrete poles. Photo: Felicia Bettschart

Territorial electricity infrastructure

Best known are the high-voltage transmission lines that criss-cross all countries and deliver high voltage electricity. While an efficient infrastructure of distribution, they often ruin the landscape views. They are also under attack from environmentalists for potential health risks. In general, building sites under high-voltage transmission lines do not have high value. As an alternative, underground distribution is possible for high-voltage.

Gallery 15.7 Territorial electricity infrastructure

High voltage power lines crossing oil palm plantations in Malaysia. April 11. 2012. Photo: Gerhard Schmitt.

Network electricity infrastructure

Network electricity infrastructure resembles territorial electricity infrastructure, yet it can develop its own, sometimes surprising forms. Examples are data centres in the Arctic to avoid high cooling costs, or data centres cattle farms with several thousand cattle provide the biogas to generate the needed electricity for running the centre and cooling it. Data centres can also contribute to district heating when they are placed inside cities in cool climates.

Gallery 15.8 Network electricity infrastructure

Train networks as one of the first network electricity infrastructures. Rottweil, Germany, January 14, 2009. Photo: Gerhard Schmitt

Building electricity production

Photovoltaic and wind are the most popular building electricity production elements. Roofs are most suited to collect the sun's energy and to convert about 15 to 20% of it into electricity. After 30 years of research and small-scale tests, photovoltaic is becoming a feasible alternative for building owners to generate their own electricity or to even sell it to the grid. Electricity generation with small windmills or light wind constructions is possible, but less popular. All of this might change once building electricity production becomes part of lifestyle.

Gallery 15.9 Building electricity production

The Monte Rosa shelter produces all of its electricity with photovoltaic elements. October 3, 2009. Photo: Gerhard Schmitt.

Urban electricity production

Electricity production on the urban scale has a long tradition. Water and wind where the first sources, more recently photovoltaics become an additional alternative. The fast flowing rivers through cities may be used to generate electricity, but will normally not be enough. Biogas plants, wind farms, or photovoltaic plants may supplement the electricity needs of the city. However, large cities and megacities need to import most of their electricity from their hinterland or from the territory.

Gallery 15.10 Urban electricity production

A 265 kW biogas plant supplying electricity for a part of a small town. Kastanienhof, Wadern, Germany, July 11, 2011. Photo: Gerhard Schmitt.

Territorial electricity production

The territory is the place for large scale electricity production. Gigantic dams, nuclear power plants, coal, oil, or gas power plants are distributed throughout the territory in best suited locations, mostly remote from city centres. Wind farms begin to populate portions of Europe, North America and China, both onshore and offshore. Large biogas or waste to energy plants collect the necessary energy sources and produce electricity centrally. Yet the leftovers of the production are a problem everywhere.

Network electricity production

The electricity grid increasingly transcends national borders, and has already crossed continents. There are powerlines between Africa and Europe, or between Asia and Oceania. This increasingly opens the opportunity for network electricity production. The most well-known art the Desertec initiative in northern Africa which would be able to supply more than one fifth of Europe‘s electricity needs, or the gigantic Grenatec network reaching from Australia through the ASEAN countries to China and beyond.

Building electricity storage

Building electricity storage is in its infancy, although it has been a topic of active research since the 1950s. Batteries are the most obvious possibility, but also scaled-down versions of the large-scale energy storage devices of thinkable, such as compressed air or water tanks on top of high-rise buildings. Building electricity storage will become increasingly important as a measure to reduce peak loads on the grid, converting buildings into smart elements in the smart grid of the future.

Urban electricity storage

Cities and urban systems have more effective ways to store energy to be converted back almost loss free into electricity. They can use city internal lakes or compressed air tanks, but through incentives and legislation they could increasingly use the batteries in electric vehicles as a temporary electricity storage that could reduce the load on the system significantly. Yet more then storing energy, cities will have the opportunity to balance the energy use in a smart grid by smart pricing.

Territorial electricity storage

On the territorial scale, water is probably the most efficient way to store energy to be converted back into electricity on short notice. This involves pumping water into a reservoir‘s in times of an electricity surplus in the great, and retrieving the energy in form of electricity in times of high demand. Switzerland, Norway, and Germany are actively using this technology on the large-scale. Also, high-pressure underground air storage is thinkable.

Network electricity storage

As it is difficult on a large scale to store electricity directly, network electricity storage involves the transformation and storage of energy that can easily be reconstructed into electricity. This involves, like into return electricity storage, the use of dams and lakes, but also the production of hydrogen or methane with excessive availability of energy sources at times when there is no demand for electricity. These sources can store the energy diet is then used to rapidly transform it into electricity.

Gallery 15.11 Network electricity storage

Sihlsee close to Einsiedeln, Switzerland, as a network electricity storage device with a capacity of 245 MW. June 26, 2011. Photo: Gerhard Schmitt.

Reflections on electricity – by Matthias Berger

When categorizing the electricity landscape (What is electricity?) from a hierarchical point of view, as it is done in the following chapter, one has to differentiate where electricity is being used (Sections 1-4), how electricity is been transmitted and distributed (Sections 5-8), it is been produced (Sections 9-12), and eventually stored (Sections 13-16). Somehow orthogonal to this view energy is usually described by its source, the primary energy carrier, the conversion into intermediate or final energy carrier and its sectorial end-use (Analysis of energy consumption by specific use). The deficit of the latter is clearly the missing link to the built environment and to the territorial as well as topological organization. Therefore, the hierarchical view shall enable a proactive integration of electricity into urban planning.

Pics: 05 Sankey [BfE], 06 Consumption [MBerger]

Electricity is today's most advanced form of energy. It is highly versatile and can efficiently be converted into the desired end-use, e.g. as mechanical energy in a tramway, heat in a furnace for melting aluminium, or light in a bulb. As well is the distribution and transmission of electricity extremely low-loss, whereas crude oil, gasoline or wood have to be carried by mass and deliver energy by their energy density. Electricity is carried as alternating current (AC) in cables or overhead lines not by directed movements of electrons, but as the electromagnetic field per se. This field is often discredited for negative influence on human health or well-being (Elektrosmog). Nevertheless, neither electrical power distribution nor wireless telecommunication might work without fields, since they are the very principle of electricity and information transmission. The most important disadvantage of electricity is that we lack a proper storage device, by means of storage capacity and cycle efficiency. A lithium-ion battery for instance has a high efficiency but small storage capacity, whereas pumped hydropower behaves vice versa. In consequence electricity production has to follow the actual demand very precisely.

Pics: 01 Grande Dixence [www.elca.ch], 02 Installations hydroélectriques de la Grande Dixence [GNU], 03 Demand curve Baden Dättwil [MBerger], 04 EPEX price 1 year [MBerger].

As we continuously substitute traditional energy use by electricity and find more and more innovative applications demanding electricity, the consumption is rising. The total primary energy supplies' (TPES) trend in contrast is kept constant through the last three decades. Energy intensive industry has been outsourced to countries with lower energy prices, lower labour costs and less restrictive environmental regulations. Together with the efficiency gain due to the substitution of traditional energy use and the technological progress requiring less energy in consumer products the energy demand has been stabilized.

Even the most efficient electricity transmission produces losses in form of heat due to the conductor’s ohmic resistance. In steady operation the natural or artificial cool capacity determines the maximum bearable load, which is much high for overhead lines compared to underground cables. Cables need, other than overhead lines, electrical insolation to the ground, which all in all makes cables ten times more expensive per length. Special cases for far distance electricity transmission are underwater cables, when overhead lines are impossible. On land transmission is never done by cables due to costs. About 30-40% of the total end-user’s electricity costs before tax and subsidies are for transmission. Zentral vs dezentral.

Pics: 07 HV Japan [MBerger]

Why we need interconnected grids instead of island operating systems. (Swissgrid)

Pics: 08 Variation_of_utility_frequency [GNU], 10 ENTSO-E [http://energy.wikidb.info/]

In the territorial scale electricity production might compete with traditional land use, be it agriculture, forestry, or nature reserves. Solar electricity production outside of cities is an exclusive land use. No intensive agriculture can be combined with PV; hence pasture is possible, when the modules are not covering the entire ground. Wind farms can easily combined with intensive agriculture, since the harvest of wind by rotor blades start far above the ground and does not influence work below. The required surface area covered by the tower of the wind mill is almost negligible. So far, wind power is the technology of choice for renewable energy in Europe. The visible impact and the local noise emissions are a nuisance for some people. Nevertheless, the environmental impact is rather small and the return of invest in capital and energy comparatively high. Hydropower is similar to PV a huge consumer of land. Mixed used is sometimes possible, as for recreational activities. Additional benefits from hydro power are usually prevention of flooding and fresh water supply.

Pics: 13 Solarwald [MBerger], 14 Windpark [MBerger], 15 EROI [GNU]

The origin of electricity use in Switzerland was, as in many other countries in the late 19th century, lighting and the production of mechanical power. Rich on running waters, hydropower became the natural source for electricity production. Standardization of transmission voltages, physical properties of the components like plugs and wires, and harmonization of prices was accelerated by the increasing demand for electricity. The primarily clean source of hydro and nuclear power are still today the spine of Switzerland’s energy supply. Whether or not nuclear energy is desirable is an open question and subject to ongoing public debates.

The efficiency of scale is the main driver resulting in even larger power plants: the bigger a plant is, the more efficient and therefore cheaper per unit of power the production will be.

Pics: 11 Gugerli Redeströme [ETH], 12 Kupper Kaiseraugst [ETH]

Section 2

Photovoltaics

PHOTOVOLTAIC INDUSTRY

The photovoltaic industry is a new industry and has grown in double-digits since the beginning of the new millennium. In several countries, the cost of producing electricity from the photovoltaic elements has reached parity with other energy transformation technologies, such as natural gas, nuclear or oil. Yet while most experts were monitoring closely development of production costs, others had their doubts about the enormous amount of fossil energy that would go into the production of the actual photovoltaic modules.

Yet the shakeout within the industry after 2010 has led to the necessity to reduce the energy input into the production of photovoltaic modules drastically which will lead to the fact that after 2015 the net clean electricity production from photovoltaics worldwide will be a reality.

As for doubletake season a very special technology and crucial for the advancement of the use of alternative energies, we dedicate a section to it. The principle has been known for decades, and first large-scale implementations are current in Germany and California already in the 70s and 80s of the last century. But it was not until the German government implemented specific incentives for the production of electricity and it‘s guaranteed purchase price back to the utilities that the installation of football tykes took off. Quickly, Germany became a leader both NT production of photovoltaic elements, and its widespread installation. While after the first decade of the 21st century factories in China were able to produce and sell photo tag modules at a lower price than any other country, most of the football tight production companies in Germany went bankrupt. However, the installation of photovoltaic elements based on the attractive incentive by the government to produce energy continued. In 2013, 40% of the world is full double tyke production area was installed in Germany, with other countries catching up quickly.

The promoters of photovoltaic had a clear agenda. The opponents argued successfully and often, that the production of the foot will take modules will take more energy than it would ever produce. Yet only in 2013, conclusive studies appeared that after 2015 the net energy bands worldwide should be positive (http://news.stanford.edu/news/2013/april/pv-net-energy-040213.html).

Chapter 16

System: Territory

The territory forms a system of its own. It is composed of urban systems and their hinterlands, which in turn consist of building systems and their infrastructure. The territorial system is made of natural and man-made components. It is also an intellectual system that changes its character and boundaries over time. The information territory is the metaphor that connects it information architecture and the information city.

Section 1

Territories

DEFINITION

A territory describes an area within natural or artificial boundaries. In the context of the human habitat, we consider two perspectives: From the view point of the city, every human settlement is surrounded by territory. From a global perspective, a territory contains settlements, cities, and infrastructure connecting them.

The term territory covers expressions related to countries, political systems, economic units, or human behaviour. It also refers to the area that animals request for their own habitat and which they defend against others.

We extend the definition of the urban system to that of the territorial system in a similar way as we extended the definition of the architectural system to the urban system. We consider that a territory can be described as a metabolic system in analogy to a city‘s metabolism or in analogy to a building‘s metabolism.

Political territories come and go. Physical territories with their mountains, valleys, rivers, fauna, flora, cities and other human made infrastructure are normally longer lasting. The size of the territory changes with the perception of the planners or inhabitants. While the citizens of Russia or Brazil could consider their territory as almost endless, the citizens of Luxembourg or Singapore are very well aware of the precise limits of their territory.

The territory includes land, sea, rivers, air, and underground. Within this multidimensional space, cities and human infrastructure are located. Humans have created more or less artificial territorial boundaries on land, sea, and sky. The physical territory is relatively stable over time, if we do not consider time spans exceeding hundreds of thousands of years.

Humans have organised the territory in many ways. Politically, they draw boundaries, declare everything inside their own, and defend this territory against other nations. The boundaries can be physical on land – as the wall across Germany between the East and the West of the country demonstrated – or they can be invisible, but enforced by defending coordinates in the sea surrounding countries or the air space above countries. With the exception of Antarctica, all continental territories are claimed and dotted with cities and human settlements of varying density. An intense transportation of people and goods occurs between those settlements in the territorial lands, sea, and air.

Territory: Relevance for the city

RELEVANCE FOR THE CITY

In planning or developing a city, knowledge of the territory is crucial for two reasons:

1. The planner needs to understand what the citizens and the city can take from or give to the territory:
    - Area of influence (import): where do citizens come from, where do goods come from
    - What can the city offer to the territory (export): know-how, finances, culture
2. The planner needs to understand the territorial decision makers‘ view on the city:

Chapter 17

The City as an Island

The boundary between the city and its surrounding countryside is dynamic and constantly changing. The walls surrounding cities in all cultures were separating the insiders from the outsiders, the citizens from the intruders, the consumers from the producers. Today‘s cities are dynamic systems wh aere physical boundaries have mostly disappeared. Yet seen from far away, or from the perspective of information architecture, cities have become islands connected by fragile strings: islands of heat, islands of information, islands of CO2 production, islands of culture, islands of mobility.

Section 1

City characters

CITY CHARACTERS

1. **The hot and noisy city**
2. **The cool and calm city**
3. **A scenario for a cooler and calmer city**

The hot and noisy city

Seen from a northern perspective, hot and noisy cities are often associated with the South. Yet the temperature in the city is not only determined by its geographic location, but increasingly by the way the city lives. The temperature of the city and its quarters throughout the day and throughout the years can be measured. In temperate climates, cities are usually slightly warmer than the surrounding area, which is often seen as comfortable during the night and especially in winter, when this condition helps to save heating costs. The noise level in the city can be measured as well different age groups are more less influenced by noise, but it is undisputed that constant noise and especially at night are detrimental to human health this has led in Western countries at high levels to heated debates and both planning and scheduling actions around airports. Just enough noise in just the right quarters is seen as a sign of liveliness and quality, and as such contributes to the livability of a city. yet looking at cities ranked highest for livability on a global scale, none of the hot and noisy cities can be found in top positions.

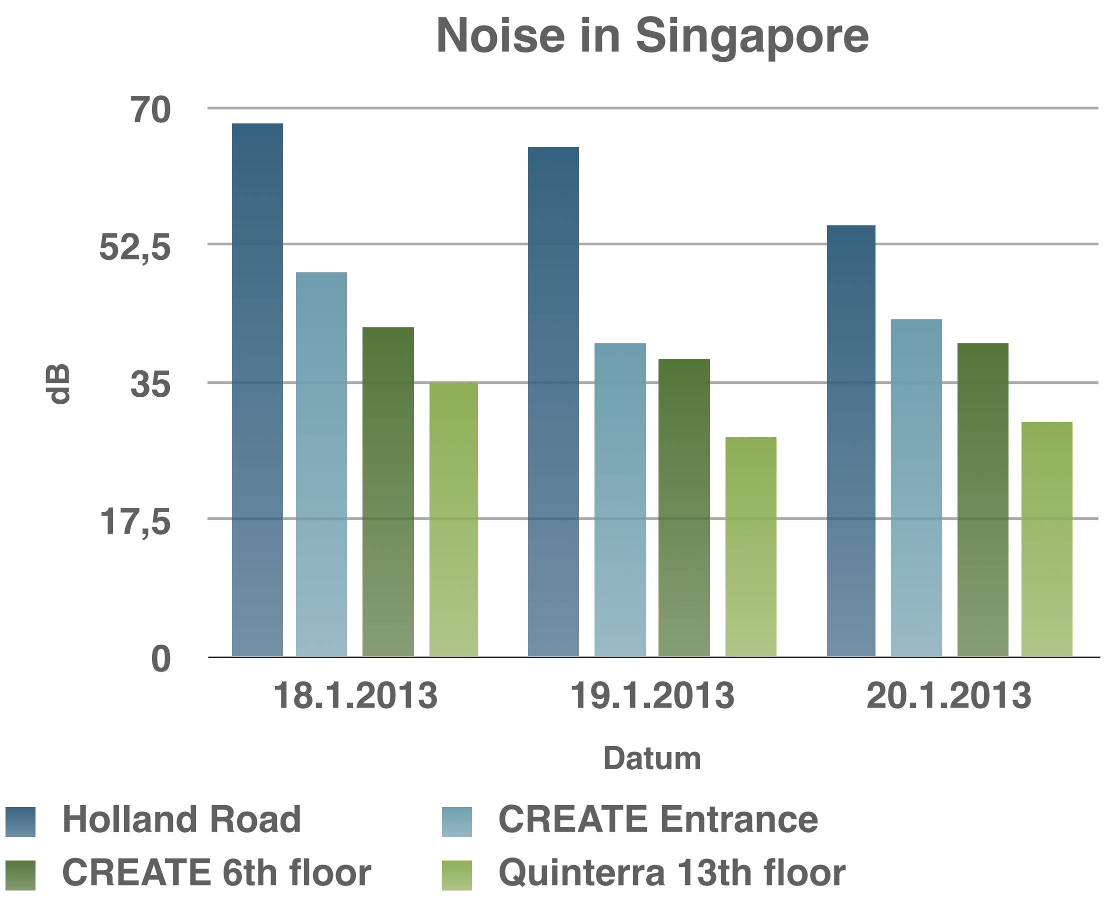
The cool and calm city

Cool and calm cities are often associated with a high quality of living and productivity. If this is a desirable property of the city, is it possible to build cool and calm cities in the tropics, or to convert hot and noisy cities towards lower temperatures and reduced noise levels in order to increase livability? And what would it take to achieve these goals? Looking at the Asian island city of Singapore might give some answers.

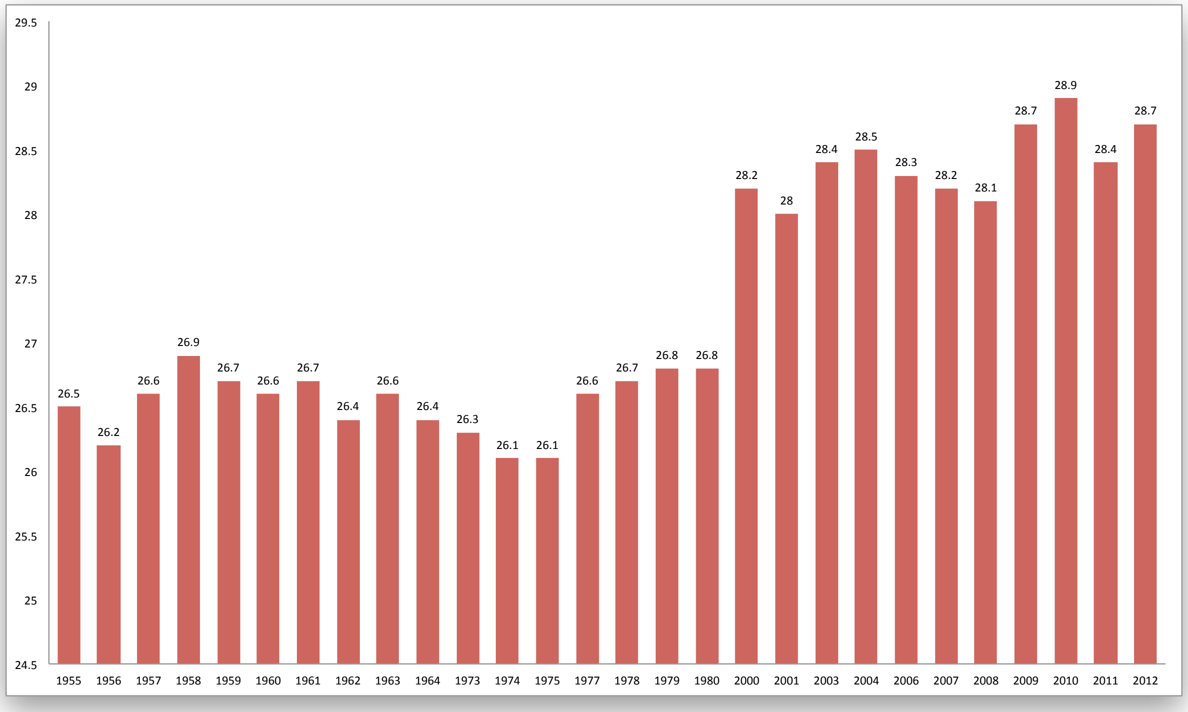
Sources of noise

http://www.gcaudio.com/resources/howtos/loudness.html

On the large scale, airplanes and particularly busy airports are a constant and prominent source of noise from above. Thunderstorms contribute to large-scale noise as well and can have a significant impact if they occur frequently – in Singapore more then 150 times a year. Above the ground, the constant hum



of external air-conditioners can create quite a noise profile in the city. On the ground, cars are the most prominent contributors to **city noise**. Up to a certain speed the engines are louder than the wheels, above a certain speed the tyres generate more noise than the engines. Inside the building, the constant noise of the air conditioning systems and ventilation of different computing and household equipment are most prominent.



Sources of heat

The main source of heat, of course, is the sun. Airplanes and airports contribute an increasing amount to urban heat. Air conditioning systems on, at, and around buildings are also contributing. Industrial areas and ports are large sources of heat. Cars, trucks, buses and subways add a significant amount.

A scenario for a calmer and cooler city

Imagine a situation in which we try to convert a hot and noisy city into a cool and calm city. Which actions are necessary, how costly would they be, what advantages would they have, and how can we make sure that they would have the expected effects in the time allocated? To answer this question, we need to understand the interactions between all factors responsible for heat and noise and the city, we need to build a model, and we need to simulate the effects of changing each factor.

Reducing heat in the city

Reducing the heat in the city is important, because above a certain temperature Range, human action and human work becomes difficult. This is increasingly the case in Singapore, and the mechanical systems used to reduce the seat for the individual are producing more heat for the overall city. Looking at the sources, the actions could be as follows: increase the reflectivity of buildings, add exterior shading devices, improve the insulation of walls and windows, and increase the efficiency of every single electrical device used in the building; move the airport to a location where the wind carries away the heat from the city, allow only fuel efficient air planes and optimise the path they take for starting and landing. Replace all combustion engines in cars with electrical drives so that minimum heat is generated where the cars are driving. Generate the necessary electricity with renewable resources far enough away from the city to not increase its temperature.

Reducing the noise in the city

Reducing the noise in the city could have very positive impact on the health of the citizens and would increase the livability of the city. Optimised starting and landing paths for more fuel efficient and thus quieter and fewer air planes is one possibility. Replacing or better eliminating individual air-conditioners from buildings and combining them in central systems would be a small-scale action. Switching from combustion engines to electrical drives would add significantly to reducing noise in the city. Placing noisy and polluting factories away from the city would be the most obvious action to take.

Chapter 18

Exercises

This chapter has 2 purposes. It gives the opportunity to revisit the most important thoughts presented in this book, to reflect on them, and to set them in relation with other topics. It also gives the opportunity to project the lessons learnt into the future: by following the trends established over the previous years, decades or centuries; or by developing quantitatively well founded or speculative design scenarios. Those might become parts of successive editions of this book.

Section 1

Exercise 1

BUILDING SCALE

Buildings contain information we do not see, but which can be made visible. This information might be important. It could, for example tell us about the energy embodiment of the material, its toxic components, the energy needed to mine the materials, to ship them, to process them, and to assemble them into components for a construction object.

The exercise might also demonstrate how little we know about the materials we are using in design and that surround us on a daily basis. As architects, we should know about the big picture and be able to make suggestions to clients on the basis of knowledge.

A third effect of the exercise will be that we shall try to identify the most CO2 intensive and the most sustainable object or material in the building.

Making the invisible visible - Information

Consider the HIT building at the ETH Zürich Science City campus. Choose a building component from the exterior or the interior of the building. Try to go as deeply as possible into the history, the presence, and the future of this component and show its impact on the past, the presence and the future in terms of different criteria. This could be the stocks and flows of material, of energy, of water, of finances, of landscape, or of information. Take a photograph, make a sketch and answer precisely the following questions:

- Which information in terms of stocks and flows is inside the material that you cannot see, but which you know is important?
- Propose the most appropriate and effective way to visualize this information
- Describe the most important information in the room or building that you cannot visualize

As an alternative, describe qualitatively and quantitatively the closest relation between an INFORMATION architecture structure, such as a data warehouse, and physical INFORMATION ARCHITECTURE and/or INFORMATION CITY planning, and show the limits of the analogy.

Hand in until March 11 to koltsova@arch.ethz.ch

Section 2

Exercise 2

URBAN DESIGN SCALE

The liveability of a city describes one of its main qualities. The urban design scale contains many characteristics for the liveability of a city. International organisations have established criteria that measure and compare cities and their liveability. Examples are:

- **The Global Liveable Cities Index**
- **The EIU's Global Liveability Report**
- **Mercer's Quality of Living Survey**
- **Monocle's Most Liveable Cities Index**
- Ranking the Liveability **oft the World's Major Cities**

Factors of liveability

Livability is one of the key characteristics that every city and urban system is struggling for. The exercise has 3 parts:

I. List the most liveable cities that you know, building on your own experience and judgement, with the most liveable city at the top of the list

II. Describe in your own words 5 characteristics for the livability of a city and order them with the most important at the top of the list 5th

III. Draw a diagram depicting the connections between those characteristics. Express the importance of the connections by graphical means

See this as a personal design exercise. You do not have to follow the official rankings for the livability of cities, but you should know the criteria they apply.

Exercise 3

TERRITORIAL SCALE

Territories interact with cities and urban systems, if we consider them as entities with a metabolism and that they are functioning in the analogy to the stocks and flows model. Territories contain cities, cities contain buildings. Yet they do not form a hierarchical system any more, as the interaction between buildings influences the city as much as the interaction between cities influences the territory.

We must question the traditional definitions of buildings, cities and territories, as the novel non-urbanised high-density settlements will significantly influence our future habitat, as well as the architectural and urban design profession.

Thinking against the current - non-urban cities

In the past, there were strong boundaries between the city and its surrounding territory, the so-called hinterland. The separation between the city, the villages and the countryside was clear, and so was the hierarchy between them.

This situation has changed drastically with the ubiquitous distribution of information technology, particularly the mobile phone and its associated services. Interestingly, the possibility to work at home has changed the life of Swiss citizens, as well as Indian citizens. As the boundaries of the city have disappeared, urbanized systems without cities, non-urbanised, high-density settlements and other unconventional forms of habitat are emerging rapidly throughout the world. Identify and prepare the following:

- Identify and describe two attractive non-urban, non-city settlements which nevertheless show characteristics of an urban settlement
- Identify and describe the most important stocks and flows entering and leaving this area
- Describe the special quality and potential of these settlements for architects and urban designers

Chapter 19

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Construction

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CITE AS: (Raphael and Smith 2013)

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Non-Scientific Publications

‘Singapore-ETH Centre features collaborative wall to enhance discussions’, System Integrations Asia, December-January 2013.

Publications in Progress

Papadopoulou, Maria, Benny Raphael, Ian F.C. Smith and Chandra Sekhar (2013). 'Sensor Placement for Predicting Airflow Around Buildings to Enhance Natural Ventilation', IAQ 2013 Conference, Environmental Health in Low-Energy Buildings, Vancouver, British Columbia, Canada (in review).

Roman, Miro (2013). ‘Four Chairs and all the others / EigenChair - Data Driven Design’, eCAADe 2013 (in review).

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Chapter 20

The Course

Spring Semester 2013 @ ETH Zürich & ETH Singapore: The course on Information Architecture and Future Cities starts on February 18 in Zürich and Singapore.

Gallery 20.1 Voices on city life in the newspapers

Information Architecture and Future Cities

Lecture I, HIT F22

Information Architecture of Cities

The elective course 'Information Architecture of Cities' opens a holistic view on existing and new cities, with focus on Asia. The goal is to better understand the city by going beyond the physical appearance and by focusing on different representations, properties and impact factors of the urban system. On the one hand, we explore the city as the most complex human-made organ¬ism with a metabolism that can be modeled in terms of stocks and flows. On the other hand, we investigate data-driven approaches for the development of the future city, based on crowd sourcing. In the course 'Information Architecture of Cities' you will learn to see the consequences when information space and physical architec¬ture merge. The first part of the course describes origins, state-of-the-art, and applications of information architecture and simulation. Both rapidly gain importance in the design of buildings, cities and territories. In the second part, we will interactively apply the findings to case studies in Eu¬rope and Asia. As course requirement, there will be three short exercises.

18-02-2013	**Einführung und Überblick.** Introduction and Overview
25-02-2013	**Das System Gebäude – Konstruktion.** Building as a System – Construction
04-03-2013	**Das System Gebäude - Habitat.** Building as a System - Habitat
11-03-2013	**Das System Gebäude – Energie.** Building as a System - Energy (Guest lecture by Marcel Brülisauer, PhD, Singapore-ETH Centre)
18-03-2013	Seminarweek (no lecture)
25-03-2013	**Das System Stadt - Materialflüsse.** City as a System – Material Flows
01-04-2013	Easter Monday
08-04-2013	**Das System Stadt - Entwurf.** City as a System - Design (Guest lecture by Carles Cortadas, B Barcelona Consulting)
15-04-2013	**Das System Stadt - Soziologie.** City as a System – Social Science
22-04-2013	**Das System Territorium - Organisation.** Territory as a System - Organization (Guest lecture by Dirk Hebel, Assistant Professor, Singapore-ETH Centre)
29-04-2013	**Das System Territorium - Mobilität.** Territory as a System - Mobility
06-05-2013	**Das System Territorium – Landschaft und Wasser.** Territory as a System - Landscape and Water (Guest lecture by Milica Topalovic, Assistant Professor, Singapore-ETH Centre)
13-05-2013	**Die Simulationsplattform.** The Simulation Platform

Reading requirements:

Yellow Book

iA Brochure

Lecture 1, February 18, 2013

Introduction and motivation

Lecture 2, February 25, 2013

The building as a system – construction

Explanations on the technology of the course

Review of lecture 1: introduction and motivation

Information ARCHITECTURE

INFORMATION architecture (interview with Prof Dr Thomas Gross)

INFORMATION ARCHITECTURE (the Value Lab)

Information MATERIAL

Information CONSTRUCTION

Introduction to exercise1

Lecture 3, March 4, 2013

The building as a system – constructing habitat

Gerhard Schmitt and Fabio Gramazio

Knowledge, information, and data needed to construct a habitat

Input from Prof Fabio Gramazio, Singapore

Questions and feedback from lecture 2

Questions and feedback for exercise 1

Lecture 4, March 11, 2013

The building as a system – energy

Gerhard Schmitt and Marcel Brülisauer

Selected results from exercise 1

Input from Marcel Brülisauer, Singapore

Questions and feedback from lecture 3

Announcement exercise 2

Lecture 5, March 25, 2013
The City as a system - material

Gerhard Schmitt

Selected results from exercise 1

Stock and Flows in Cities

Energy: stocks and Flows

Material: Stocks and flows

Introduction of exercise 2

Lecture 6, April 8, 2013
The City as a system - Design

Gerhard Schmitt

Carles Cortadas, B Barcelona Consulting

Design: Stocks and Flows

Guest lecture

Questions Exercise 2

Lecture 7, April 15, 2013
The City as a system - Urban Sociology

Gerhard Schmitt

Urban System Design

Urban Sociology

Feedback to Exercise 2

Lecture 8, April 22, 2013
Territory as a system - Organization

Gerhard Schmitt in Shanghai

Dirk Hebel

Introduction to exercise 3l

Lecture 9, April 29, 2013
Territory as a system - Mobility and Transportation

Gerhard Schmitt

Alexander Erath

Explanations exercise 3

Lecture 10, May 6, 2013

Territory as a system - Landscape and water, territorial planning

Gerhard Schmitt

Milica Topalovic

Explanations exercise 3

Lecture 11, May 13, 2013

Simulation Platform

Gerhard Schmitt

Physical aspects, content aspects, simulations

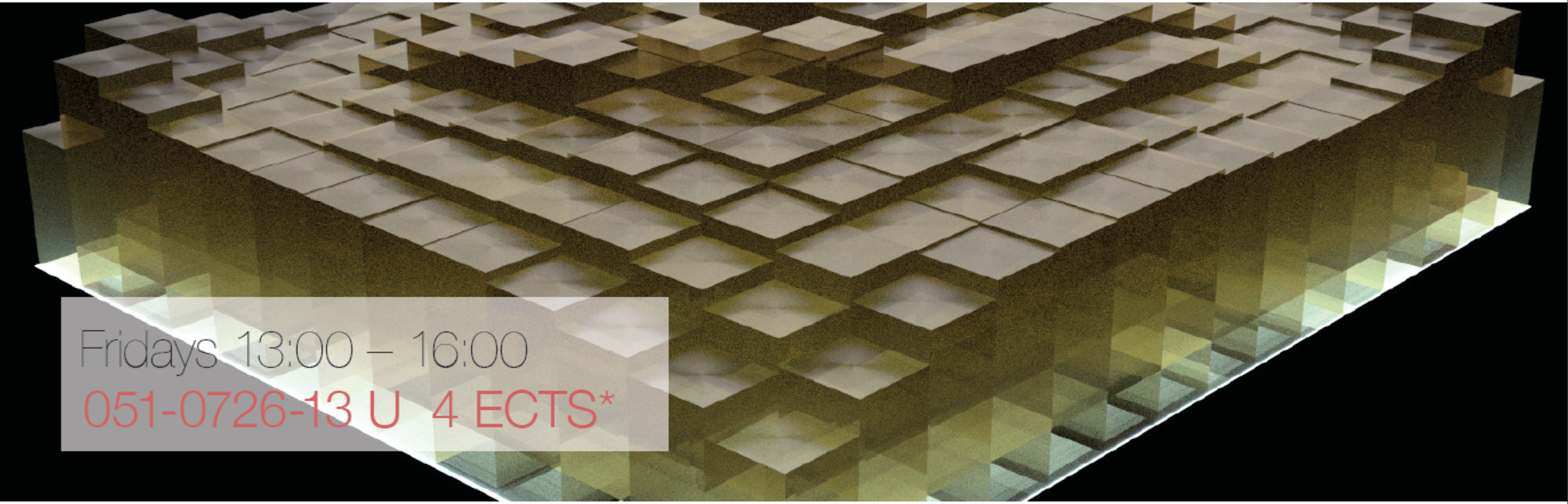
Discussion exercise 3

Supervision:

Prof. Dr. Gerhard Schmitt	schmitt@arch.ethz.ch
Anastasia Koltsova	koltsova@arch.ethz.ch
Dongyoun Shin	shin@arch.ethz.ch

Chair of
Information
Architecture

Information Architecture



Visualize ComplexCity

Data is beautiful! With this in mind, students learn how to visualize information. Presenting information in an understandable way has the potential to enhance the design process considerably, especially in the concept phase.

The students will learn how to visualize urban-related data in a meaningful way using Blender and Python. The goal is to make raw data visible by the generic means of program code (Python). The resulting visualizations will be incorporated into urban video footage by using animation and rendering tools of Blender.

The weekly course “Visualize ComplexCities” investigates the potential of the visualization methods provided by Blender for urban design challenges. The final presentation of the student works will take place in the Value Lab.

The course will start on February 11th with an intense block course on the basics of Blender. You will learn learn how to animate, model, texturize, render. Furthermore we will have a look into motion tracking, the compositor workflow and the game engine of Blender. The aim is to know the software before we start scripting with it.

The case study area is Zurich. You will create video footage of an neighborhood that corresponds with your data and merge them together using Blender and Python. No previous programming knowledge is required.

Where: HIT H12
When: **INTRO WEEK from FEB 11 to 15**, Fridays 13:00 - 16:00

Supervision:
Dani Zünd, Lukas Treyer

11.02.2013 - 15.02.2013	**1 WEEK:** Blender Introduction (& Basic Film Cutting) Animation, Modelling, [ShapeKeys, DupliFrames, Drivers] Textures, Rendering, Compositing, Motion Tracking, Film Cut
22.02.2012	Programming Language: Python Syntax Overview: From Bits & Bytes to Language: Variables, Arrays/Lists, Loops: rules to make humans and machines understand each other
01.03.2013	Data Organization & Algorithms & Blender Object oriented vs. procedural, simple programming patterns, recursion, Fibonacci & sorting algorithms, shortest path
08.03.2013	Space Syntax From shortest path to space syntax: implementation in Blender and Python
15.03.2013	Segregation & Distribution Models / Open Data Modeling of social segregation in Zurich
22.03.2013	Seminar week
29.03.2013	Good Friday
05.04.2013	Spring Break
12.04.2013	Visualization Development Finalize your idea / rendering
19.04.2013	Visualization Development Finalize your idea / rendering
26.04.2013	Visualization Development Finalize your idea / rendering
03.05.2013	Final presentation of student works in the Value Lab

Acemoglu and Robinson

Daron Acemoglu and James A. Robinson (2012), *Why Nations Fail: The Origins of Power, Prosperity, and Poverty*, Ramdom House

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Verwandte Glossarbegriffe

Drag related terms here

Index Find Term

Chapter 5 - Urban sociology

Chapter 8 - Urban System Design

Alex Lehnerer

Architecture and Urban Design, Homepage http://www.futurecities.ethz.ch/research-modules/assistant-professorship-of-architecture-and-urban-design/ (accessed December 15, 2012)

Verwandte Glossarbegriffe

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Future Cities Preface - Future Cities Preface

Barriers

In parallel computing, a barrier is a type of synchronization method. A barrier for a group of threads or processes in the source code means any thread/process must stop at this point and cannot proceed until all other threads/processes reach this barrier.

Many collective routines and directive-based parallel languages impose implicit barriers. For example, a parallel do loop in Fortran with OpenMP will not be allowed to continue on any thread until the last iteration is completed. This is in case the program relies on the result of the loop immediately after its completion. In message passing, any global communication (such as reduction or scatter) may imply a barrier.

http://en.wikipedia.org/wiki/Barrier_(computer_science)

Verwandte Glossarbegriffe

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Chapter 1 - INFORMATION Architecture

Chen ZHONG

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http://www.futurecities.ethz.ch/people/#09-phd-students

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Chapter 2 - Information city

Christian Schmid

Urban Sociology, Homepage. http://www.futurecities.ethz.ch/research-modules/urban-sociology/ (accessed December 15, 2012)

Verwandte Glossarbegriffe

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Find Term

Future Cities Preface - Future Cities Preface

Chapter 2 - Information city

Christoph Girot and Paolo Burlando

Landscape Ecology, Homepage. http://www.futurecities.ethz.ch/research-modules/landscape-ecology/ (accessed December 15, 2012)

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City noise

„Le bruit est depuis longtemps la principale source de nuisance de la population, en particulier en milieu urbain, et les exigences en matière de confort sonore ne cessent d'augmenter. L'approche de la dimension sonore prend donc une place de plus en plus importante tout au long des processus d'élaboration des projets architecturaux et urbanistiques, tant au niveau de la conception que de la réalisation ou de l'exploitation."

A.-G. Dumont ing. civil (ENAC / ICARE/ LAVOC), Acoustique et mobilité, 2011-2012, Bachelor semestre 6, http://isa.epfl.ch/imoniteur_ISAP/!itffichecours.htm?ww_i_matiere=321157184&ww_x_anneeAcad=2011-2012&ww_i_section=69034007&ww_i_niveau=&ww_c_langue=fr (accessed January 24, 2013)

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Chapter 17 - Energy and exergy

Data

„Data (pron.: /ˈdeɪtə/ day-tə, /ˈdætə/ da-tə, or /ˈdɑːtə/ dah-tə) are values of qualitative or quantitative variables, belonging to a set of items. Data in computing (or data processing) are represented in a structure, often tabular (represented by rows and columns), a tree (a set of nodes with parent-children relationship) or a graph structure (a set of interconnected nodes). Data are typically the results of measurements and can be visualised using graphs or images. Data as an abstract concept can be viewed as the lowest level of abstraction from which information and then knowledge are derived. Raw data, i.e., unprocessed data, refers to a collection of numbers, characters and is a relative term; data processing commonly occurs by stages, and the "processed data" from one stage may be considered the "raw data" of the next. Field data refers to raw data collected in an uncontrolled in situ environment. Experimental data refers to data generated within the context of a scientific investigation by observation and recording.

The word data is the plural of datum, neuter past participle of the Latin dare, "to give", hence "something given". In discussions of problems in geometry, mathematics, engineering, and so on, the terms givens and data are used interchangeably. Such usage is the origin of data as a concept in computer science or data processing: data are numbers, words, images, etc., accepted as they stand.“

http://en.wikipedia.org/wiki/Data

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Chapter 1 - Data, information, knowledge

Chapter 1 - Data, information, knowledge

Datum

Etymology: From Latin data, plural of datum (‘that is given’), neuter past participle of dare (‘to give’). http://en.wiktionary.org/wiki/data#English

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Chapter 1 - Data, information, knowledge

Dirk Hebel

Architecture and Construction, Homepage. http://www.futurecities.ethz.ch/research-modules/assistant-professorship-of-architecture-and-construction/ (accessed February 10, 2013)

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Chapter 9 - Future Cities Laboratory: construction

DOE-2

„Project Status: Legacy

DOE-2 is a computer program for the design of energy-efficient buildings. Developed for the U.S. Department of Energy by Lawrence Berkeley National Laboratory's Simulation Research Group, DOE-2 calculates the hourly energy use and energy cost of a commercial or residential building given information about the building's climate, construction, operation, utility rate schedule, and HVAC equipment.“

http://simulationresearch.lbl.gov/projects/doe2

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Chapter 6 - Types of simulation

Ecotect

„Autodesk® Ecotect® Analysis sustainable design analysis software is a comprehensive concept-to-detail sustainable building design tool. Ecotect Analysis offers a wide range of simulation and building energy analysis functionality that can improve performance of existing buildings and new building designs. Online energy, water, and carbon-emission analysis capabilities integrate with tools that enable you to visualize and simulate a building's performance within the context of its environment.“

http://usa.autodesk.com/ecotect-analysis/

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Chapter 6 - Types of simulation

Electricity

„Electricity is the set of physical phenomena associated with the presence and flow of electric charge. Electricity gives a wide variety of well-known effects, such as lightning, static electricity, electromagnetic induction and the flow of electrical current. In addition, electricity permits the creation and reception of electromagnetic radiation such as radio waves.

In electricity, charges produce electromagnetic fields which act on other charges. Electricity occurs due to several types of physics:

- electric charge: a property of some subatomic particles, which determines their electromagnetic interactions. Electrically charged matter is influenced by, and produces, electromagnetic fields.
- electric current: a movement or flow of electrically charged particles, typically measured in amperes.
- electric field (see electrostatics): an especially simple type of electromagnetic field produced by an electric charge even when it is not moving (i.e., there is no electric current). The electric field produces a force on other charges in its vicinity. Moving charges additionally produce a magnetic field.
- electric potential: the capacity of an electric field to do work on an electric charge, typically measured in volts.
- electromagnets: electrical currents generate magnetic fields, and changing magnetic fields generate electrical currents

In electrical engineering, electricity is used for:

- electric power where electric current is used to energise equipment
- electronics which deals with electrical circuits that involve active electrical components such as vacuum tubes, transistors, diodes and integrated circuits, and associated passive interconnection technologies.

Electrical phenomena have been studied since antiquity, though advances in the science were not made until the seventeenth and eighteenth centuries. Practical applications for electricity however remained few, and it would not be until the late nineteenth century that engineers were able to put it to industrial and residential use. The rapid expansion in electrical technology at this time transformed industry and society. Electricity's extraordinary versatility as a means of providing energy means it can be put to an almost limitless set of applications which include transport, heating, lighting, communications, and computation. Electrical power is the backbone of modern industrial society.[1]

The word electricity is from the New Latin ēlectricus, "amber-like"[a], coined in the year 1600 from the Greek ήλεκτρον (electron) meaning amber, because electrical effects were produced classically by rubbing amber."

http://en.wikipedia.org/wiki/Electricity

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Chapter 15 - Electricity Infrastructure

Exergy

„"Available energy" redirects here. For the meaning of the term in particle collisions, see Available energy (particle collision).

In thermodynamics, the exergy of a system is the maximum useful work possible during a process that brings the system into equilibrium with a heat reservoir.[1] When the surroundings are the reservoir, exergy is the potential of a system to cause a change as it achieves equilibrium with its environment. Exergy is the energy that is available to be used. After the system and surroundings reach equilibrium, the exergy is zero. Determining exergy was also the first goal of thermodynamics.

Energy is never destroyed during a process; it changes from one form to another (see First Law of Thermodynamics). In contrast, exergy accounts for the irreversibility of a process due to increase in entropy (see Second Law of Thermodynamics). Exergy is always destroyed when a process involves a temperature change. This destruction is proportional to the entropy increase of the system together with its surroundings. The destroyed exergy has been called anergy.[1] For an isothermal process, exergy and energy are interchangeable terms, and there is no anergy.

Exergy analysis is performed in the field of industrial ecology to use energy more efficiently. The term was coined by Zoran Rant in 1956,[2] but the concept was developed by J. Willard Gibbs in 1873.[3] Ecologists and design engineers often choose a reference state for the reservoir that may be different from the actual surroundings of the system.[2]

Exergy is a combination property[3] of a system and its environment because unlike energy it depends on the state of both the system and environment. The exergy of a system in equilibrium with the environment is zero. Exergy is neither a thermodynamic property of matter nor a thermodynamic potential of a system. Exergy and energy both have units of joules. The Internal Energy of a system is always measured from a fixed reference state and is therefore always a state function. Some authors define the exergy of the system to be changed when the environment changes, in which case it is not a state function. Other writers prefer[citation needed] a slightly alternate definition of the available energy or exergy of a system where the environment is firmly defined, as an unchangeable absolute reference state, and in this alternate definition exergy becomes a property of the state of the system alone.

The term exergy is also used, by analogy with its physical definition, in information theory related to reversible computing. Exergy is also synonymous with: availability, available energy, exergic energy, essergy (considered archaic), utilizable energy, available useful work, maximum (or minimum) work, maximum (or minimum) work content, reversible work, and ideal work.

The exergy destruction of a cycle is the sum of the exergy destruction of the processes that compose that cycle. The exergy destruction of a cycle can also be determined without tracing the individual processed by considering the entire cycle as a single process and using one of the exergy destruction equations. ---Information found in thermodynamics by Yunus A. Cengel“

http://en.wikipedia.org/wiki/Exergy

(accessed March 10, 2013)

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Chapter 11 - Energy and exergy

Extraction

In their book „Why Nations Fail: The Origins of Power, Prosperity, and Poverty“, Daron Acemoglu and James Robinson identify extraction as the main negative aspect in leading a country to failure. They describe extractive businesses, extractive corporations, extractive governments and extractive countries. None of them enables the long-term growth and sustainability that help nations to survive over long periods of time.

Daron Acemoglu and James Robinson (2012), *Why Nations Fail: The Origins of Power, Prosperity, and Poverty*, Crown Business

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Chapter 5 - Urban sociology

Fabio Gramazio and Matthias Kohler

Digital Fabrication, Homepage. http://www.futurecities.ethz.ch/research-modules/dfab/ (accessed December 15, 2012)

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Fences

„Fencing is the process of isolating a node of a computer cluster or protecting shared resources when a node appears to be malfunctioning.[1][2]

As the number of nodes in a cluster increases, so does the likelihood that one of them may fail at some point. The failed node may have control over shared resources that need to be reclaimed and if the node is acting erratically, the rest of the system needs to be protected. Fencing may thus either disable the node, or disallow shared storage access, thus ensuring data integrity."

http://en.wikipedia.org/wiki/Fencing_(computing))

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Chapter 1 - INFORMATION Architecture

Firewall

„A firewall can either be software-based or hardware-based and is used to help keep a network secure. Its primary objective is to control the incoming and outgoing network traffic by analyzing the data packets and determining whether it should be allowed through or not, based on a predetermined rule set. A network's firewall builds a bridge between the internal network or computer it protects, upon securing that the other network is secure and trusted, usually an external (inter)network, such as the Internet, that is not assumed to be secure and trusted.[1]

Many personal computer operating systems include software-based firewalls to protect against threats from the public Internet. Many routers that pass data between networks contain firewall components and, conversely, many firewalls can perform basic routing functions.[2]“

http://en.wikipedia.org/wiki/Firewall_(computing)

Accessed February 22, 2013

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Chapter 1 - INFORMATION Architecture

Gini coefficient

„The Gini coefficient (also known as the Gini index or Gini ratio) is a measure of statistical dispersion developed by the Italian statistician and sociologist Corrado Gini and published in his 1912 paper "Variability and Mutability" (Italian: Variabilità e mutabilità).[1][2]

The Gini coefficient measures the inequality among values of a frequency distribution (for example levels of income). A Gini coefficient of zero expresses perfect equality, where all values are the same (for example, where everyone has an exactly equal income). A Gini coefficient of one (100 on the percentile scale) expresses maximal inequality among values (for example where only one person has all the income).[3][4] However, a value greater than one may occur if some persons have negative income or wealth. For larger groups, values close to or above 1 are very unlikely in practice however.

It has found application in the study of inequalities in disciplines as diverse as sociology, economics, health science, ecology, chemistry, engineering and agriculture.[5]

Gini coefficient is commonly used as a measure of inequality of income or wealth.[6] For OECD countries, in the late 2000s, considering the effect of taxes and transfer payments, the income Gini coefficient ranged between 0.24 to 0.49, with Slovenia the lowest and Chile the highest.[7] The countries in Africa had the highest pre-tax Gini coefficients in 2008–2009, with South Africa the world's highest at 0.7.[8][9] The global income inequality Gini coefficient in 2005, for all human beings taken together, has been estimated to be between 0.61 and 0.68 by various sources.[10][11]

There are some issues in interpreting a Gini coefficient. The same value may result from many different distribution curves. The demographic structure should be taken into account. Countries with an aging population, or with a baby boom, experience an increasing pre-tax Gini coefficient even if real income distribution for working adults remain constant. Scholars have devised over a dozen variants of the Gini coefficient.[12][13][14]“

http://en.wikipedia.org/wiki/Gini_coefficient

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Chapter 5 - Urban sociology

Global Report on Human Settlements

„The Global Report on Human Settlements provides the most authoritative and up-to-date assessment of conditions and trends in the world's cities and other human settlements. Written in clear non-technical language and supported by informative graphics, case studies and extensive statistical data, these reports are essential tools and references for researchers, academics, planners, public authorities and civil society organizations around the world.

The Global Report on Human Settlements is one of UN-HABITAT's two flagship report series and is prepared under a mandate from the United Nations General Assembly (resolution 34/114). The General Assembly also encouraged " Member States and Habitat Agenda partners to provide support for the preparation of the Global Report on Human Settlements … so as to raise awareness on human settlements issues and to provide information on urban conditions and trends around the world" (resolution 55/194).“

http://www.unhabitat.org/categories.asp?catid=555

Link

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Chapter 10 - Habitat

Hans-Jürg Leibundgut and Arno Schlüter

Low Exergy, Homepage. http://www.futurecities.ethz.ch/research-modules/lowex/ (accessed March 11, 2013)

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Chapter 11 - Energy and exergy

Human habitat

„Any of the conditions in which people live. Also all human settlements in villages, towns or major cities, which require environmental management to provide water, public spaces, remove public wastes, etc. (Source: WRIGHT)

broader terms

human settlement

related terms

Housing“

http://www.eionet.europa.eu/gemet/concept?ns=1&cp=13120

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Inclusion

„Inclusion is an organizational practice and goal stemming from the sociological notion of inclusiveness which is the political action and personal effort but at the same time the presence of inclusion practices in which different groups or individuals having different backgrounds like origin, age, race and ethnicity, religion, gender, sexual orientation and identity and other are culturally and socially accepted and welcomed, equally treated, etc.

Miller and Katz (2002) presents a common definition of an inclusive value system where they say, "Inclusion is a sense of belonging: feeling respected, valued for who you are; feeling a level of supportive energy and commitment from others so than you can do your best work."[1] Inclusion is a shift in organization culture. The process of inclusion engages each individual and makes people feeling valued essential to the success of the organization. Individuals function at full capacity, feel more valued, and included in the organization's mission. This culture shift creates higher performing organizations where motivation and morale soar.

Gasorek (1998) notes her success of instituting diversity and inclusion initiatives at Dun & Bradstreet, a credit-reporting firm.[2] Hyter and Turnock (2006) offer several case studies of engaging inclusion with corporate organizations such as BellSouth, Frito-Lay, Home Depot, and Procter & Gamble.[3]

Roberson (2006) notes that the term inclusion is often coupled with the term diversity and these terms are often used interchangeably, however they are distinctly different.[4] The Institute for Inclusion, a nonprofit organization, has collectively attempted to define inclusion apart from diversity. It has developed a set of core values and general principles and conceives of inclusion as requiring a paradigm shift in human consciousness, awareness, and interaction.[citation needed]

Interactional participation skills are not currently standardized in formal evaluations of communicative competence, and there will probably be much controversy surrounding any proposals to standardize the testing of interactional competence. Nonetheless, we need some set of inclusion guidelines to decide what skills to look for and how to document them. (page 116, Sawzin, 1984)

This study focused on the aspects of Jennie that can be appreciated. "Positive analysis" is a strategy which has much utility in many contexts, but is very much needed in the lives of children and adults with developmental difficulties. There are many opportunities for parents, professionals and neighbors to minimize their fears, and to move from expectations of deviance to acceptances of difference. (page 122, Sawzin, 1984)

Also see for paradigms out of phase, Martin Sawzin, 1981, Paradigmatic Aphasia and An Antidote: Developmentalism"

http://en.wikipedia.org/wiki/Inclusion_(value_and_practice)

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Chapter 5 - Urban sociology

Information

„Information, in its most restricted technical sense, is a sequence of symbols that can be interpreted as a message. Information can be recorded as signs, or transmitted as signals. Information is any kind of event that affects the state of a dynamic system. Conceptually, information is the message (utterance or expression) being conveyed. The meaning of this concept varies in different contexts.[1] Moreover, the concept of information is closely related to notions of constraint, communication, control, data, form[disambiguation needed], instruction, knowledge, meaning, understanding, mental stimuli, pattern, perception, representation, and entropy.“

http://en.wikipedia.org/wiki/Information

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Chapter 1 - Data, information, knowledge

Information architecture

„Information architecture (IA) is the art and science of organizing and labelling data including: websites, intranets, online communities and software to support usability.[1] It is an emerging discipline and community of practice focused on bringing together principles of design and architecture to the digital landscape.[2][page needed] Typically it involves a model or concept of information which is used and applied to activities that require explicit details of complex information systems. These activities include library systems and database development.

Historically the term "information architect" is attributed to Richard Saul Wurman,"[3][page needed] and now there is a growing network of active IA specialists who comprise the Information Architecture Institute.[4]"

http://en.wikipedia.org/wiki/Information_architecture

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Chapter 1 - INFORMATION Architecture

Information cities

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Chapter 2 - Information city

Jantar Mantar

„The jantar mantar is located in the modern city of New Delhi. It consists of 13 architectural astronomy instruments. The site is one of five built by Maharaja Jai Singh II of Jaipur, from 1724 onwards, as he was given by Mughal emperor Muhammad Shah the task of revising the calendar and astronomical tables. There is plaque fixed on one of the structures in the Jantar Mantar observatory in New Delhi that was placed there in 1910 mistakenly dating the construction of the complex to the year 1710. Later research, though, suggests 1724 as the actual year of construction.

The primary purpose of the observatory was to compile astronomical tables, and to predict the times and movements of the sun, moon and planets. Some of these purposes nowadays would be classified as astronomy."

http://en.wikipedia.org/wiki/Jantar_Mantar,_Delhi

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Chapter 1 - INFORMATION ARCHITECTURE

Kay Axhausen

Mobility and Transportation Planning, Homepage. http://www.futurecities.ethz.ch/research-modules/mobility-and-transportation-planning/ (accessed December 15, 2012)

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Kees Christiaanse

Urban Design Strategies and Resources, Homepage http://www.futurecities.ethz.ch/research-modules/urban-design-strategies-and-resources/ (accessed December 15, 2012)

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Knowledge

„Knowledge is a familiarity with someone or something, which can include facts, information, descriptions, or skills acquired through experience or education. It can refer to the theoretical or practical understanding of a subject. It can be implicit (as with practical skill or expertise) or explicit (as with the theoretical understanding of a subject); it can be more or less formal or systematic.[1] In philosophy, the study of knowledge is called epistemology; the philosopher Plato famously defined knowledge as "justified true belief." However, no single agreed upon definition of knowledge exists, though there are numerous theories to explain it. The following quote from Bertrand Russell's "Theory of Knowledge" illustrates the difficulty in defining knowledge: "The question how knowledge should be defined is perhaps the most important and difficult of the three with which we shall deal. This may seem surprising: at first sight it might be thought that knowledge might be defined as belief which is in agreement with the facts. The trouble is that no one knows what a belief is, no one knows what a fact is, and no one knows what sort of agreement between them would make a belief true. Let us begin with belief."

Knowledge acquisition involves complex cognitive processes: perception, communication, association and reasoning; while knowledge is also said to be related to the capacity of acknowledgment in human beings.[2]“

http://en.wikipedia.org/wiki/Knowledge

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Chapter 1 - Data, information, knowledge

Lee Yi Shyan

Giap, T. K., Woo, W. T., Tan, K. Y., Low, L., and Ee L. G. A. (2012) Ranking the Liveability oft he World's Major Cities, World Scientific, Singapore, p IX

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Liveability

Giap, T. K., Woo, W. T., Tan, K. Y., Low, L., and Ee L. G. A. (2012) Ranking the Liveability of the World's Major Cities, World Scientific, 2012, Singapore, page IX

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Chapter 18 - Exercise 2

Low Exergy

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Manto Report

Martin C. Rotach, MANTO — a research project of telecommunication applications for the future information society, Transportation, 1987, Volume 14, Issue 4, pp 377-393

„Abstract

The impact of new technologies has been mostly under-estimated in the past and, as a result, the transitions from one era to another have occurred more or less by chance. The MANTO research project is intended to avoid mischances. So it indicates potential developments in the telecommunications sector and, in particular, investigates their effects upon transport and settlement and also upon society, the economy and the environment. Nevertheless, MANTO does not merely take a look at the future, like the Greek oracle from whom it takes its name; by means of concrete recommendations, MANTO is intended to provide persons in responsible positions with a tool with which they can consciously organise that future. Risky developments are to be precluded in advance while desirable consequences are to be promoted.“

http://link.springer.com/article/10.1007%2FBF00145758

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Chapter 10 - Habitat

Marc Angélil und Franz Oswald

Territorial Organisation, Homepage. http://www.futurecities.ethz.ch/research-modules/territorial-organisation/ (accessed December 15, 2012)

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Memes

„The selected approach also introduced the notion of memes to design. British scientist Richard Dawkins first suggested in his book “The Selfish Gene” (Dawkins 1976) that cultural evolution is based on similar mechanisms as biological evolution. Ideas or memes, as the smallest units of memetic evolution tend to replicate by separating themselves from their authors and being picked up by the public. The Phase(x) setup tries to apply this theory to architectural content. By splitting a rather complex design process into clearly defined units (the phases), compatible memes6 are generated. The memes are stripped from their authors by being placed into the public realm of the database and can then be copied as digital files by the next author without loss of substance. The attention is focused on how ideas develop under the hands of changing authors, rather than by any single author; the Phase(x) replaces single authorship through collective authorship because all relations between works, authors and timeline are recorded in the database and can be rendered and evaluated.“

acadia’98, Association for Computer-Aided Design in ArchitectureBranko Kolarevic Gerhard Schmitt Urs Hirschberg David Kurmann Brian Johnson

http://faculty.washington.edu/brj/Publications/ACADIA98.PDF

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Chapter 8 - Urban System Design

Milica Topalovic

Architecture and Territorial Planning, Homepage. http://www.futurecities.ethz.ch/research-modules/assistant-professorship-of-architecture-and-territorial-planning/ (accessed December 15, 2012)

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Mobility

„the ability to move or be moved freely and easily: this exercise helps retain mobility in the damaged joints

the ability to move between different levels in society or employment: industrialization would open up increasing chances of social mobility“

http://oxforddictionaries.com/definition/english/mobility

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Chapter 14 - System: Mobility

Chapter 14 - System: Mobility

Modeling

„Scientific modelling is the process of generating abstract, conceptual, graphical or mathematical models. Science offers a growing collection of methods, techniques and theory about all kinds of specialized scientific modelling. A scientific model can provide a way to read elements easily which have been broken down to a simpler form.

Modelling is an essential and inseparable part of all scientific activity, and many scientific disciplines have their own ideas about specific types of modelling. Modeling involves abstraction, simplification, and formalization, in light of particular methods and assumptions, in order to better understand a particular part or feature of the world, and to potentially intervene [1] [2]. There is also an increasing attention to scientific modelling[3] in fields such as philosophy of science, systems theory, and knowledge visualization.“

http://en.wikipedia.org/wiki/Scientific_modeling

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Chapter 1 - Information ARCHITECTURE

Richard Saul Wurman

„Richard Saul Wurman (March 26, 1935) is an architect and graphic designer who coined the phrase 'Information Architecture' and is considered to be a pioneer in the practice of making information easily understandable. Wurman has written and designed over 83 books, and created the TED conference, as well as the EG conference, TEDMED and the WWW suite of gatherings, now in development.“

http://en.wikipedia.org/wiki/Richard_Saul_Wurman

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Chapter 1 - INFORMATION Architecture

Sacha Menz

SEC FCL Research Module Housing, Homepage http://www.futurecities.ethz.ch/research-modules/housing/ (accessed January 26, 2013)

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Chapter 10 - Habitat

Senseable City Lab

http://senseable.mit.edu

„The MIT Senseable City Laboratory aims to investigate and anticipate how digital technologies are changing the way people live and their implications at the urban scale. Director Carlo Ratti founded the Senseable City Lab in 2004 within the City Design and Development group at the Department of Urban Studies and Planning, as well as in collaboration with the MIT Media Lab. The Lab's mission states that it seeks to creatively intervene and investigate the interface between people, technologies and the city. Recent projects include "The Copenhagen Wheel"[1] which debuted at the 2009 United Nations Climate Change Conference, "Trash_Track" [2] shown at the Architectural League of New York and the Seattle Public Library, "New York Talk Exchange" [3] featured in the MoMA The Museum of Modern Art, and Real Time Rome included in the 2006 Venice Biennale of Architecture.“

http://en.wikipedia.org/wiki/MIT_Senseable_City_Lab

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Chapter 2 - Information city

Server farms

„A server farm or server cluster is a collection of computer servers usually maintained by an enterprise to accomplish server needs far beyond the capability of one machine. Server farms often consist of thousands of computers which require a large amount of power to run and keep cool. At the optimum performance level, a server farm has enormous costs associated with it, both financially and environmentally.[1] Server farms often have backup servers, which can take over the function of primary servers in the event of a primary server failure. Server farms are typically colocated with the network switches and/or routers which enable communication between the different parts of the cluster and the users of the cluster. The computers, routers, power supplies, and related electronics are typically mounted on 19-inch racks in a server room or data center.“

http://en.wikipedia.org/wiki/Server_farm

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Chapter 1 - INFORMATION Architecture

Simulation

In science, simulation is becoming an important method in addition to theory and experiment. In architecture, simulation has been used for decades, mainly to predict structural behavior, energy consumption or life cycle cost. In urban design, simulation is gaining importance in exploring future scenarios in pedestrian movements, vehicle mobility, or land use alternatives. And in territorial planning, simulation helps to predict the functioning of large-scale operations in transportation or energy supply.

„Simulation is the imitation of the operation of a real-world process or system over time.[1] The act of simulating something first requires that a model be developed; this model represents the key characteristics or behaviors of the selected physical or abstract system or process. The model represents the system itself, whereas the simulation represents the operation of the system over time.

Simulation is used in many contexts, such as simulation of technology for performance optimization, safety engineering, testing, training, education, and video games. Training simulators include flight simulators for training aircraft pilots to provide them with a lifelike experience. Simulation is also used with scientific modelling of natural systems or human systems to gain insight into their functioning.[2] Simulation can be used to show the eventual real effects of alternative conditions and courses of action. Simulation is also used when the real system cannot be engaged, because it may not be accessible, or it may be dangerous or unacceptable to engage, or it is being designed but not yet built, or it may simply not exist.[3]

Key issues in simulation include acquisition of valid source information about the relevant selection of key characteristics and behaviours, the use of simplifying approximations and assumptions within the simulation, and fidelity and validity of the simulation outcomes.“

http://en.wikipedia.org/wiki/Simulation

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Simulation Platform

Simulation Platform, Homepage http://www.futurecities.ethz.ch/research-modules/simulation-platform/ (accessed December 15, 2012)

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Singapore White Paper 2030

http://population.sg (accessed February 11, 2013)

http://www.mnd.gov.sg/landuseplan/ (accessed February 11, 2013)

http://www.todayonline.com/singapore/visualising-singapore-2030-and-beyond (accessed February 11, 2013)

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Chapter 7 - City projection

Social equality

„Social equality is a social state of affairs in which all people within a specific society or isolated group have the same status in certain respects. At the very least, social equality includes equal rights under the law, such as security, voting rights, freedom of speech and assembly, property rights, and equal access to social goods and services. However, it also includes concepts of economic equity, i.e. access to education, health care and other social securities. It also includes equal opportunities and obligations, and so involves the whole of society.

Social equality requires the absence of legally enforced social class or caste boundaries and the absence of discrimination motivated by an inalienable part of a person's identity. For example, sex, gender, race, age, sexual orientation, origin, caste or class, income or property, language, religion, convictions, opinions, health or disability must not result in unequal treatment under the law and should not reduce opportunities unjustifiably.

Social equality refers to social, rather than economic, or income equality. "Equal opportunities" is interpreted as being judged by ability, which is compatible with a free-market economy. A problem is horizontal inequality, the inequality of two persons of same origin and ability.

Perfect social equality is considered by Liberals to be an ideal situation that, for various reasons, does not exist in any society in the world today. The reasons for this are widely debated. Reasons cited for social inequality commonly include economics, immigration/emigration, foreign politics and national politics. Also, in complexity economics, it has been found that horizontal inequality arises in complex systems.“

http://en.wikipedia.org/wiki/Social_equality

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Chapter 5 - Urban sociology

Social inequality

„Social inequality refers to relational processes in society that have the effect of limiting or harming a group's social status, social class, and social circle. Areas of social inequality include access to voting rights, freedom of speech and assembly, the extent of property rights and access to education, health care, quality housing, traveling, transportation, vacationing and other social goods and services. Apart from that it can also be seen in the quality of family and neighbourhood life, occupation, job satisfaction, and access to credit. If these economic divisions harden, they can lead to social inequality.[1]

The reasons for social inequality can vary, but are often broad and far reaching. Social inequality can emerge through a society's understanding of appropriate gender roles, or through the prevalence of social stereotyping. Social inequality can also be established through discriminatory legislation. Social inequalities exist between ethnic or religious groups, classes and countries making the concept of social inequality a global phenomenon. Social inequality is different from economic inequality, though the two are linked. Social inequality refers to disparities in the distribution of economic assets and income, while economic inequality is caused by the unequal accumulation of wealth; social inequality exists because the lack of wealth in certain areas prohibits these people from obtaining the same housing, health care, etc. as the wealthy, in societies where access to these social goods depends on wealth.

Social inequality is linked to racial inequality, gender inequality, and wealth inequality. The way people behave socially, through racist or sexist practices and other forms of discrimination, tends to trickle down and affect the opportunities and wealth individuals can generate for themselves. Thomas M. Shapiro presents a hypothetical example of this in his book, The Hidden Cost of Being African American, in which he tries to demonstrate the level of inequality on the "playing field for blacks and whites". One example he presents reports how a black family was denied a bank loan to use for housing, while a white family was approved. As being a homeowner is an important method in acquiring wealth, this situation created fewer opportunities for the black family to acquire wealth, producing social inequality.[2]

In many developing countries, the increase in the number of NGO's has perpetuated social inequality. The work of NGO's and their expatriate employees and volunteers has "fragmented the local health system, undermined local control of health programs, and contributed to the growing local social inequality".[3] The work of the NGO's disrupts the local health care system by taking control away from the local population. This in turn means access to proper health care for the poor is inefficient, while those who have money can pay for sufficient medical care. This increases the 'outcome gap' between the people, thereby increasing social inequality. This inequality is the result of various NGO's putting their interests and goals ahead of those of the people they are trying to help, along with struggles between various NGO's working on the same issue.[4]“

http://en.wikipedia.org/wiki/Social_inequality

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Chapter 5 - Urban sociology

Stack

„ • 1a pile of objects, typically one that is neatly arranged:a stack of boxes

• (a stack of/stacks of) informal a large quantity of something:there's stacks of work for me now

• a rectangular or cylindrical pile of hay or straw or of grain in sheaf.

• a vertical arrangement of hi-fi or guitar amplification equipment.

• a number of aircraft flying in circles at different altitudes around the same point while waiting for permission to land at an airport.

• a pyramidal group of rifles.

• (the stacks) units of shelving in part of a library normally closed to the public, used to store books compactly: the demand for items from the stacks

[as modifier]:the new premises provided a reading room and a stack room

• Computing a set of storage locations which store data in such a way that the most recently stored item is the first to be retrieved.“

http://oxforddictionaries.com/definition/english/stack

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Stocks and flows

„Economics, business, accounting, and related fields often distinguish between quantities that are stocks and those that are flows. These differ in their units of measurement. A stock variable is measured at one specific time, and represents a quantity existing at that point in time (say, December 31, 2004), which may have accumulated in the past. A flow variable is measured over an interval of time. Therefore a flow would be measured per unit of time (say a year). Flow is roughly analogous to rate or speed in this sense.

For example, U.S. nominal gross domestic product refers to a total number of dollars spent over a time period, such as a year. Therefore it is a flow variable, and has units of dollars/year. In contrast, the U.S. nominal capital stock is the total value, in dollars, of equipment, buildings, inventories, and other real assets in the U.S. economy, and has units of dollars. The diagram provides an intuitive illustration of how the stock of capital currently available is increased by the flow of new investment and depleted by the flow of depreciation.“

http://en.wikipedia.org/wiki/Stock_and_flow

„...Mapping Sovereign Debt: Find out how much your country owes, to whom – and vice versa. And discover the intricate web of global debt. This application has been designed to display countries‘ present and past levels of national debt as well as debt relations between them. It offers two basic viewing options. You can either build a network of up to six countries, showing individual national debt levels as well as funds owed to, and claimed by, each other. Or you can select an individual country to find out its debt level and then view its five largest creditors. You can also click on a country bubble and find further debt details – for instance, whether the debt in question is carried by the private or public sector, or whether it must be settled in the long-or short term. The bubble size is a relative reflection of the country‘s national debt. The thickness of the in-and outgoing arrows between countries is proportionate to the funds that are owed and claimed respectively. You can use the time slider at the bottom of the screen to create past debt networks, or to chart the development of an individual country‘s debt level. National debt as displayed in this application is defined as consolidated foreign claims of a given countries banks, as reported to the International Bank of Settlements (BIS). Please note that not all countries‘ banks report to the BIS. In fact, only 24 do so. We hope, of course, that the group will expand. Please also note that the figures displayed in the application are different from, for instance, foreign debt, which is made up of government debt plus private (e.g. company) debt, and which is is financed by non-nationals. The BIS's reporting arrangements changed after the first quarter of 1999. As a result, data accessed before this cut-off point will appear different to users – notably more limited. This application is a beta-version, and we would very much welcome feedback on the existing features, as well as suggestions for expanding the application as a whole, in particular by adding new economic indicators.“

http://www.stocks-flows.org

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Chapter 4 - Stocks and flows

SUPat

„Aim of research
Establishing a collaborative platform for the transdisciplinary development of sustainable urban patterns; tools for evaluating urban quality and visualising urban patterns to promote shared objectives.

Expected output

- Documentation of urban typologies
- Guidelines for formative analysis of scenarios in a functional collaboration between science and practice; development of systematically established, relevant regional scenarios
- Quality indicators for sustainable urban patterns
Criteria for urban quality which can be applied to other case studies (procedural modelling)
- Modelling and visualisation tools
- Elaboration of a model for collaborative processes of urban development

Preliminary results
The Limmattal between Zurich and Baden serves as an example of a "normal city" in Switzerland. Green sites in the area are nothing more than space which is not reserved for urban development; there is no productive concept. The "normal city" is defined as non-urban, a fact that is related not only to the actual landscape but also to attitudes: Residents are unwilling to be or become urban. Overall, there is a need for gentle transformation strategies which build upon local patterns and connect the numerous spatial and functional fragments in a plausible way.

SUPat scenarios describe four perspectives focusing on design, technological, economical and ecological aspects of urban development in the Limmattal region.
The scenario "City with Character" presents the Limmattal as a valley with a strong identity, created by a clear sequence of centres and a good mix of land use and architecture. In the scenario "Smart City", the valley positions itself as a cleantech pioneer; it boasts the greatest possible energy efficiency, a high density of services and an optimum modal-split-infrastructure design.

The scenario "Pure Dynamics" does without a joint regional development concept. The valley is shaped by a vaguely defined mix of industrial areas, housing developments, green sites and transport infrastructures with no character of their own. The scenario "Charming Valley" presents the valley as a human ecological system with a strong mix of concentrated developments (informed by modern small-town values) and a productive and resource-rich agriculture.

The research project defines new urban quality as the interaction between human behaviour and the built and non-built environment. The needs and objectives of the population are linked to urban structures (e.g. sufficient open spaces) and their functions (e.g. recreation)“

http://www.nfp65.ch/E/projects/urban_expansion_natural_resources_better_life/Pages/default.aspx

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Systems design

Systems design is the process of defining the architecture, components, modules, interfaces, and data for a system to satisfy specified requirements. Systems design could see it as the application of systems theory to product development. There is some overlap with the disciplines of systems analysis, systems architecture and systems engineering.

http://en.wikipedia.org/wiki/Systems_design

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Chapter 8 - Urban System Design

Takashi Uzawa

Uzawa, Takashi, 1996, Archaeology of the Future City: Mirai Toshi No Kokogaku [Exposition Itinérante, 1996], Tokyo Shimbun, 1996

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Chapter 2 - Information city

TED

„TED (Technology, Entertainment and Design) is a global set of conferences owned by the private non-profit Sapling Foundation, formed to disseminate "ideas worth spreading."

TED was founded in 1984 as a one-of event.[1] The annual conference began in 1990, in Monterey, California.[4] TED's early emphasis was technology and design, consistent with its origins in the Silicon Valley.

The TED main conference is held annually in Long Beach, and its companion TEDActive is held in Palm Springs. Both conferences will move from Long Beach and Palm Springs to Vancouver and Whistler, respectively, in 2014.[5] TED events are also held throughout the U.S. and in Europe and Asia, offering live streaming of the talks. They address a wide range of topics within the research and practice of science and culture, often through storytelling.[6] The speakers are given a maximum of 18 minutes to present their ideas in the most innovative and engaging ways they can. Past presenters include Bill Clinton, Jane Goodall, Malcolm Gladwell, Al Gore, Gordon Brown, Richard Dawkins, Bill Gates, Google founders Larry Page and Sergey Brin, and many Nobel Prize winners.[7] TED's current curator is the British former computer journalist and magazine publisher Chris Anderson.

Since June 2006,[1] the talks have been offered for free viewing online, under Attribution-NonCommercial-NoDerivs Creative Commons license, through TED.com.[8] As of November 2011, over 1,050 talks are available free online.[9] By January 2009 they had been viewed 50 million times. In June 2011, the viewing figure stood at more than 500 million,[10] and on Tuesday November 13, 2012, TED Talks had been watched one billion times worldwide, reflecting a still growing global audience.[11]“

http://en.wikipedia.org/wiki/TED_(conference)

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Chapter 1 - INFORMATION Architecture

Urban sociology

„Urban sociology is the sociological study of life and human interaction in metropolitan areas. It is a normative discipline of sociology seeking to study the structures, processes, changes and problems of an urban area and by doing so provide inputs for planning and policy making. In other words it is the sociological study of cities and their role in the development of society.[1] Like most areas of sociology, urban sociologists use statistical analysis, observation, social theory, interviews, and other methods to study a range of topics, including migration and demographic trends, economics, poverty, race relations and economic trends.

The philosophical foundations of modern urban sociology originate from the work of sociologists such as Karl Marx, Ferdinand Tönnies, Émile Durkheim, Max Weber and Georg Simmel who studied and theorized the economic, social and cultural processes of urbanization and its effects on social alienation, class formation, and the production or destruction of collective and individual identities.

These theoretical foundations were further expanded upon and analyzed by a group of sociologists and researchers who worked at the University of Chicago in the early twentieth century. In what became known as the Chicago School of sociology the work of Robert Park, Louis Wirth and Ernest Burgess on the inner city of Chicago revolutionized the purpose of urban research in sociology but also the development of human geography through its use of quantitative and ethnographic research methods. The importance of the theories developed by the Chicago School within urban sociology have been critically sustained and critiqued but still remain one of the most significant historical advancements in understanding urbanization and the city within the social sciences.[2]"

http://en.wikipedia.org/wiki/Urban_sociology

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Chapter 5 - Urban sociology

Uta Hassler

Transforming and Mining Urban Stocks, Homepage http://www.futurecities.ethz.ch/research-modules/transforming-and-mining-urban-stocks/ (accessed December 15, 2012)

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