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Options and constraints of a parcel based approach in 'UrbanSimE'

Patrick Schirmer,

Institute for Transport Planning and Systems, ETH Zurich

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Patrick Schirmer

Institute for Transport Planning and Systems

ETH Zurich

Wolfgang-Pauli-Str. 15

8093 Zurich

Phone: +41 44 633 62 58

Fax:

email: patrick.schirmer@ivt.baug.ethz.ch

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Abstract

UrbanSim has done the step from a partly aggregated gridcell-based simulation to a fully disaggregated simulation model. Progress in computer graphics techniques (e.g. procedural modeling) and the integration of geometries as basis for simulation allows an outlook to new options deriving by combining those two approaches.

The disaggregated approach of UrbanSim in the parcel version is currently being tested within the Zurich case study of the SustainCity Project. A previous study has already been using the gridcell version of UrbanSim on Zurich. This project will thus allow the comparison of the results, but also the preparatory work needed to run the model.

This paper will concentrate on the parcel-based version of UrbanSim and is structured in two main parts. The chapter "data" will report on the experiences while trying to gather data for running UrbanSim on Zurich. Patterson (2010) and Löchl (2007) have been discussing the work that has to be done on the data (for running UrbanSim in the gridcell version), nevertheless no one is describing where to get those data and what costs need to be implemented. As the data required for the parcel version is more detailed than the ones needed

in the gridcell version, this becomes an essential aspect of the work with UrbanSim. Furthermore the paper will discuss the content of data, data owners, that need to be contacted, as well as the need of UrbanSim in the parcel version.

The chapter “simulations and visualisations” will explore for new options deriving by integrating the parcels and the buildings into the simulation process of UrbanSim. Progresses and interests that are arising for procedural modelling will allow to link those geometric rules and behavioural rules as used in UrbanSim within the simulation process. This first outlook will discuss urban growing scenarios in form of Urban sprawl and Urban transformation and link to the tools that can be used to implement those into the simulation process. Finally a concept of a typological approach being part of urban transformation will be presented and discussed.

Keywords

UrbanSim - SustainCity - Swiss Data Structure - Urban Simulation - Urban Patterns - Typological Simulation - Urban Morphologies

1. Introduction

1.1 UrbanSim

UrbanSim is an open-source software being developed by Waddell and colleagues (Waddell and Ulfarsson, 2004), simulating land use-development in cities based on the choices of households, businesses, land owners and developers, interacting in urban Real Estate markets and connected by a multimodal transportation system.

Within the project of SustainCity¹, UrbanSim is being adapted as an European version (UrbanSimE) with new calibration of choice-models and additional models for households, demographics and firmographics. Previous versions of UrbanSim used gridcells as spatial resolution for its choice-models, the latest version of UrbanSim provides for parcel resolution. This new approach results in a different workflow of UrbanSim-use, creating new chances but also new constraints in the practical use, as for example experienced within the Zurich case study.

1.2 SustainCity and the Zurich case study

SustainCity is an EU-funded project with twelve European research-institutions², coordinated by the IVT of the Swiss Federal Institute of Technology Zurich (ETHZ). The aim of SustainCity is to extend the integrated land-use-model UrbanSim to the so-called version “UrbanSimE”, being adapted to the European context of cities. For this UrbanSim will be used in three case studies: Brussels, Paris and Zurich. The work necessary to set up an UrbanSim environment in these cities/countries, as well as the results of the simulation process will be compared within the project. In addition the integration of various transport models and the integration of new models on demographics, inner-household-decisions and developers-behaviour will be advanced.

All three case studies have a running UrbanSim environment of previous studies. For Zurich this has been the Project “Zukunft Urbaner Kulturlandschaften” (ZUK, Bürgle 2005, Löchl

1 www.sustaincity.org

2 Participating institutions are Swiss Federal Institute of Technology Zurich, Ecole Normale Supérieure de Cachan, Institut National d'Études Démographiques, Université Catholique de Louvain, Katholiek Universiteit Leuven, STRATEC SA, National Technical University of Athens, Technical University Berlin, Ecole Polytechnique Fédérale de Lausanne, Bocconi University, Université de Cergy Pontoise, Berkeley-University of California

2007), which was based on the gridcell version of UrbanSim. For Paris and Bruessel a Zone-based version has been implemented (de Palma et al., 2005;Patterson et al., 2010).

Instead the Zurich case study of SustainCity will make use of UrbanSim's parcel version and implement the created models and parameters of the ZUK-Project. Through this it will be possible to compare the work, necessary to set up the modelling-environment and also compare the results of these two versions.

2. Data

2.1 Base-data for the Zurich case study

The Zurich case study created in the ZUK-project (Löchl, 2007) is a well-documented UrbanSim simulation of the Zurich region in a gridcell version. SustainCity will use the parcel version of UrbanSim, implementing the same parameters as in the ZUK and compare the results.

Unfortunately most of the data and tables used for the ZUK-project cannot be used in the SustainCity-project for three reasons:

- Original Data of ZUK is aggregated to a gridcell of 100m*100m and is not based on parcels.
- The ZUK-project has another base-year as the SustainCity project. Simulation within SustainCity will use the base-year 2000 to be comparable to Brussels and Paris, which will use a similar simulation period. ZUK used 1996 as base-year, mainly based on interpolated data.
- Requirements of UrbanSim in the parcel version differ from the ones needed in the gridcell version. Thus base-data needed to run UrbanSim in those versions are different as well.

Therefore the setting up of a simulation environment for the Zurich case study in the parcel mode requires to set up the model from scratch. Patterson describes very well how this can be done. Patterson (2010) recommends to create a prototype model as a start for an UrbanSim run. Following him it is best to use an existing model (one of the available examples) as basis for a prototype in UrbanSim. Additionally comes the fact that no European case study is reported with the parcel version of UrbanSim yet, so no relevant starting point exists.

Löchl (2007) and Patterson (2010) show that the data available for Switzerland is very detailed and makes it relatively easy to implement the gridcell version. Most of the needed data for the gridcell version can be downloaded from governmental Internet sites in a grid of 100m*100m.

The experience of getting the data, required to feed the parcel version of UrbanSim, is a different one. To set up a simulation environment with the detail of the ZUK-project in the parcel version of UrbanSim leads to problems that can be categorized as followed:

- Required data is not captured and thus does not exist. An example would be the improvement value of a building or parcel. This problem is already described by Löchl (2007) and Patterson (2010) and will therefore not get explained more in detail here.
- Data is not available on disaggregated level. This is basically a common challenge of UrbanSim-use in all versions of UrbanSim. The available data might not fit to the zoning or grid and a transformation is needed.
- The scale and detail of data is inconsistent. Although data might include a lot of information that is needed by UrbanSim, they often will have “holes” or are only available for parts of the studied region.
- The available survey data and cadastral data represent different base-years. For example the micro census is of 2005, the population census is of 2000 and the enterprise census is of 2001. Creating a common base-year needs an interpolation or the use of a population-synthesizer thus. For cadastral information accuracy might vary within the layers of a dataset. The street-layer might be up to date meanwhile the landscape-layer was not updated for two years.
- Data is not available for privacy reasons, as the high level of detail allows links to persons and their buildings. There are restrictions in law that make it impossible to get those data, unless a governmental institution is involved and/or there are special contracts on the use and the project.
- Some required data are highly detailed GIS-information that are individually hosted by the communes and have to be paid per commune. Obtaining them is therefore only possible with high costs. Data affected to this are particularly the shapes of parcels and buildings, which are essential to the use of UrbanSim (parcel). The costs for those datasets make it hard to get a historical overview, means data for several steps in time.
- Data-owners are not known or the content of their data is not known in detail. A lot of data is gathered by the different hierarchies of administration, and is spread over these institutions in various aggregations.

The experience in the Zurich case study shows that the availability of the data and their costs differ from institution to institution. The next chapter will therefore give an overview of the data-owners including the data that could be achieved and the restrictions or costs that they provide for SustainCity. A detailed overview of the data used can be found as table 1 in the appendix.

2.2 Dataowners in Zurich case study

The first step of setting up any environment is to get an overview of what data is available and where this data can be obtained (under what kind of condition). This chapter will concentrate

on the aspect of where data can be obtained and show what the costs and conditions are for the Zurich case study.

Data owners can be structured in two main classes: governmental and private. Each of those relate to certain constraints on availability of data, accuracy and content of data.

2.2.1 Governmental datas

Governmental data do have a high accuracy, as they form the basis for administrative decisions and have a clear definition of the time (-period) they represent. They are collected on various hierarchical levels of Swiss governments:

- Federal Offices
- Cantonal Offices
- Municipal Offices

Federal Offices

Federal offices are collecting nationwide data and make them comparable. They therefore are the best address when data are needed for more than one canton. Relevant offices on the federal hierarchy are the Federal office of statistics and Swisstopo explain. As the data is collected nationwide, the detail and accuracy is not as precise as for most data of the cantons, e.g. the Vector 25 represents streets as axes and building-structures are merged to bigger polygons when they are directly next to each other.

Statistical data is often only available in aggregated form per commune or per canton. Data exchange of the ETHZ with the Federal offices is often regulated by general contracts that allow the use of their data without needing further contracts. For SustainCity some additional project-specific contracts were signed which allow the use of data only in the specific project, but does not create any or only minor costs.

Cantonal Offices

Cantonal offices are guiding the inner-municipal activities and planning processes. As such they collect data and provide specific analyses that are not done by the municipalities and also have cantonal simulation models on travel.

The Zurich case study is using the Canton as simulation area, so these offices are of high importance. The provided data are relatively consistent across the communes and allow for

comparison of the communes. The level of detail is significantly higher than the ones of the Federal offices.

Getting the data of cantonal office is in general possible for the ETHZ, but not regulated through general contracts. Individual, project-specific contracts need to be signed therefore. Costs will be quite low in most cases; eventually a relatively low processing-fee will be claimed.

Municipal Offices

Municipal offices are the hosts of cadastral information and local statistics. The canton Zurich has 171 municipalities, which makes it hard to collect the individual data of each. Often these data can also be accessed via the Canton as well, but with a loss of detail and eventually with restrictions on use and additional costs. Data on municipal level is highly detailed but are often inconsistent between municipalities.

UrbanSim (parcel) requires shapes on parcels and buildings as references in the simulation process. Although the cantons get all these data and patches them together, cantonal offices will not be allowed to give out the data unless they are directly involved in a project. There is a contract signed by 141 municipalities to support research and education and those municipalities will give out their cadastral information for a low processing-fee. Still in total the sum would exceed 20.000CHF for those 141 municipalities.

For the SustainCity-project the canton of Zurich is involved and through this it was possible to get access to the required data.

2.2.2 Private Data

Besides the governmental data a lot of private data are available. Although they have been proven to be useful, they are often less accurate than the official ones and will not be related to a defined point in history. As they are of no legal relevance, they will often be less complete but also less restrictive than governmental data. Nonetheless a lot of information can be collected here which is especially interesting for private persons and institutions who want to set up an UrbanSim-model.

The group of private data can be categorized into following subgroups:

- Private institutions
- Web-based data
- Self-created data

Private institutions

Private institutions are collecting data instilling mandates (for administrative institutions) or as basis for their work. The amount of such institutions and their data is incredibly high, as they are of high value and serving for market analyses and location analysis. Though these data can have contents that are very specific and seemingly not of value for administrations, they might become a good basis for discrete choice models. An example would be the amount of pay- television- subscriptions in the districts of a city, which might give a insight on the socio-demographic mix of the population.

The data of private institutions can often be compared to governmental data in terms of accuracy or completeness. Also time-periods, i.e. when the data was collected, are mostly defined in a clear way. In general getting these data is quite difficult and cost-intensive as they are the basis for services provided by the institutions. Nevertheless prices will often be lower than governmental data for private persons.

Web-based data

Since the web is expanding every day, data that can be found here is becoming more and more interesting. As already mentioned a lot of governmental data and other data that is made available for public can be downloaded in some aggregate form. Good examples are the SRTM-project, the CORINE-data or on level of Switzerland the data of the Federal and Cantonal Statistic Offices.

Beside those, various disaggregated data can be found in Web 2.0 -projects. As these data are “collected” by various independent users, the accuracy is not guaranteed at all and there is no time stamp. Content and detail of these can be higher than governmental data, they often have a very big extent and they are free of charge. These data can become the perfect starting point to produce a prototype UrbanSim model. The most famous Web2.0-project examples would be Wikipedia³ or Openstreetmap⁴.

The web is an open market and also used to compare products which can be very useful for extracting information that does not exist, as for example land-prices or Real-Estate prices. In the ZUK - project a parser was the only way to get Real-Estate-prices with a spatial distribution for Zurich. For an example see Figure 1.

3 www.wikipedia.org

4 www.openstreetmap.org

Figure 1 Points of interest registered for Zurich in Google Earth



Source: Google Earth

2.2.3 Self-created Data

A last point is the self-creation of needed data and information. For the ZUK - project this has mainly been surveys and the resulting discrete choice model parameters. For the SustainCity-project additional types of self-created data will be useful for modelling the UrbanSim environment. These can be structured in the following categories:

- Surveys and modelling outputs
- Interpolation- and synthetisation- methods
- Geometric extraction and generation

Surveys and modelling outputs

Surveys are the basis for most discrete choice models and essential data for UrbanSim as well. Beside the governmental surveys mentioned above, also individual surveys can be done to evaluate specific behaviours within a study area. The Institute of Transport Planning and -Systems (IVT) at the ETHZ is conducting surveys within its projects, so that various additional data can be integrated in the Zurich case study.

Outputs of other modelling-tools can also be used, which will especially be the case for the output of MatSim-runs as external transport model.

Interpolation- and synthetisation- methods

As mentioned for the governmental data, the base-year of essential censuses will vary and make it difficult to create a common base-year. As described by Löchl (2007) this creates the need for interpolation of various timesteps of the same dataset. Although the linear interpolation will be a fast way to do this, it might not give the best results. Another method is the synthetisation of various data to create a synthetic population being consistent over all time-steps. This approach will be implemented and tested within the Zurich case study of SustainCity as well.

Also data inconsistency can be reduced with these or similar methods. Inconsistency is a problem often reported when using UrbanSim: in theory all data should be in a dataset, but in reality the data has a lot of missing or wrong values. As this is essential to the work with UrbanSim, Waddell and his team are experimenting with machine-learning algorithms to solve this problem (Waddell, 2010).

Beside interpolation also combination of spatial data via GIS and extraction of relevant data is an important method. For the ZUK-project the viewshed being derived of the slope was found to be an important parameter in the Real-Estate model.

Geometric extraction and generation

When no geometric shapes in GIS or CAD-format are available as basis data for a run in UrbanSim (parcel), other methods to create those data will be needed. One possible solution will be the extraction of shapes out of images. Meinel (2007) presents an approach to extract building-types out of rastermaps as a possibility to analyse development of a city and to evaluate construction activities.

Other approaches are the extraction of information out of overlapping photos, as in aerial stereo photography or laser scans from satellites. Kim (2001) presents an approach for describing complex building structures. With the option of using satellite images and scans this method might soon be used for the fast creation of 3D-cities and landscapes and as such it will be a very good start for UrbanSim prototypes.

A last approach being presented here is already closely linked to UrbanSim. Procedural modelling techniques have recently been evolving and are being linked to urban visualisation and urban simulation as Waddell, Müller and Vanegas show (Vanegas et al., 2010, 2009). These techniques will make it possible to subdivide plots and also to generate buildings out of plots following geometric rules. Vanegas has undertaken first trials with very promising results to generate various patterns of urban districts out of aerial photos. As soon as these techniques have reached a satisfying level of validation they will allow to create base data for any region of interest, even if no data should exist, e.g. as in some 3rd world countries. The section “simulation and visualisation” of this paper will discuss options resulting when linking these techniques.

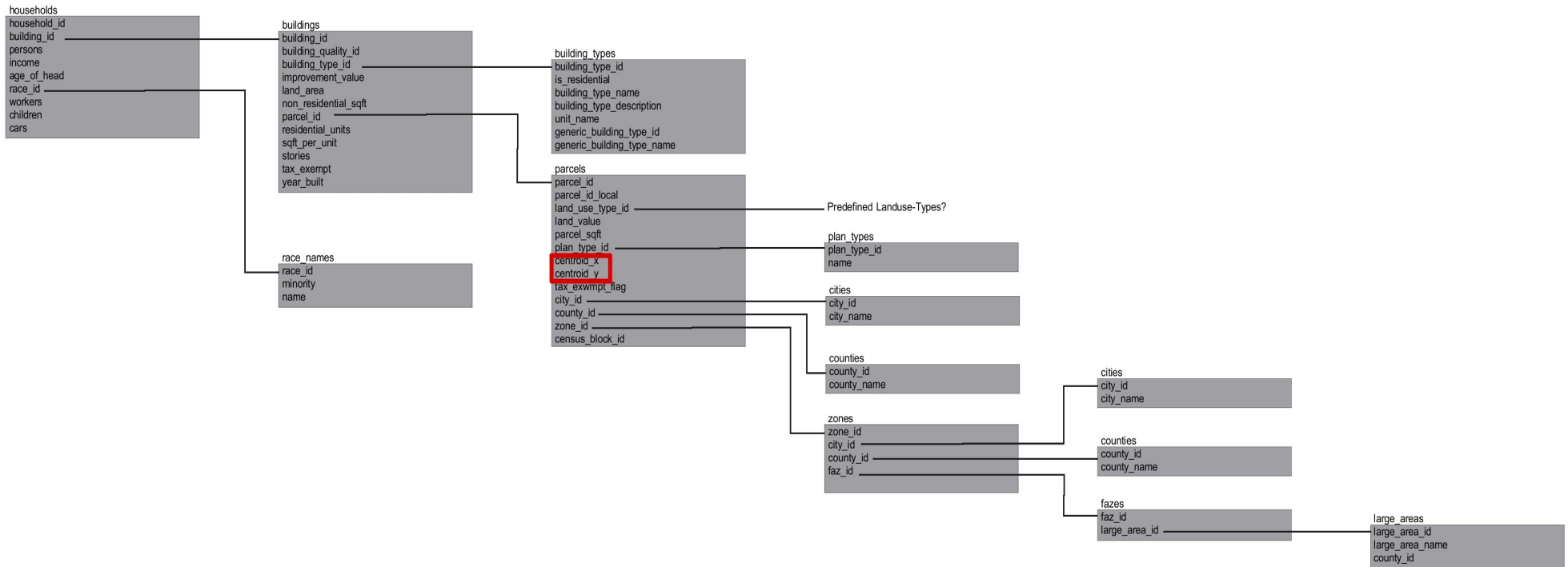
2.3 Needs of UrbanSim (parcel) in Zurich case study

Through the disaggregated approach the needs of UrbanSim are highly detailed. Although most of the needed information exist in Switzerland, data might not be available for the (private) user of UrbanSim. For this reason variables need to be created out of data that is easily available (see above) or to find replacmen data and default-values. Patterson (2010) demonstrates this with the example of Lausanne by using gridcell population and employment density as a replacement for land price data.

Waddell describes the Über-Über-Simplified Zonal version as a way to build-up an UrbanSim Model in the parcel-based version. Patterson (2010) proposes to create a prototype model instead, which is based on existing examples. Either approach demands a minimum of data, which again are linked to other data. The diagram below shows this by the example of the building-variable.

At present there is no experience within the Zurich case study, which gives a feedback of what data is needed to run a minimum version of UrbanSim in the parcel mode. Table 2 in the appendix is based on the required data of UrbanSim reported on the UrbanSim homepage and gives an overview about what data are expected to be useful to fill the variables of the UrbanSim parcel version in the Zurich case study.

Figure 2 Dependancies of household-table within UrbanSim



2.3.1 Conclusion and outlook

The data that UrbanSim needs in its parcel version is very specific and highly detailed information. Although most of this data is available for all of Switzerland in the hectare aggregation (100m*100m) and could thus directly be used in the gridcell version of UrbanSim, it is very hard to gather the disaggregated data needed for the parcel-based version.

Beside the high accuracy of the data, as for example the parcel-shapes, which are available as a commercial product sold by the municipalities, it is often for privacy reasons that usage and availability of such data is restricted. Even if data is available, gathering the required data becomes a big challenge through the various data sources. Contacting all the data-owners is a time consuming aspect of preparation that retard setting up a simulation environment.

European data still vary considerably in their structure across the countries although some standardizing steps are on the way through the European Union, as shown in the INSPIRE-project⁵. But even within one country, scale and detail of data is not consistent and different data are often are not available for the same point in time. Thus the transformation of data is an essential part of work to create a common simulation base year.

A solution to do so might be a population synthesis, as it will be created for the Zurich case study. Whether this can be generalized and be used for other cities through a synthesis model needs to be seen.

Another approach will be machine learning algorithms and procedural methods. This might guarantee availability of shape-data as parcel data, which was the hardest to obtain in the Zurich case. For buildings and points of interests across a city automated extraction out of raster maps and aerial photos as well as web 2.0 approaches are a promising way. How good the results of simulation based on such data is, remains to be seen.

As a first feedback of data acquisition in the Zurich case study, the parcel-based version of UrbanSim is a lot more difficult to set up than a prototype model as described by Patterson (2010). As such, the use of UrbanSim in the parcel based approach remains interesting for governmental institutions that want to create an operational model and do have access to the data required. Private institutions who want to create their own model for evaluating a certain plan or strategies, e.g. an urban planning office, will supposedly not be able to implement this version for the high costs it imposes to gather the basis data.

5 <http://inspire.jrc.ec.europa.eu/>

3. Simulation and Visualisation

3.1 Introduction

As shown in the Chapter “Data” the use of UrbanSim in the parcel version requires a data-basis, which is a lot more involved to gather, than the one required for the gridcell version. To the authors knowledge no direct comparison of the results in the gridcell version and the parcel version have been done in Europe until now. This will first be done within the Zurich case study, which is currently being set up in the parcel version. Nonetheless this does already allow for the question why the parcel-based approach seems to be an essential step forward in the modelling approach of UrbanSim. This sector will therefore concentrate on the options that derive from this new approach and that will be tested within the Zurich case study.

3.1.1 Arguments for a disaggregated approach (via parcels)

Although the data required for the parcel version of UrbanSim are (more) difficult to obtain in comparison with the gridcell version, there are strong arguments for this approach in Urban Simulation:

- The parcel does represent the scale of urban planning. In all European countries the parcel is the reference of constraints on density, program and buildings types. These can vary from parcel to the neighbored parcel, which is why the gridcell can only represent an aggregated value.
- Parcels are objects that are owned by a legal person. This person will decide what happens with or on the parcel. As UrbanSim is an environment, where these and other behavioural aspects are modelled it makes sense to include the parcel as objects of reference.
- Urban design starts with the zoning and definition of networks, plots and densities. Integrating these objects in UrbanSim will allow for integrating urban design studies. This will allow evaluating the effects of various design-options for creating a sustainable design that is adapted to the city.
- Each parcel has a different size and shape. Implementing the parcel therefore allows to implement geometric aspects in the simulation process. This is the basis for combining behavioural modelling and geometric modelling, which will result in a higher explanatory power for the model.
- The combination of “geometric modelling” with “behavioural modelling” will additionally allow to create other forms of output. “Geometric modelling” stand for

the changes of geometry over time, meanwhile behavioural modelling will describe agents behaviour . Vanegas (2009) has shown how aerial views can be a good forms of communicating urban developments. Parish and Müller (2001) show how to create buildings out of the parcel-geometries based on procedural methods.

In conclusion it can be said that the integration of parcels (and buildings) as reference objects, with a defined geometry, into the UrbanSim modulation environment, strengthens the disaggregated approach of UrbanSim. Besides it allows to combine the behavioural models of UrbanSim with geometric models and to combine these into a new modelling framework.

3.2 Agents and objects

As described, parcels are an essential aspect of urban development. Buildings, households and jobs are reacting on attributes a parcel provides. The parcel therefore is part of the utility function for households and jobs (and buildings) including its geometric aspects. On the other side the owner (user) of a parcel as well as planners will decide what happens to a parcel, e.g. by selling it or by building on it. Through this the parcel is reacting to the behaviour of households and jobs and other individuals, which again can be represented by behavioural rules via discrete choice modelling.

The parcel-geometry (and eventually the building geometry) can be understood as an agent following geometric or behavioural rules. To clarify the interaction of them with the agents of households, jobs and individuals within UrbanSim a differentiation into agents and objects is introduced here. The way objects can react, what aspects are related to objects and how they can be modelled will be highlighted afterwards.

Table 1 Characteristics of agents and objects

Agents	Objects
<ul style="list-style-type: none"> • can move around • perceive the world around them • make autonomous decisions • act into the world 	<ul style="list-style-type: none"> • defined location and geometry • owned by agents • influenced by agents • react on existing constraints
=> <i>follow behavioural rules</i>	=> <i>follow geometric rules</i>

3.3 Urban development scenarios

Having understood the importance of parcel (and buildings) in the urban simulation process it is worth to have a closer look to the meaning of parcels within European urban developments. When studying the sizes of parcels in Zurich and comparing them to the existing building structure, it becomes obvious that parcels are different within the city as from the outside. Development scenarios will require to treat those two categories differently:

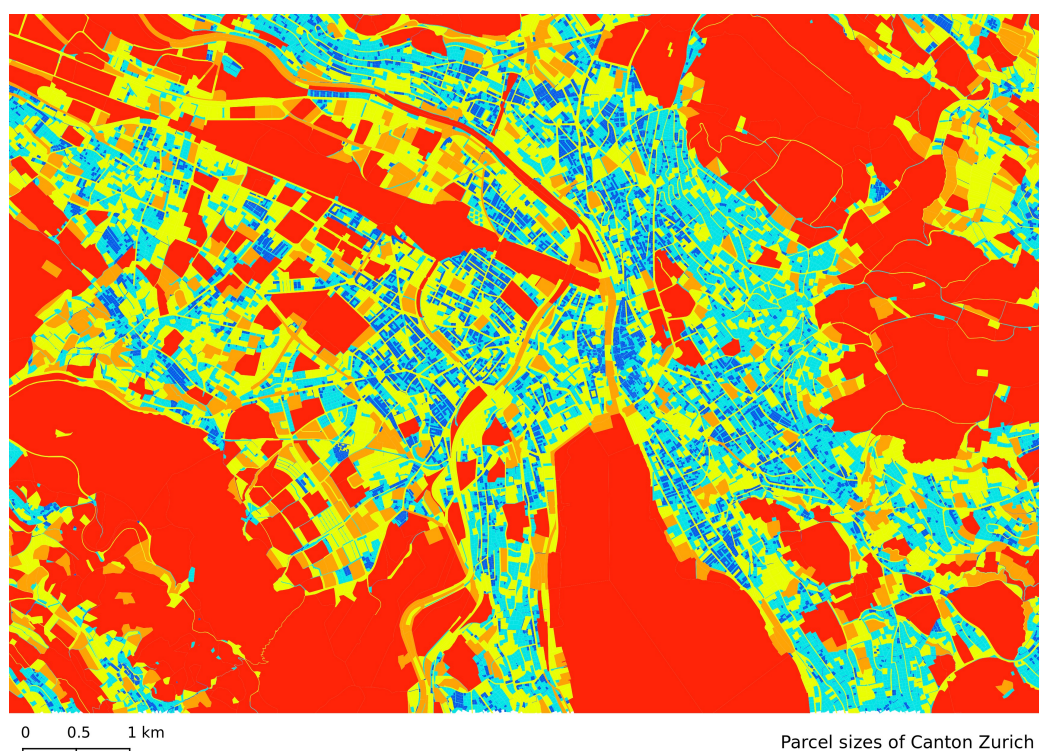
- Urban sprawl
- Urban transformation

Figure 3 Buildings in Zurich



Source: Vector25 (© swisstopo)

Figure 4 Parcel sizes in Zurich



Source: Cadastral Information (Kanton Zurich © Amt für Raumordnung und Vermessung)

3.3.1 Urban sprawl

Urban sprawl is characterized by huge developments outside of the existing border of the agglomerations. Basis of urban sprawl is the change of landscape or agricultural sites into construction sites through changes in regulations, e.g. zoning maps. These developments are most times taking place on very big parcels that have only few ownerships and existing streets. They demand for subdivision and structuring, which can highly depend on design-strategies and developers aims.

Unlike the urban transformation, those developments create a new environment and cannot or only partly be derived from the existing city as described in the Urban transformation chapter. Urban sprawl will therefore have to be represented through the interaction of two other models: the Urban Sprawl Model and the Developer Model. The Urban Sprawl Model will have to classify urban patterns that are typical for certain urban design strategies. These will

include subdivision and restructuring of plots and the growing of networks and urban structures.

The developer's behaviour, which will define the chosen strategy, will have to be represented as behavioural rules within a Developer Model.

Basis for the Urban Sprawl Model will be the implementation of geometric rules. There are different approaches to this theme; two relevant approaches are listed in the following:

- Procedural modelling is a technique coming from computer graphics and is based on L-Systems (Parish and Müller, 2001). This method allows to create large urban scenes based on a set of rules. As geometries are subdivided into new geometries that will execute another rule, procedural modelling as described by parish and Müller is a top-down-approach for geometric rules. They show how these rules can be used to reproduce urban scenarios or create new scenarios. Their model includes attribute maps that can be implemented in the rules and define for example the height of generated buildings. Vanegas (2009) includes an interactive mode into the procedural modelling method and begins to combine the geometric rules of procedural modelling with behavioural rules: The geometries of the city will rearrange and change the distribution of its densities when a new motorway is being created.
- A bottom-up approach iprovided by geometric dynamic adaptive systems, which are based on self-organization of objects. Brach et al. show in KaisersRot⁶ how this method can be used in urban design and architecture. The rules in this approach define the interaction of the objects, which then will result in self-organisation. The number of objects and an interactive repositioning of the objects can be controlled by the user. Another approach of this kind is the optimisation of networks as presented by Vitins and Axhausen (2010). Different network grammars are tested on a featureless plain to find the optimal network.

3.3.2 Urban transformation

The urban transformation is taking place on one or several (often neighbouring) smaller parcels within the existing city, which makes it possible to describe the (existing) influences in the simulation process. Urban transformation often is characterized by a new development on an empty parcel, a refurbishment of an existing building or a demolition and rebuilding activity, but sometimes also by creation of public space.

This type of development is based on the geometry of a parcel and the location of a parcel within the existing city. The start of an urban transformation process is motivated through a change of the surrounding urban tissue, a change in value of the parcel or a change of ownership. Examples would be the construction of a new road, a new definition of constraints for the parcel, but also the change of owners through inheritance.

Urban transformation is linked to four categories of variables:

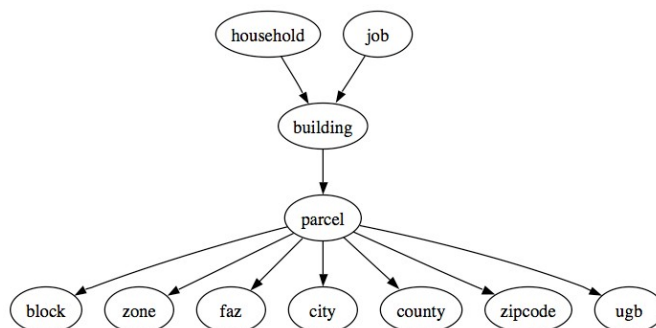
- Location aspects of a parcel within an agglomeration. It includes time as a relevant variable and measures the distance and accessibility of a parcel to relevant facilities, as the city centre, leisure facilities, retail, job location or a school. These are the variables that are already part of the urban simulation framework.
- Important aspects of urban developments are markets and constraints as they are guiding the options and demands within the simulation process. UrbanSim is already accounting for this in the Real-Estate price model that is including vacancy and demand. A Developer Model that is envisioned for the Zurich case study might include the benefit a certain construction creates and therefore also include further market-aspects.
- Geometric aspects are the ones being directly related to the shape of “objects” as parcels and buildings. These will be their size, side-ratio, but also position of buildings on a parcel, the relation of buildings to each other or the number of accesses a parcel has to main roads. In interaction with the constraints of a parcel, that are guiding optional construction, they are the basis for evaluating the value of transforming the parcel and its construction. Geometric aspects are not or only in minor form part of urban simulation until now. UrbanSim does respect these by implementing parameters that are deriving from the shape, as for example “improvement values”, defining how much additional construction is possible on a parcel. Geometric aspects will become important in urban simulation as soon as geometric recognition can be implemented in the simulation process. The parcel-based approach, including building shapes will be the essential start to do so.
- Quality aspects can be socio-demographic variables or related to the construction and public space. They are an important aspect of urban transformation. Still it is very hard to implement these, as appropriate metrics are currently missing. Only related effects, as the Real Estate price, can be observed and implemented. That new construction with new public space might enhance the quality of a neighbourhood is not considered yet.

These two types of developments (urban transformation and urban sprawl) do show what aspects need to be respected to implement parcels and buildings as objects into the simulation process. This approach will enhance the simulation results by accounting for geometry and avoiding unrealistic construction on parcels. Meanwhile urban sprawl has a lot of unpredictable parameters that need to be studied first, urban transformation is depending very much on a given situation. This allows integrating processes of urban transformation into the urban simulation process. Parcels will be handled as “objects” following agent-based rules, which will be shown, by presenting the concept of a typological class model.

3.4 A Typological class model

The diagram of Waddell (2010) links parcels through buildings to households and jobs and shows the importance of buildings and parcels in the simulation process. This is also the way that we act within real world: we live in a building, that is situated on a parcel and we work in a building that is situated on a parcel.

Figure 5 Functional diagram of UrbanSim (parcel)

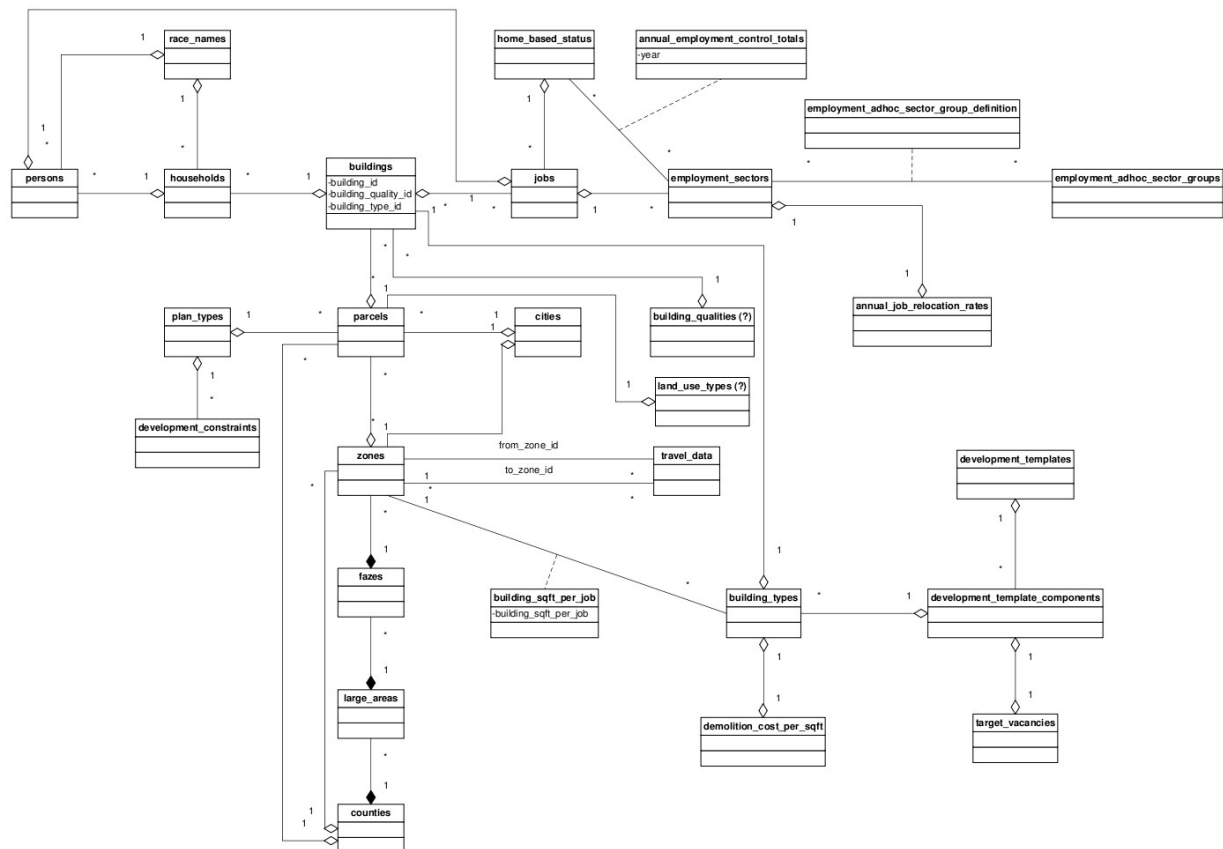


Source: www.urbansim.org

The UML below shows the dependencies of the tables in the UrbanSim parcel version in higher detail. At present the link between parcels and buildings is realized by integrating the parcel-ID in the building-table. The information that is included for a building in this table is the quality, type, improvement value and some spatial information as land-area (footprint of building) residential units, non-residential footage and stories. “Type” is the kind of use a buildings has, e.g. residential, industrial or employment and mixed forms of those. The geometry and shape of a building are not considered in the simulation process.

The following chapter will introduce a typological-class-model as concept for a model that integrates these geometric aspects.

Figure 6 UML of UrbanSim (parcel) showing dependancies of buildings



3.4.1 Defining building-typologies and parcel-value

First we have to think of the way UrbanSim is modelling processes in the urban environment with the example of households. Basically households do choose their residential location based on parameters such as the location of their jobs, distances to important facilities (which are described by the traffic analyses zones) or the Real Estate price and construction year of a building.

Now lets think of how we would choose our residential location. Most people of course would choose it based on these parameters but additionally they would react to what kind of building this is. Young couples and students might favour an apartment in an urban block, families

might prefer to live in a detached house with garden and others might like to live in a loft of an industrial quarter. What is valid for residential also is valid for jobs and enterprises. A restaurant will have other preferences than a supermarket, a carpenter or a garage.

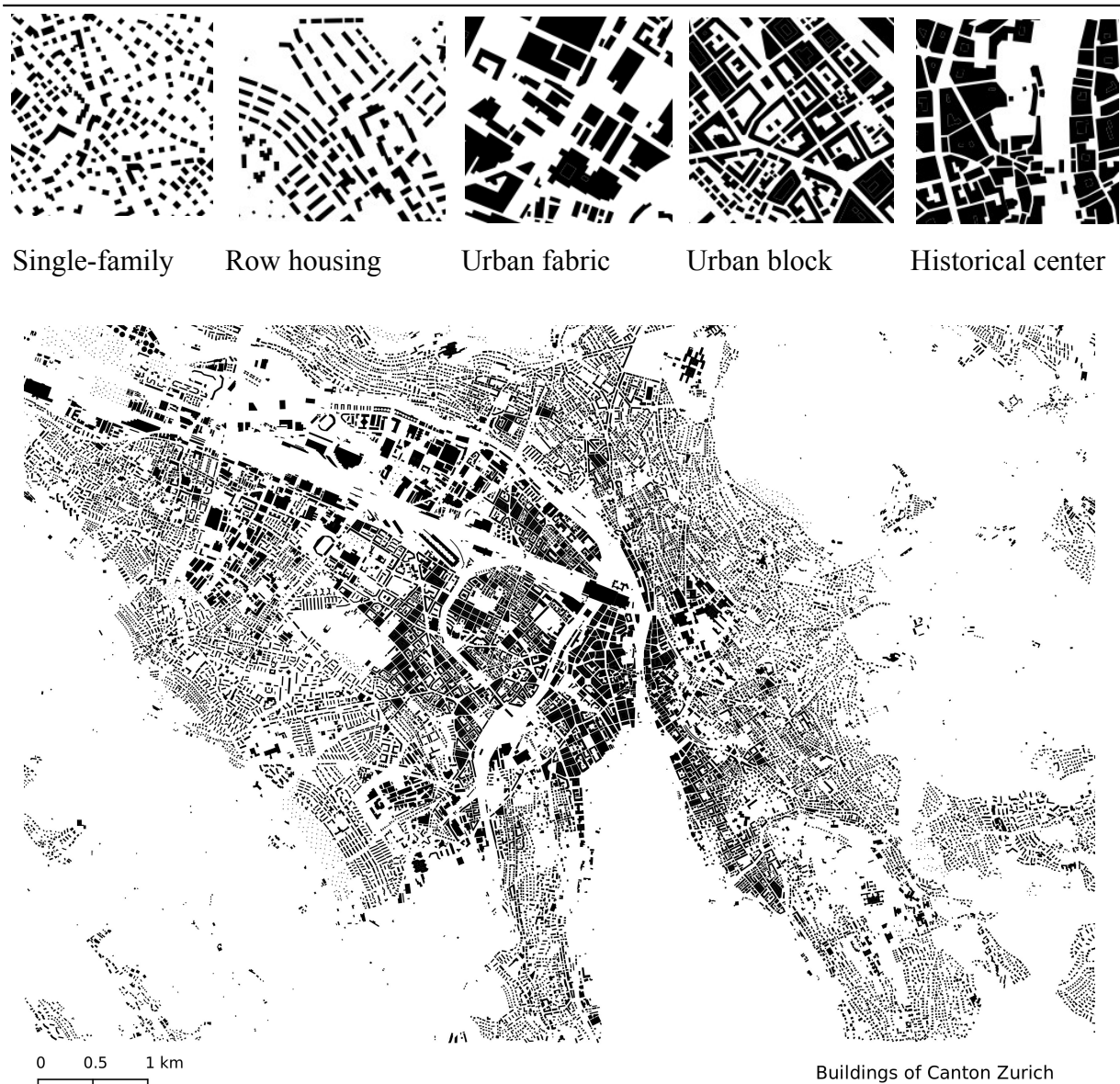
These kinds of categorization are nothing new in urban planning. Alexander (1977) mentions the “variation of different people along the extrovert-introvert dimension” when analysing towns and their patterns. The “degrees of publicness” he mentions, can be interpreted as the amount and ratio of public, semi-public and private space one has. Also Cortes (2009) finds kinds of buildings when analysing the urban landscape. He takes the structural approach of urban patterns and links them to networks, parcels and their characteristics for certain periods in history.

This leads to the question what is this “kind of building”, and what can it be in the context of urban simulation? The kind of building as mentioned here refers to what is called “urban typologies”, there classifications are not defined yet and can be done in several ways. Four main aspects are distinguished here:

- **Building:** This can include all attributes related to the building’s geometric appearance, as the height, the material of the facade or construction, but also the footprint or the depth. This is a wide spread of aspects and might as well be the differentiation between a wooden house or a glass building as the differentiation between a high-rise and a hall.
- **Space:** This will relate to the interaction of a building's volumetry with its environment. This can be the public, semi-public and private space around it in terms of amount and ratio, but also the relation to its parcel. Examples would be the urban block, creating a courtyard or the urban villa standing on a plain.
- **Function:** This is based on the buildings main function. Examples would be a hospital and a school or more generally a Health-Care Institution and an Educational Institution. This works very well for public uses but the differentiation within residential or commercial is less clear. It might be solved by describing the housing-style (office-style) as single-family house or apartment-building.
- **Location:** This is mainly the classification of rural, suburban, urban typologies, but can also be aspects of location within the urban landscape, for example the distance to highway, or the amount of direct street contact, as an edge building or inner-row building.

Planning regulations in Europe will be a mix of these aspects and steer building-typology through the parcel by defining building lines, distances to the street or to the neighbouring building, maximum height and function of a building, and maximum density of a parcel. Some of these aspects are already considered by UrbanSim, e.g. the sqm per use.

Figure 7 Buildings typologies of Zurich



Source: Vector25 (© swisstopo)

3.4.2 Integrating a typological approach- an outlook

The aim should be implementing aspects that cannot be described in values as such and prevent the reintegration of parameters already included. In addition it would make sense to be able to derive related parameters from a typology, as for example the amount of semi-public space from a block-structure. The typological approach should therefore concentrate on the geometric aspects, i.e. the shape, geometry and volume of a building.














A first sketch on how this could look like for a general European city and expectations of dependencies between blocks and parcels is shown in the following overview. Looking at the building structure of Zurich various types of these building-typologies can be distinguished on the urban landscape often clustered into zones forming the character of a certain street or area. The dependency of parcel and building is another important aspect, which will have to be characterized by the parcel's value. A parcel has certain constraints and certain characteristics that make it valuable for a certain type of typology. As an example a long and narrow parcel will not allow to build an urban block on it, and a parcel with a constraint of maximum 5 stories will not result in single-family housing.

Implementing these two categories into UrbanSim will allow a first approach to account for geometry and the value these do have for certain agents. It thus should significantly enhance the quality of the simulation results.

This implementation will happen in four steps:

1. Evaluation and categorization
2. Simulation and parcel-value
3. Extraction and visualisation
4. Urban rules and geometric options

Figure 8 Example of geometric dependancies of parcels and buildings including typological uses

Basis Typologies Characteristics	Spatial Integration (SpaceSyntax) global/local	Distance to street (closest side)	Orientation to street (x/y)	height (levels) min avg max	possible program
	very low - low / low	very low-high (depending on global integration)	----	1 2 - 3 4	Rs: residential, homeoffice, atelier
	low - medium / medium	medium - high	----	2 - 3 4 6	Rs: residential, homeoffice, atelier Rt: small retail shops, office, doctors, etc
	low - medium / medium	very low - medium	----	1 2-3 4	Rs: residential, homeoffice, atelier
	low - medium / medium - high	very low - medium	----	2 3-6 20	Rs: residential, homeoffice, atelier (all floors) Rt: small retail shops, office, doctors, etc (Groundfloor) C: Commercial, office & big offices (all floors)
	medium / medium - high	very low - low	----	3 4-6 8	Rs: residential, homeoffice, atelier (all floors) Rt: small retail shops, office, doctors, etc (Groundfloor) C: Commercial, office & big offices (all floors)
	medium / medium - high	very low - low	----	3 4-6 8	Rs: residential, homeoffice, atelier (all floors) Rt: small retail shops, office, doctors, etc (Groundfloor) C: Commercial, office & big offices (all floors)
	high / high	very low - low	----	3 4-6 8	Rs: residential, homeoffice, atelier (all floors) Rt: small retail shops, office, doctors, etc (Groundfloor) C: Commercial, office & big offices (all floors)
	high / high	very low - low	----	3 4-6 8	Rs: residential, homeoffice, atelier (all floors) Rt: small retail shops, office, doctors, etc (Groundfloor) C: Commercial, office & big offices (all floors)
	high / high	very low - low	----	3 4-6 8 (base) +2 +6 +10 (tower)	Rs: residential, homeoffice, atelier (all floors) Rt: small retail shops, office, doctors, etc (Groundfloor) C: Commercial, office & big offices (all floors)
	medium - high / medium - high	low - high	----	8 15 35	Rs: residential, homeoffice, atelier (all floors) Rt: small retail shops, office, doctors, etc (Groundfloor) C: Commercial, office & big offices (all floors)
	medium - high / low-medium	low - high	----	1 1-2 3	
	medium - high / low-medium	low - high	----	1 1-2 3	
	medium - high / medium - high	low - high	----	diverse	

Evaluation and categorisation

A first step will be a clear definition and categorisation of building typologies as well as the definition of the categories of households and jobs (or enterprises) they relate to. This will be the basis for evaluating the typology's relevance for household and job location, which will be undertaken with the methods of discrete choice modelling on historical data.

Several reports already mention the importance public space or the building type. The report of Gans et al. (2010) show that an essential factor to move out of the studied area of Mannheim is to live within an area which is green. When asking people who moved out of the city, 23.7% will say that this is the main reason to move out of the city. Additional 36.4% will say this might not have been the main reason, but was an essential reason.

This report also shows that different types of persons live in different quarters of the city of Mannheim, which underlines that preferences are different. Although it is not stated as thus in the report, these districts distinguish each other especially by the typology of buildings that can be found there.

Simulation and parcel-value

When the importance of typologies for households and jobs is shown through evaluation, they might be included in the simulation process. The first implementation in UrbanSim will happen via an extra attribute in the building table. As the geometric processing tools of the OPUS environment are relatively limited, automated extraction will not work from the beginning. In a first step this will have to be done manually, but later automatically through external tools either by raster-based building recognition as presented by Meinel et al. (2007) or geometry-analyses with GIS. As already mentioned the parcel has an important effect on the typology options that derive from it and this link needs to be implemented in the simulation process as well. The approach will understand buildings typologies as objects that react along behavioural rules, based on the parcels variables (its parcel-value).

The result what typology would fit, when urban transformation takes place, could thus be represented in form of a utility function.

$$U(\text{typo}) = \sum V(\text{constraint}) + \sum V(\text{market}) + \sum V(\text{location}) + \sum V(\text{geometry}) + \varepsilon \square$$

U(typo): Utility for a certain typology of building.

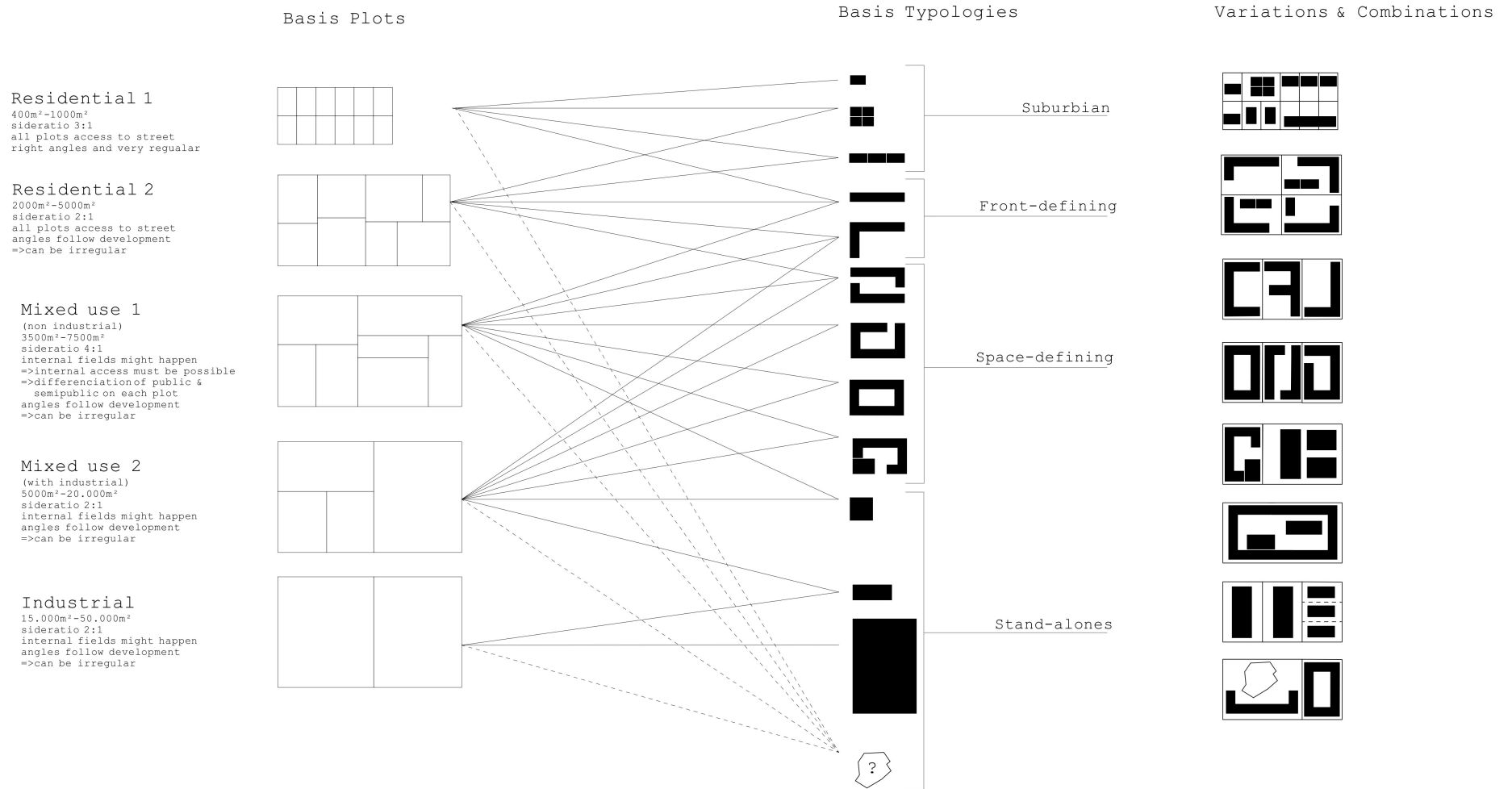
V(constraint): Constraints and planning regulations will include all regulation mechanisms that limit the building options on a parcel, as regulations on height, density and mix of use.

V(market): The Market is generating the price and demand for a parcel. It thus regulates how much effort will be spent to realize a certain kind of typology on a parcel, even if this one should not be ideal. As it is done for households and jobs the general market will have to be included for parcels and typologies as well.

V(location): Location will include all aspects that derive from the parcel's location within the urban landscape. This can be the distance to centre, access to public transport or the noise-immissions that affect the parcel. Partly these are aspects found in the Traffic Analyse Zones and that might be included at the detailed scale of parcels.

V(geometry): Geometric value of parcel allows integrating aspects that derive from the shape and geometry as the size (area, perimeter), site-ratio, slope and the number of street accesses.

Figure 9 Urban design study based on typologies and their relation to parcel



Source: KCAP Architects and Planners, 2009 (designed by P. Schirmer)

Extraction and Visualisation

The typological distribution found within the simulation process can also be used as basis for visualisation. Using procedural methods will allow visualizing the results of the simulation process as a volumetric output within a very short time. Seeing the future city in volumes will be a great possibility to communicate abstract aspects such as population density. The automated approach can be repeated various times and thus will allow giving a feeling for future developments but avoids creating a final image of the future.

This option will not only significantly enhance the quality of communication it will as well allow to start further calculations on the urban tissue. Examples could be the ratio of public space, the landscape covered and also aspects as the carbon-dioxide-footprint of city quarters.

Urban Rules and volumetric options

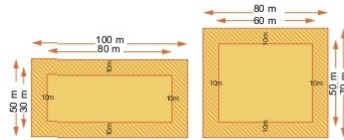
The implementation of typology into the simulation environment represents urban transformation processes based on attributes. They do not account for restructuring options based on geometry.

A later step might therefore be the implementation of urban rules based on geometry. This cannot be done within today's OPUS environment but will have to be done via external tools such as GIS or procedural modelling techniques. This approach will refine the simulation process and include aspects on whether a building can be enlarged or whether this building geometry does not allow an enlargement.

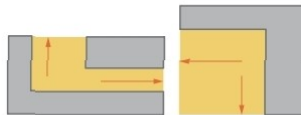
An example for urban rules is also shown in the design for ScienceCity (ETH Zurich) by KCAP: The masterplan is a rule-based urban design and accounts for flexibility. The rules will define some minimum aspects for the character of the site such as distances to neighbouring buildings and a minimum width of passage ways- the volumetry of the buildings can be varied based on these. Basically all regulation mechanisms describing such or similar urban rules can be included in the simulation process.

Figure 10 Development-rules for Science City (ETH Zurich)

1. A maximum construction of 60-70% per lot. Minimum 10m of distance between lots.



2. Buildings need to be placed on the border of a lot or keep a minimum distance of 10m.



3. Each lot needs to have at least one pathway between its buildings, connecting two other lots.

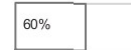
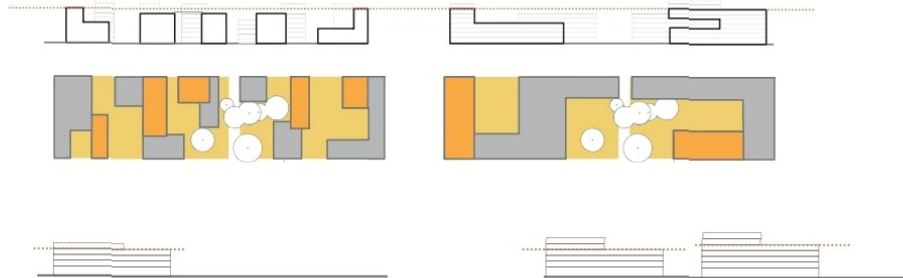


4. It is allowed to build on maximum 80% of the lot's surface without having a pathway or an opening of minimum 8m width and 7m height. This could also be an inner courtyard. Minimum distance between building volumes is 10m.

5. All four borders of a lot need to be occupied by a building.

6. Height rules

max. height: +544,50m



6.1. Within a lot the maximum height of 544,50m can be raised by one floor on 60% of the build surface.

6.2. When distributed on two levels, 100% of the build surface can be higher than the maximum height of 544,50m.



6.3 It is recommended to plan the ground level with a floorheight of 4.5-5m, to enhance public uses.

3.4.3 Challenges to expect

As the implementation of typologies into urban simulation processes, has not been performed yet, it is hard to predict all challenges that come up with this approach. This section will only mention some major challenges that are expected.

The integration of typologies as an attribute into the building-table of UrbanSim should be possible without any problems. The difficulty will rather be to define the categories of typologies and to extract them from given data.

Another expected problem is the categorisation of households and jobs (or enterprises) that shall relate to those typologies as this can only be based on survey data. It is likely that the results of such a survey being done in Zurich cannot be used as default values in other cities. Setting up a simulation environment with a typological model would require preliminary studies every time then. The use of a typological approach would then only be expected in operational models, and not in prototype-models.

The evaluation of dependencies between parcels and buildings will need historical datasets of those. These are often not available or associated to high costs. Creation (or extraction) of the needed information out of raster maps or aerial photos as described within the chapter “self-created data” would be an option, but is only possible for buildings and not possible for parcels. The needed evaluation therefore might only be possible within scientific research projects or for the preparation of operational models with government as the client.

The last big challenge will be the calculation of the geometric aspects for each element (building or parcel) of a simulation area. At present this can only be done outside of the OPUS-environment. For the Zurich case study the use of GRASS-GIS is envisioned at present but even having these tools the calculation time will become an issue.

3.4.4 Conclusion simulation and visualisation in UrbanSimE

UrbanSim has recently done the step from an aggregate gridcell model (with disaggregate data for households and jobs) towards a parcel-based model that is completely disaggregate. This highly detailed approach allows to account for geometric aspects that were not possible before. On the other hand those require the analyses and modelling of geometric rules:

Two forms of transformation are characterising changes in the urban tissue. Urban sprawl is the growth of the city by enlarging the surface of the city, often through transforming

landscape into urban landscape. This generally happens on big plots and will need methods to represent subdivision and developers behaviour. Urban transformation is the other form of urban change and is characterized by transformation within the existing urban tissue. These rely strongly on the given context of the city and can be modelled in the simulation process by typological models.

The typological approach seems to be the next logical step as it will allow to implement new relevant aspects of urban development and eventually derive others already needed in UrbanSim, e.g. the improvement value.

Additionally this approach creates new options for the simulation process. A 3D visual output in form of volumetric shapes of buildings and the evaluation of resulting local parameters, as the carbon-dioxide-footprint of an area can be named as example. This makes this approach a very powerful option.

As shown in the chapter “data” the acquisition of data for the parcel-based version of UrbanSim is a lot more involved as the one for the gridcell version and makes it a big challenge to set up an UrbanSim environment. The typological approach will need even more input data than the parcel version, which raises the question of efficiency.

In conclusion the focus at the beginning of a project should therefore lie on what kind of simulation result is needed. Is it a design evaluation that might be done with a prototype model or a fully operational model for regulatory decisions?

The implementation of the parcel-based version in the Zurich case study approach will show how much more effort is needed to create such a model in comparison with a gridcell-based approach. It will also give a feedback on how much better the results of simulation are. Only this can be the basis on decisions whether this approach is a significantly better one or not.

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APPENDIX

Annex 1: Data owners of Zurich case study (part 1 of 3)

Hierarchy	Office	Dataname	Content	scale	Costs (for ETHZ)
Governmental-federal	Swisstopo, federal office of topography	LK25, LK50, LK100	The pixel map with a scale of 1:25'000 is a topographic map of Switzerland with detailed representation of transport, settlement, terrain and vegetation. The hole area of Switzerland is divided into 247 single maps. Revision is made by sector within a cycle of 6 years.	25m	global agreement ETH
		DHM25	Digital terrain model. In a grid of 25m mesh size each point is assigned an x-, y-, and z-value.	25m	global agreement ETH
		Vector25	VECTOR25 is the digital landscape model of Switzerland that is based on the topographic map 1:25'000. VECTOR25 includes natural and antropogenic objects and is most suitable for usage in GIS. The topic layers are: road network, railway network, other transport infrastructure, hydrological network, primary areas, buildings, bushes and trees, facilities and single objects.	25m	global agreement ETH
		GG25	Contains the geometry and location of the administrative boundaries defining the municipalities. Municipalities are a very important spatial unit because a lot of data is aggregated to that level.	25m	free of charge
	Federal office of statistics (BFS)	Population census/STATPOP	The population census is describing the demographic, spatial, social and economic development in Switzerland. It es full survey based on written questionairs which are sent to the household per post. Attributes to the following entities are collected: Persons, households, buildings, housing units, residence, working location, school location.	table	global agreement ETH
		Public use sample of swiss population census	A sample out of the population census that is made publicly available on a CD-ROM.	table	free of charge
		Enterprice census (sector 1)	This dataset contains characteristic of firms and enterprices.	adress	new agreement for project
		Enterprice census (sector 2+3)	This dataset contains characteristic of firms and enterprices.	adress	new agreement for project
		Microcensus travel behaviour	In 2000 some 27, 918 households (29, 407 individuals) were questioned by telephone on the following main topics: ownership of vehicles, driving licenses and season tickets; daily amount of travel(number of journeys, time spent, distances); reasons for travel and use of means of Abstract: transport, journeys with overnight stays and air travel; attitudes to Switzerland's transport policy.	10%-census	global agreement IVT/ETH
		Federal building and dwelling register, (GWR)	All buildings dedicated to housing and all dwellings in Switzerland are registered within the building and dewlling register. Suveyed attributes are for example: parcel number, coordinates, category of building, construction period, year of renovation, area of footprint, number of floors, number of housing units.	adress	new agreement for part of data (see cantonal data GWR-ZH)

Source: Schirmer, P. and C.Zöllig, 2010 (SustainCity, ETHZ)

Annex 1: Data owners of Zurich case study (part 2 of 3)

Hierarchy	Office	Dataname	Content	scale	Costs (for ETHZ)	
Governmental-cantonal	Cantonal assurances of buildings	Data of buildings for canton and communities (GVZ)	This dataset contains all buildings, including non-residential buildings. Surveyed attributes are for example kind of building, construction year and value of building		new agreement for project	
	Office for regional planning and surveying	Cantonal building and dwelling register (GWR-ZH)	extract of Federal buildings and dwelling register			new agreement for project
		Construction zones	Contains the geometry and legal status of the construction zones. The legal status defines for example the allowed ratio of floorspace to land area.	polygone (zone)		new agreement for project
		Demands for building permissions	List of permissions being demanded to be able to preview future development projects and locate past projects.	adress		new agreement for project
		Data on development projects	Entities are development projects with attributes like: description of project, municipality, parcel number, constructing zone, type of principal, name and adress of principal, costs of the project, number of new buildings and dwellings.	adress		no information
		Parcels and Buildings as Geometries	Geometry of the parcels in the city of Zurich.	5-10cm		special contract otherwise very high
		Spatial development plans: -Transportation -Traffic -Infrastructure and Public Use	Political strategy of spatial development in the canton of Zurich concerning aspects of transportation.	concept		new agreement for project
		Points of Interests: Education, culture, health, leisure, recreation, infrastructure, administration, etc	facilities that are of interest for the residing or working population.	point		no information
		Orthophotos	orthographic photos are photos where the topographic distortion is corrected to allow measuring and to match GIS-files			new agreement for project
	Office for traffic and public works service	Generic Traffic model (GVM)				global agreement IVT/ETH
		Traffic model of Canton Zurich (KVM-ZH)				global agreement IVT/ETH
		Traffic model of Canton Zurich (Zoning)				global agreement IVT/ETH
		Traffic models of Canton Zurich (Public Transport)				global agreement IVT/ETH
	Office for traffic, Company of Public Transport (ZVV)	Station and Stops of Public Transport				new agreement for project
	Public works service, department of noise	Critical Noise immission value	Builds a summary of different kind of noises by defining an edge of noisy regions where residents are disturbed by noise. Includes street, rail, airplanes and shooting ranges.	Isophonic areas		new agreement for project
		Noise immissions, shooting ranges	Shows isophonic zones with a given decibel level produced bei shooting ranges.	Isophonic areas		new agreement for project
		Noise immissions, Fly-over	Shows isophonic zones with a given decibel level produced bei aircrafts visiting the airport of Zurich.	Isophonic areas		new agreement for project
		Noise immissions, street noise	Line segments (representing the street network) are assigned frequencies out of which noise emissions may be calculated.	Street		new agreement for project
		Noise immissions, rail and public transport	Line segments (representing the railway network) are assigned noise emissions levels (Leq for day and night).			new agreement for project
	Cantonal office of statistics	Population forecast Canton of Zurich	Number of people living in regions, wards and boroughs of canton Zurich. The age structure of the population is also available. Further more migration data is at hand.			no information
Estimated land prices canton of Zurich		The cantonal statistic office estimated land prices for each municipality with a multi-level-model. This model calualtes land prices for developed, unbuilt land dedicated to housing.			free of charge	
landprices and real estate prices Canton					no information	
Governmental-communal	Communal office of statistics	detailed indexes of land prices	Landprices based on construction kind (BOMA-Tables) Land trade information		no information	

Source: Schirmer, P. and C.Zöllig, 2010 (SustainCity, ETHZ)

Annex 1: Data owners of Zurich case study (part 3 of 3)

Hierarchy	Office	Dataname	Content	scale	Costs (for ETHZ)
private data	Self-created	Relocation Probabilities	Probabilities depending on households attributes. Based on questionnaire of S.Beige (2001)	parameter	free of charge
		Probabilities of branch relocation	Probabilities per industry sector. Based on dissertation of B.Bodenmann (2010)	parameter	free of charge
		<i>Share of home workplaces.</i>	Describes how many persons stay at home for working. Based on questionnaire of M.Löchli (2001)		
	Web-based	Real Estate prices	During three months a parser parsed a website, which lets its user upload and compare offers of housing units in Switzerland. The offers contain some attributes of the unit like address, size, period of construction and price offer.		free of charge

Source: Schirmer, P. and C.Zöllig, 2010 (SustainCity, ETHZ)

Annex 2: UrbanSim (parcel) requirements and related data in Zurich case study (part 1 of 3)

annual_employment_control_totals	Y	Control totals containing the aggregate targets for employment by sector. The annual_employment_control_totals table contains the control totals or aggregate quantities of employment that will be used to set the total employment in the model system for each year. Totals by employment sector are split into home-based and non-home based components, on separate records.	governmental-federal	enterprise census
annual_household_control_totals	Y	Control totals containing the aggregate targets for households by type. The annual_household_control_totals table contains the control totals, or aggregate targets for the number of households for each year.	governmental-federal	communal population statistics; population census; micro census (traffic);
annual_relocation_rates_for_households	Y	Annual relocation rates for households by type. The annual_household_relocation_rates table contains estimates of the probabilities of moving within the region for one-year time frames. The rates can be obtained from analyzing Current Population Survey data. Users can use any range or categorical variable (primary or computed) defined for households. By default it includes households of different income and age of head categories.	private data	relocation probabilities
annual_job_relocation_rates	Y	Annual relocation rates for jobs by employment sector, contains the probabilities that a job in a sector will relocate within the region within a one-year time frame.	private data	probabilities of branch relocation
buildings	Y	Individual buildings on a parcel. The buildings table in the parcel version of the model system is an individual building located on a parcel. There can be multiple buildings on a parcel (a many to one relationship). Buildings that are mixed use, such as retail on the first floor and apartments above, can be represented as two separate buildings, on the same parcel. The land area would generally be assigned by the user to each component as a pro-rated amount.	governmental-cantonal	cantonal building and dwelling register (GWR-ZH); data of buildings for canton and communities (GVZ)
building_sqft_per_job	Y	Non-residential sqft used by each job. The building_sqft_per_job table contains information on the amount of space each job will take in a particular building type, by zone.	governmental-federal governmental-cantonal	enterprise census; data of buildings for canton and communities (GVZ)
building_types	Y	Building types as classified by the user, usually at least 2 residential types and several non-residential types. The building_types table provides a list of the unique building types used to classify buildings. These typically are derived from local land use codes or building typologies.	governmental-cantonal	cantonal building and dwelling register (GWR-ZH); data of buildings for canton and communities (GVZ)
cities	N	List of cities within the region, primarily for indicators. The cities table provides a list of cities in the region and is typically used for computing indicators by city.	governmental-federal	GG25
counties	N	List of counties within the region, primarily for indicators. The counties table contains a unique list of the counties in the region. These are mainly used for computing indicators.	governmental-federal	GG25
demolition_cost_per_sqft	Y	The demolition_cost_per_sqft table provides information to the developer model about the costs of demolition by building type. These numbers are used to calculate the cost of demolition of existing development so that a more accurate cost of redevelopment can be calculated.	private data	<i>unknown at present; eventually info by developers</i>
development_constraints	Y	Regulatory constraints on development, from comprehensive plans or other sources. The development_constraints table defines constraints to restrict development on parcels. Each row in the table defines a unique constraint. The Development Project Proposal Sampling Model (DPPSM) generates proposals for a parcel using the constraint(s) and by selecting appropriate records from the development_templates_table that will fit on the available land of the parcel. The DPPSM determines the applicable constraint(s) for a parcel by selecting a record in the development_constraints table based on the parcel's plan_type_id (not generic_land_use_type_id). A parcel may have a constraint for 'far' and/or 'units_per_acre'. Note that this table is substantially different than its gridcell counterpart due to the differences in the real estate models of these versions.	governmental-cantonal	construction zones
development_event_history	N	Development projects that have been built over a historical period of (for example) 10 years. Not used in Development Proposal Choice Model. The development_event_history table provides historical data, usually over a period of 10 years, of observed development events. For the parcel version of the model system, these are individual development projects.	governmental-cantonal	cantonal building and dwelling register (GWR-ZH); data of buildings for canton and communities (GVZ)

Source: Schirmer, P. and C.Zöllig, 2010 (SustainCity,ETHZ)

Annex 2: UrbanSim (parcel) requirements and related data in Zurich case study (part 2 of 3)

1.1.1

TABLE NAME	OVERALL REQUIRED	DESCRIPTION	DATAOWNER	BASIS DATASETS IN ZURICH CASE STUDY
development_project_proposals	Y	Proposals for development projects, either user-specified or simulated . The development_project_proposals table is an optional table to include in the base year database. This table should be populated for the base year if the user desires to include known future projects. The model will generate this table for future years and include projects from the base year table if it is populated.	governmental-cantonal	data on development projects; demands for building permissions; cantonal building and dwelling register (GWR-ZH); data of buildings for canton and communities (GVZ)
development_templates	Y	User-provided templates describing different types of development projects. The development_templates table, along with corresponding records in the development_template_components table, represent templates that can be used to define virtually any size and configuration of a development project. The template structure is robust enough to include projects from a single house on an infill lot to a large subdivision, to a mixed use project with retail on the first floor and condominiums above. Templates are selected if the density and land_use_type_id fit within the constraints of a parcel with enough available land. Note that the land_use_type_id of a template does not need to match the land_use_type_id of a parcel. Instead, there must be a record in the development_constraints table with a generic_land_use_type_id that corresponds to the land_use_type_id of the template, and has a plan_type_id that matches the parcel.	private data	<i>to be defined</i>
development_template-components	Y	The development_template_components table represents buildings or parts of buildings included in a particular template. The records in this table are combined with the records in the DevelopmentTemplates table to generate project proposals. By breaking development templates into components, development project templates can be configured as hierarchies or combinations of building blocks, providing a very flexible means of representing a wide variety of development types. Note that the templates can be generated using real or hypothetical data, since they will be compared to regulatory constraints and the size constraints of parcels. This table is roughly equivalent to the development_project_proposal_components table.	private data	<i>to be defined</i>
employment_adhoc_sector_groups	N	Aggregations of employment sectors into groups such as basic, retail, service. The employment_adhoc_sector_groups table contains data for user-specified aggregation of employment sectors.	governmental-federal	enterprise census;
employment_adhoc_sector_group_definition	N	The employment_adhoc_sector_group_definitions table contains data for user-specified aggregation of employment sectors.	governmental-federal	enterprise census;
employment_sectors	Y	The employment_sectors table contains definitions for the employment sectors used to classify jobs by industrial sector. In the U.S. these are typically based on either the older Standard Industrial Classification (SIC) system or the newer NAICS (North American Industrial Classification System).	governmental-federal	enterprise census;
fazes	N	The fazes table contains a list of aggregated zones (the original name was Forecast Analysis Zones) which can be assigned by the user as any aggregation of zones (Traffic Analysis Zones used in the travel model) that would be useful for computing indicators or aggregate variables used in any of the models.	governmental-cantonal; private-data	traffic model of canton Zurich (zoning); MATSIM-output
generic_land_use_types	Y	Broad classifications of land uses. The generic_land_use_types table contains the generalized land use classification used for models such as the Real Estate Price Model.	governmental-cantonal	construction zones
home_bases_status	N	Indicator table for jobs that are home-based . The home_based_status table contains a (short) list of the home-based status values used to classify jobs.	private data	share of home workplaces
household_characteristics_for_ht	Y	The household_characteristics_for_ht table contains the classification used in the annual_household_control_totals table to determine how many households of particular categories will be in the region in a simulation year. Any attribute on the household table may be used.	governmental-federal	population census
households	Y	Household data, for socioeconomic and density variables . The households table contains the synthesized households for the region. It typically reflects an expansion of the Public Use Microdata Sample (PUMS) to approximate a 100% sample of households. Households may optionally be linked to individual persons, particularly for use in coupling to activity-based travel models.	governmental-federal	population census
households_for_estimation	N	Households table used in estimation, from a household survey with recent movers, if available. The households_for_estimation table contains a sample of households for the region, usually from observed data from a travel survey. It mimics the format of the households table, and is used to estimate the parameters for the Household Location Choice Model (HLCM). Ideally, if the household survey contains a question regarding how long a household has lived in their current address, this dataset will reflect recent movers (say within the past 5 years) since these reflect recent conditions.	governmental-federal	population census

Source: Schirmer, P. and C.Zöllig, 2010 (SustainCity, ETHZ)

Annex 2: UrbanSim (parcel) requirements and related data in Zurich case study (part 3 of 3)

TABLE NAME	OVERALL REQUIRED	DESCRIPTION	DATAOWNER	BASIS DATASETS IN ZURICH CASE STUDY
jobs	Y	Employment data, for accessibility and density variables . Jobs The jobs table contains an inventory of jobs for the region. It is usually derived from either ES202 Unemployment Insurance data which monitor businesses by state for unemployment insurance purposes (and have had issues historically with under-reporting self-employed and proprietor employment, and also with headquarter reporting of jobs in multi-establishment firms) or from commercial sources such as InfoUSA (which have different issues of rolling updates).	governmental-federal	enterprise census
jobs_for_estimation	N	Jobs table used in estimation, from sample of newly locating jobs, if available. The jobs_for_estimation table contains a sample of jobs for the region for estimating the employment location choice model. Ideally these would represent recently locating jobs, but sufficient data is not always available, and a sample of existing jobs is often used as a second best alternative.	governmental-federal	enterprise census
large_areas	N	Optional higher level geography, aggregations of FAZ geography (user-determined), for indicators . The large_areas table contains user-specified (optional) large areas that are aggregates of FAZes, and therefore of Zones. These are used for computing indicators.		<i>optional aggregation of "fazes" via GIS or administrative border as GG25</i>
parcels	Y	Parcels, usually based on property ownership, which may contain 0, 1 or more buildings . The parcels table contains attributes of individual parcels. Note that there may be alternative definitions of parcels, such as those based on legal boundaries or based on ownership. Most commonly used parcels are based on ownership since most relevant data (like land and improvement value) is associated with ownership records, though some applications (e.g. Honolulu) prefer using legal, or regulatory definitions. Either may be used. Note that additional geographies may be added by the user to the parcel table, using the same approach as below. If one wanted to add a geography called Neighborhoods, for example, one would put the neighborhood_id on this table, which is an integer reflecting the primary key of a table called Neighborhoods, which would contain one record per neighborhood, with a neighborhood_id (Integer) and a neighborhood_name (String(50)).	governmental-federal governmental-cantonal private data	GG25; parcels and buildings as geometries; construction zones; Spatial joins with construction zones & GG25 in GIS; <i>internet parser</i>
persons	N	Optional persons table, used for workplace choice model and activity-based travel model integration. The persons table contains the synthesized population for the region, linked to households. It typically reflects an expansion of the Public Use Microdata Sample (PUMS) to approximate a 100% sample of households and persons.	governmental-federal	population census
plan_types		Plan types are a composite of development regulations, represented as polygons in a GIS layer . The plan_types table contains the list of plan_types, reflecting some classification of land use regulations defining permissible uses and densities of future development.	governmental-cantonal	construction zones
race_names	N	Optional names for race groups defined in the synthetic population. The race_names table contains a list of the races and descriptive names from the census if racial categories are used in the model system.	governmental-federal	<i>no information; can eventually be derived of population census</i>
target_vacancies	Y	Structural or target vacancies - trigger development when vacancies fall below this . The target_vacancies table is used by the development proposal choice model. It gives the model information about acceptable vacancy rates. The table has one row for each year the simulation runs. Each row gives target values for the residential and nonresidential vacancies for that year, which are defined below. Only data after the base year is used.		<i>no information</i>
travel_data	Y	Zone-to-zone skims from the travel model, for accessibility variables. The travel_data table contains zone-to-zone morning peak period travel times for vehicles traveling in mixed flow lanes.	governmental-cantonal	traffic model of canton Zurich (KVM-ZH)
velocity_functions	Y	The velocity_functions table is designed to hold the velocity functions that specify the rate at which development occurs. A Development Project Proposal has a calculated variable called units_proposed that is the total number of units that will be built. The calculated variable annual_construction_schedule on the Development Project Proposal Components dataset uses units_proposed to select which of the velocity functions in this table should apply based on the building_type_id and units_proposed of the Development Project Proposal Component. The user can specify a record from this table, using the velocity_function_id, to specify the construction schedule for projects specified in the development_project_proposal base year table.		<i>no information</i>
zones	Y	Zones used in the travel model, for accessibility and density variables . The zones table contains attributes of traffic analysis zones used in the travel model.	governmental-cantonal	traffic model of canton Zurich (zoning)

Source: Schirmer, P. and C.Zöllig, 2010 (SustainCity, ETHZ)