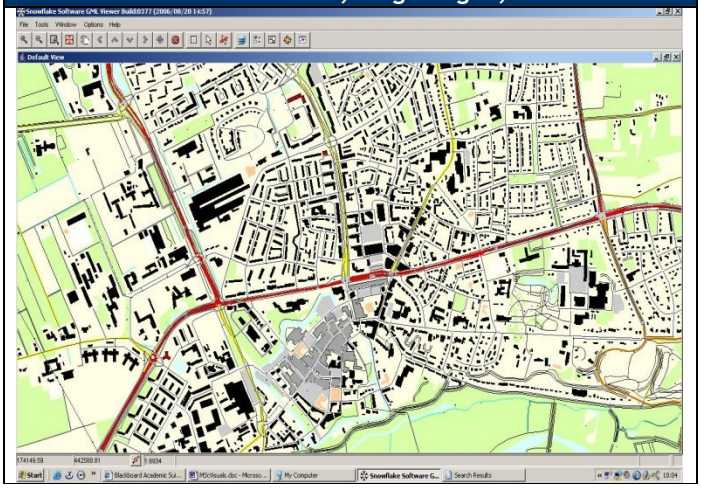
1 Annex: The urban design phases in the Netherlands

Reference: Chapter 3
The interviews conducted at the Municipalities of Rotterdam, Den Haag, Delft and Oldebroek revealed the urban planning phases. Each of the Dutch municipalities has their own terminologies and it is difficult to give a complete definition valid for all municipalities. Some of the urban planning phases are definitive and are used in different planning processes as inputs. For example the finalized land use and zoning plans (*bestemmingsplan*), master plan, urban phase, final architectural design, etc are milestones in the design process. However, there can be many intermediary phases, which are not standardized and can vary from municipality to municipality.

Land use & Zoning plans (*bestemmingsplan*)

For a certain area within the local municipality boundary the *bestemmingsplan* (zoning plan) is a juridical product that the municipality receives and sends in digital format (Annex Figure 1). This plan is compulsory and exchanged with the province (higher level in hierarchy) and other municipalities in the region (same level in the hierarchy). Until now each of the municipalities were creating the land use plans in their own standards, which made interoperability and exchange of data difficult if not impossible. The IMRO regulation makes it compulsory for the municipality to share land use plans with the citizens. According to the DURP project (*Digitaal Uitwisselbare Ruimtelijke Plannen*) the data format shall be GML (Geography Mark-up language) from 2007. The land use plan defines in which area what kind of development can take place and the function of the allocated land. It already defines what kind of height restrictions should be applied and what kind of construction and use of land is allowed, etc.

Annex Figure 1: Zoning plan (Bestemmingsplan) in GML format in Snowflake viewer, Wageningen, Netherlands



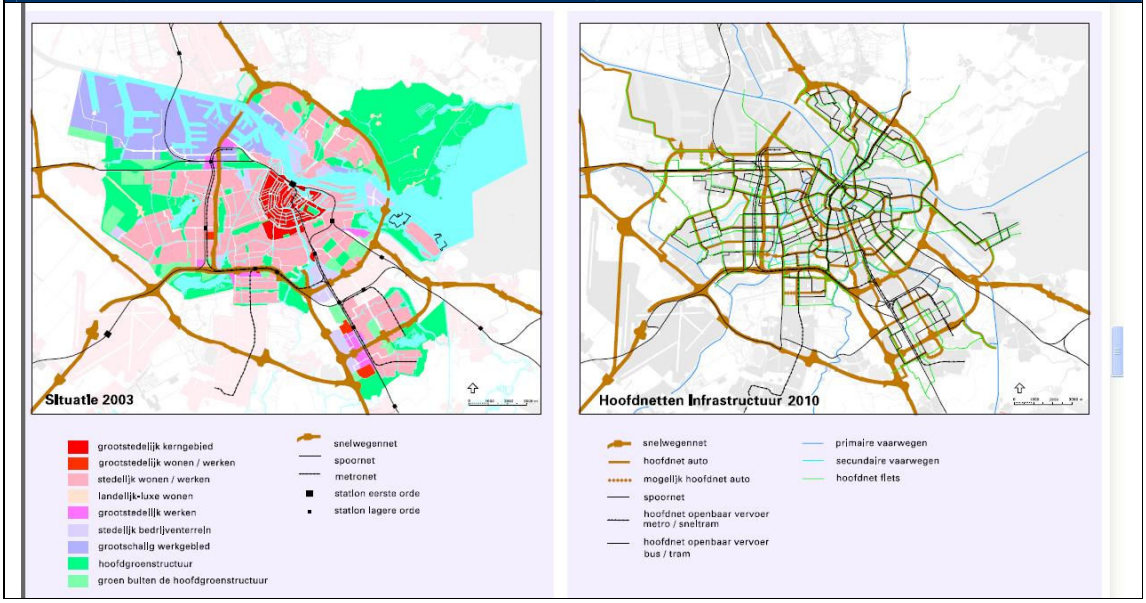
The Initiation Planning Phases

The municipality makes a master plan of that certain area for development according to the land use plans and zoning plans. But reaching the master plan can be a complex process and each of the municipalities in the Netherlands has their own steps of development. In most of the municipalities there is always structure plan often known as vision plan (‘*visie*’, ‘*gebiedsvisie*’, ‘*sturctuurplan*’, ‘*structuurvisie*’ (Annex Figure 2), etc) enlisted with a list of ‘program of criteria’ or ‘Programma van Eisen’ that have to be achieved. The ‘*Programma van Eisen*’ not only indicates how many houses, offices, shops, etc should be there in the plan but also the number of parking or the density of population of the area, etc. The document contains the juridical restrictions and the possibilities that are allowed according to the land-use plan. It acts as a contract document to move forward in

the design phases for the different involved parties (designers and the '*organizatie van opdrachtgever*') of what should be achieved when the final design is implemented.

The exact net square meters of the design area with the design requirements are enlisted (according to the NEN 2580 standards) in the '*Programma van Eisen*'. The document explains the spatial functionalities of the spaces and their logical inter-relationships. In the municipality of Rotterdam, the design process starts with the '*inrichtingsplan*', which points out free areas of development. In these open areas places are point out where it is allowed to build in the '*bouwplangebieden*' or building plan areas. Elaborated study is conducted to analyze the effects of '*bouwplangebieden*' or building plan areas in the '*gebiedsvisie*' or visionary plan of the area. Recently, in the municipality of Rotterdam, planners use GIS multi-criteria analysis to find appropriate building areas and formulate master plan.

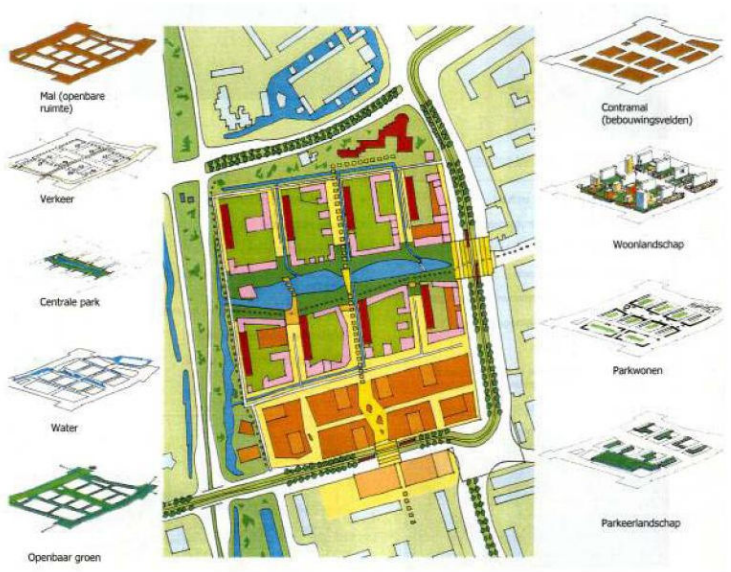
Annex Figure 2: Visual material used in *structuurplan* of Amsterdam, from www.amsterdam.nl



The Master Plan

The master plan (Annex Figure 3) is a flexible plan that gives a specific direction on the development of the built environment of a certain area. The master plan is a large-scale plan that shows the future shaping of the area emphasizing not on the detail but the important spatial relationships at large. Master plan can also be applied for the whole region. It is a sketch plan and usually altered in gradual steps. It also gives a social and economic character of the design. The master plan indicates the planning of functions of areas like shopping centers, schools, offices and houses etc. It is a global plan showing the financial feasibility of the design. Usually very simplistic 3D models and non-detailed 2D plans are used to visualize the master plan. When the master plan is implemented it is incorporated again to the land-use plan ('*bestemmingsplan*') fulfilling a loop (source: interview with Rotterdam Municipality).

Annex Figure 3: Master plan of Poptahof, Delft Municipality in 2D symbolic representation



afbeelding 6: Masterplan Poptahof

The master plan is the realistic logistic step for completing and putting all together the aspiration of the vision plan or '*structuurvisie*' of a certain area. This a global spatial translation of the '*structuurvisie*' and the basis of the development of a certain area that needs to be further developed into a detailed construction program. The master plan forms the base ('*onderlegger*') of the zoning plans ('*bestemmingsplan*').

The urban plan

The urban plan ('*stedenbouwkudig plan'*) is the detailed plan of the development of an area (Annex Figure 4, 5). A project developer, urban planning department or private urban design firms usually make the urban plans depending on the context. This comes out according to the '*gebiedsvisie*' or visionary plan. In general the urban plans shows where buildings will be built, how high should they be, the new streets, sidewalks, bicycle lanes, street lamps, gardens, plain etc. Often the urban plan is often a collection of sketches and description. The urban plan is a real scale plan, making distinctively clear what should happen in the plan in a detailed scale. But detailed sections and elevations of the buildings are not yet designed at this phase. A general section of the whole area shows the height and space relationship. The doors, windows etc of the building are not yet known.

The urban plans are made following the regulations being a part of the master plan. The difference between the two is that the urban plans are detailed and the master plan is generalized. In 3D the urban plans can be best viewed in simple large volumes to give an impression on the building heights, the notion of space created by parks or plains, distance to nearest shopping center, etc.

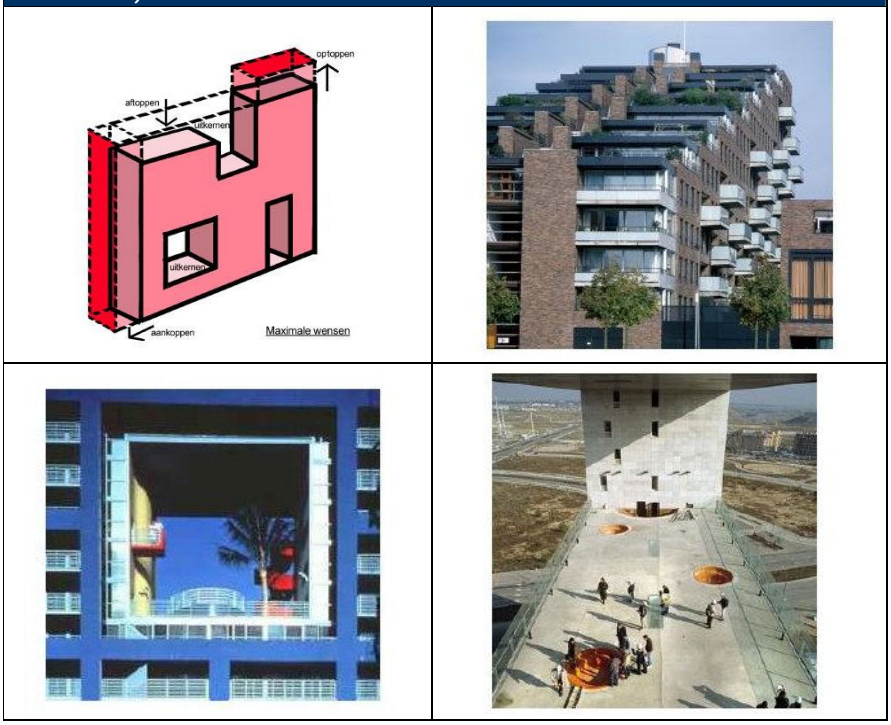
Annex Figure 4: Master plan of Poptahof, Delft Municipality in 2D symbolic representation

Annex Figure 5: Urban plan of Poptahof, Delft Municipality in full 3D iconic representation.

The SPvE phase

The next phase is called the 'Specification of Urban Plans' or '*Stedenbouwkundig Programma van Eisen (*SPvE)', which indicates the functions and the detailed volumetric structure of the buildings (Annex Figure 6). This is a toolbox used by the professional group in the design process like the urban planner to allocate spatial functions in space. It contains details like density of inhabitants, functionalities the spaces should have, spatial arrangements in square-meters, etc.

Annex Figure 6: Visual materials used in SpvE phase where the urban plan and the requirements (roof terrace, punch and passage) are visualized, Potahof.



In this phase, all the spaces are allocated in precision for each of the functions and they are enlisted. Often such development projects of a certain area are conducted in the combination of housing corporations ('*wooningbouw corporatie*'), project developers and real estate investor. Working together with such different actors, can be achieved if there is a workable and feasible SPvE. The SPvE is used to follow suit the urban plan ('*stedenbouwkundig plan*') and the restrictions as mentioned in the land use plans ('*bestimmingsplan*'). The completion of this phase can be a long-term procedure, depending on the scale of the project. It contains and points out the judicial possibilities, restrictions of the area from many sectors like nature, traffic etc. It is often accompanied by the façade quality of the buildings or the '*beeldkwalitiesplan*'.

The architectonic-quality plan (*beeldkwaliteitsplan*)

The architectonic-quality plan ('*beeldkwaliteitsplan*') is detailed enough to show architectural aspects and aspiration and the form and shape of the buildings. This is a toolbox for the urban planners to communicate with the architects. It represents the architectural aspiration of the project area when implemented. This means that this plan should not only show the height of the buildings but also the building forms, window openings, choice of material and the type of greenery. Usually the '*beeldkwaliteitsplan*' is shown also in combination of reference pictures of similar projects done by the design firm. There is lots of interaction going on during this phase between urban planners and architects, architects and clients and urban planners and citizens, etc. The architect communicates with the urban designers through this toolbox and designs the building in detail based on the aspirations present in the '*beeldkwaliteitsplan*'.

1.1.1 Temporary & Definitive Design

In large-scale urban projects there is usually an initial architectural design or '*voorlopig ontwerp*' done in detail containing the allocated functions to individual rooms/spaces with building facades. In a case of a large-scale urban renewal project the architectural firm also makes a separate program called the '*Bouwkundig Programma van Esien (BPvE*)' that respects the parts containing the installation and technical aspects of the construction.

Annex Figure 7: Finalized architectural model of Poptahof, Delft Municipality in full 3D verisimilar representation.

When the initial design is completed (Annex Figure 7), it gives the first architectural impression of the building project. This stage of design it needs to fit in the construction area in terms of functions, transport, nature, technical aspects and quality of architecture, etc. The design is shown to the citizens/clients to get response on their satisfaction level. The citizens or clients interact and comment on the initial architectural design that is used as inputs for the final design. This leads to the definitive design or '*definitief ontwerp*' and the design process ends. However, interior architectural firms usually complete the interior design of urban spaces and buildings.

2 Annex: Visual interaction between actors in urban design and planning in the Netherlands

Reference to Chapter 3

2.1 Interview results: Rotterdam, Den Haag, Delft and Oldebroek Municipality

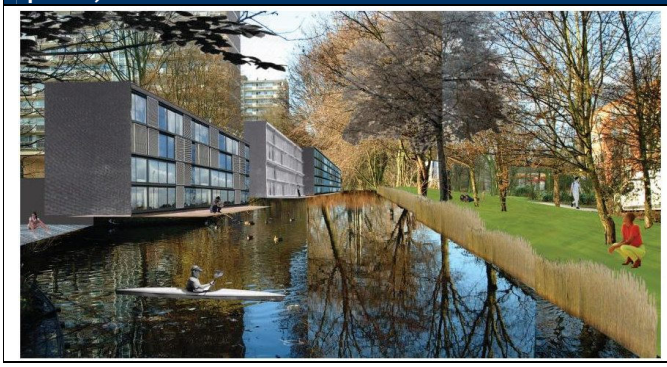
At the elicitation phase, interviews at four municipalities of the Netherlands revealed how the Municipalities interact with exterior actors through visual objects. While dealing with design projects, the urban planning departments of the Dutch municipalities undergo a lot of communication procedures and inter-exchange of ideas between various actors that are involved. Many of the communications related to design are visual interactions. All the municipalities have Internal Web Map Viewers (2D). Usually interaction with the citizen is arranged through '*gespreksavonden*', email contact, municipality web sites, etc. Land use plans are disseminated through the Internet as static maps on municipality web sites for the citizens.

2.1.1 Visual interaction using digital reference images

When explaining designs, the architects and planners use reference pictures, photographs, panoramic pictures, etc as communication mediums (Annex Figure 8). The citizens, decision makers etc tend to associate these graphic images as certain end product for the design especially in the digital form. Even though the goal of using images is to study the design aspiration of the area, the non-professional actors (specially citizens and '*gemeenteraad*') complain about the color and textures of facades used in the graphic images. They imply that through the image the finished state of the building is presented. (Interview with urban planner in Delft).

Reference pictures and computer images are used in the beginning phase of the design. What happens with reference pictures is that the citizen shows interest in matters of least importance that are not directly related to the design itself (Interview with urban planner, Delft). There is risk of misunderstanding if detailed representation through reference pictures is shown too soon to the citizens (Interview with urban planner, The Hague).

Annex Figure 8: Reference image (Cyclomedia) collages with 3D digital model, Poptahof, public spaces, Delft



2.1.2 Visual interaction through digital 2D maps/plans

In the cognition of human understanding, certain colors represent certain objects in the real world and this can be misguiding if they are not used properly. For instance, blue is always understood as water body and green as vegetation. In digital 2D maps the straight edges give an impression that the design is definitive. The urban renewal project of Poftahof plan in Delft was presented in 2D

through a clear layout using abstract neutral colors. The urban planners in the municipality used neutral colors only wishing to have discussion about the plan. But as the layout was clear and the buildings were shown in defined straight lines people thought that the design was definitive and little feedback was shown. There is always a need of oral, textual and graphical explanation to accompany the maps and models in a virtual environment. (Interview with urban planner, Rotterdam).

The citizens have difficulties to mentally visualize design in 2D plan view. The future occupants in the Delft Poptahof urban renewal project missed out the high-rise tower in plans that were presented in 2D. Later there were complains that the views from some of the balconies will be blocked. In 2D maps, it is important that the actors do not become overwhelmed by the amount of information as people can grasp only a certain amount of information at a time (Interview with draftsman, Rotterdam). Care should be taken in the use of legends and texts in 2D maps, as improper use hinders transfer of information in the digital environment. Orientation of 2D maps is difficult for citizens. Location of the maps is easy to grasp in 2D than in 3D. Designers prefer 2D maps with provisional alternative plans, as they do not imply definitive solutions. There are always risks of knowledge-gap if design is shown in such static 2D. (Interview with urban planner, Rotterdam, Delft, The Hague). The combination of 3D models and 2D plans can improve the situation. A virtual environment has promises in these regards.

2.1.3 Visual interaction through digital 3D models

Using 3D models enhances the perception of design compared to only 2D maps. In 3D models it is usually easier to find directions and navigate if the user can relate to a known reference point in the 2D map (Interview with urban planner, Rotterdam). Sometimes the area chosen for urban renewal is quite known to the citizens and the municipality can get proper feedback if urban plans are shown in 3D. (Interview with urban planner, Oldebroek) Realism in 3D models is desirable when the design reaches a definitive stage (Interview with urban planner, Delft).

In the urban project in *Haarnasploder* in Delft, the municipality had designed 2/3 storey buildings and the project was shown in 'bird's eye view'. The future occupants got the impression that they were high-rise flats. This implies that design needs to be shown in human scale. In 3D, actors often complain about the absence of windows and doors in 3D block models. But the utility of such block model is to analyze volumetric envelopes and space created within the volumes. They are not supposed to represent the façade quality or materializing of the building project. On the other hand if the design is only presented at 'human eye level' many people miss out the bigger picture as seen in Annex Figure 9.

Annex Figure 9: Design presented in eye level with human activity, Poptahof urban project, Delft

Therefore, a synchronous combination of 2D map, a 3D view showing street level activities and a representation of the whole 3D model in axonometric view can improve the perception of the viewer. (Interview, Municipality of DH). It becomes obvious that in the 3D environment, views in street level should be present. Communication in urban design is a bottom up approach and therefore the citizen is more interested in his/her own street than how the whole neighborhood

looks like from the sky. The citizens and city councilors (*gemeenteraad*) have difficulties in the translation from 2D plans to 3D models. (Interview with urban planner, The Hague). Often 3D virtual spaces look often deserted and unfriendly. Friendly space in 3D models can be created when there are activities going in the space with people involved (Interview with urban planner, Delft). Sound (oral) and textual explanation is needed to make visual materials dynamic and eventful (Interview with urban planner, The Hague).

The risk of digital visualization is that visual materials (models, maps) seem to be very polished and definite (Interview with urban planner, the Hague). In urban planning the present situation needs be presented with the final design for the citizens for comparison and judgment. (Interview with urban planner, Rotterdam). 3D panoramic views on different clickable points in the synchronized 2D map can visualize the present condition. The final design can be presented in textured 3D on the same site. (Interview urban planner, Rotterdam) But there will always be a need for hand-made models for some specific reasons. (Interview with urban planner, Municipality of Den Haag).

There is a relationship of representation of digital 3D models and the design phase. If the design is not definitive it is better to visualize the design in sketchy representation in rough lines and not through photo-realistic 3D scenes (Interview with Urban Planner, Delft). Usually politicians, policy makers and citizens are hard to convince with 3D block models (volumetric models). On the other hand, textured 3D models can make the design look excessively beautiful hindering objective opinion. Detailed 3D models at the initial stage give wrong impressions to the public that might be not implemented in the final stage. Textured models give the impression of the construction materials and colors of building façade relate to specific object or material. There is a difference of how the different phases of urban design are represented. In the '*land use plan (bestemmingsplan*)' and '*master plan*' phase to communicate with the citizens the municipality uses sketchy drawings. On the other hand in the phases of '*urban plan (stedenbouwkundig plan)*' more detailed drawings and models are used. The municipality of Delft found that the citizens had difficulties understanding the sketchy representation compared to the detailed urban design.

In terms of human perception, what is noticeable is that large-scale plans are often difficult to perceive by the citizens, especially if the design is at an initial stage (Interview with urban planner, Rotterdam). Users often are not interested to look carefully and read the plans. When plans are shown in high 'level of detail' at street level citizens can perceive information better, but there is always risks that people get too involved in design and this makes alternation difficult. Therefore, awareness is needed to implement a new visual interaction medium especially in terms of usability, perception and technical complexity. In this regard the context of trans-cultural issues in the perception of space in digital environment need attention.

> *'It may be that all human beings have the same perception of space at the biological level of perception. But certainly every society uses its space differently, both technologically and artistically'.* (J. David Bolter 1986, Turing's Man, p 80)

2.2 Conclusion

From the interview at the four municipalities the following conclusion can be drawn about interaction through visual materials with actors in different planning phases:

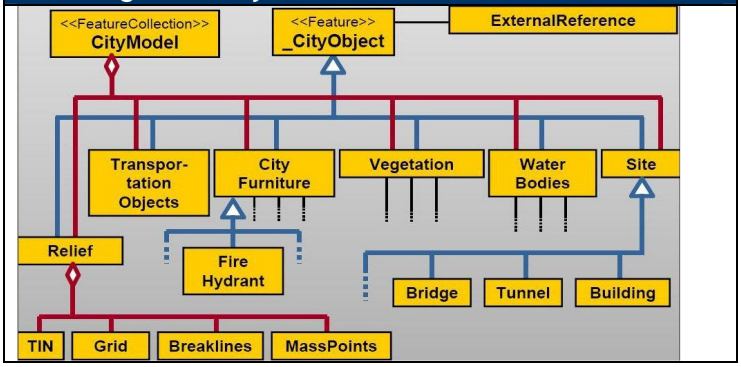
	Annex Table 1: Finding of present situation of interaction with visual materials at Dutch Municipalities
1	At this moment the visual material that are used in visual communication are reference images, panoramic photos, handmade sketches, 2D digital maps, and 3D models (both digital and handmade).
2	The biggest risk in using visual materials is passing wrong information to the citizens. People are different and the information they extract from the visual materials is different. Show only what you want to design and shows only in proper representation methods.
3	Plain 2D plans and 3D models are static. Through combination of text, graphs, animation and oral explanation they become interactive. 3D space looks deserted without human activities.
4	Navigation through the 3D models and appropriate orientation in 2D maps help user understand design better. Proper interaction with the visual materials make then intelligible to users.
5	The use of digital visualization environment where the citizens can access the information at multiple places and different time-settings make the flow of information fluid.
6	In 3D, a reference point is necessary for directions and should be synchronous and simultaneous movements in the 2D plan view. Visualization of design should take a bottom-up approach.
7	There is a relationship to the phases of urban design and the 'type of representation' and 'level of detail' of the visual material.
8	When the design becomes certain, digitally photorealistic 3D representation can be used. Mechanical tools and pencils are used in the initial stages. As the design progresses, so does the use of digital materials.
9	The design passes from different phases and proper visualization be supported in different level of detail and representation of these phases.
10	The larger the scale the more difficult the design is to understand for citizens. But the more detail a design or plan becomes the more complex the information in the data reaches to the point that some abstraction in visualization is necessary.
11	Building design process is usually a top down process but communication using visuals is a bottom up process. Thus while urban design is implemented from larger scale to eye-height, communication through visualization needs a bottom-up approach.
12	Visualization in a virtual environment will not be a substitute of the existing condition but a supplementary for the Municipality to interact with citizens.

3 Annex: Representation of urban objects in CityGML thematic- schema

Reference to Chapter 5

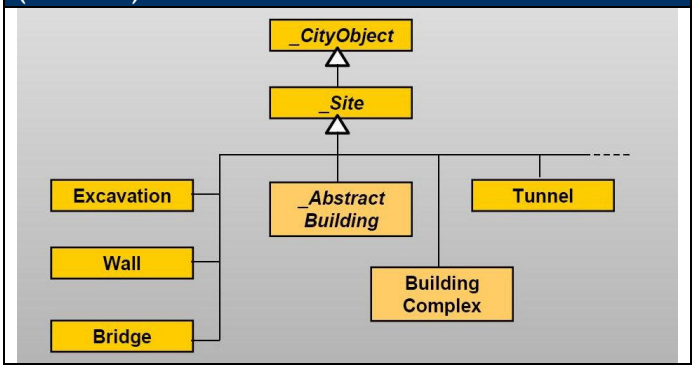
A. The CityGML format higher-level class contains a CityModel, which is a subclass of _CityObject that contains a Site. The site contains a building. The _CityObject can have external reference of KML/Collada and X3D/VRML models.

Annex Figure 9: CityGML overview of the thematic schema



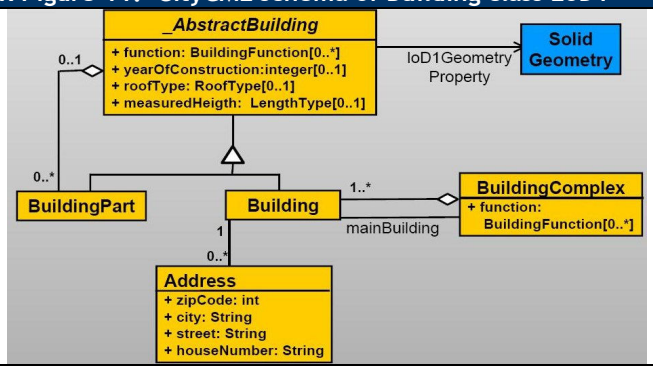
B. The CityGML _AbstractBuilding contain a geometric class schema based on GML 3.1 schema. But it contains also Building and BuildingParts.

Annex Figure 10: CityGML schema of Site class (thematic)



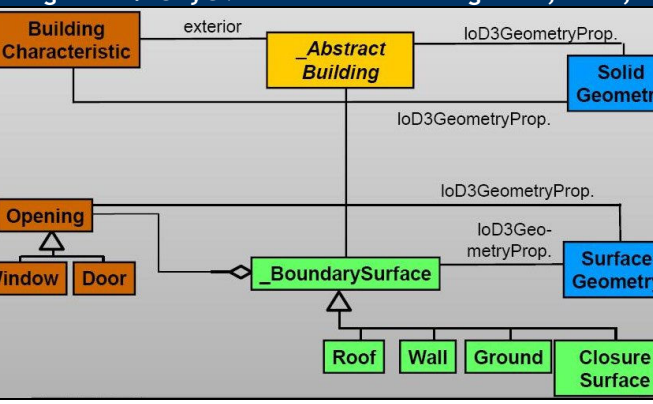
C. The CityGML LOD1 building contains the following features as seen in the diagram. The LoD1 model does not have any roofing or exterior envelope in the structure. However it inherits the Address class. The building does not have any boundary surface. The function of the building is defined in the BuildingComplex class.

Annex Figure 11: CityGML schema of Building class LoD1



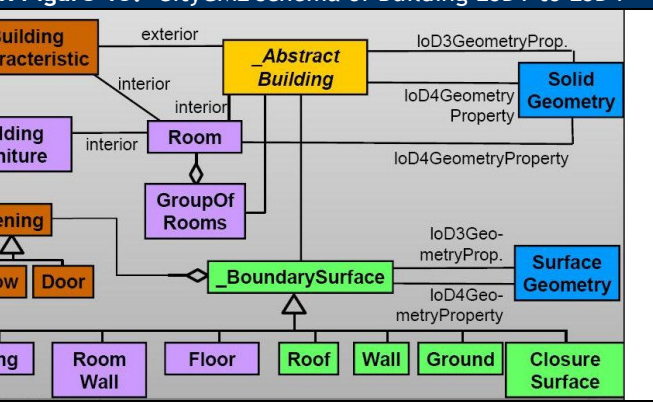
D. The CityGML LoD1 to LoD3 models have the following thematic features. The thematic and geometric features that LoD1 contains are inherited by LoD2 model. All the thematic and geometric features of LoD2 model have is inherited by LoD3 model. The features of LoD2 are seen in GREEN and the features of LoD3 building model are seen in BROWN in the figure below. The LoD2 model has a boundary surface, which contains the roof, wall, ground, etc. The LoD3 model inherits all these features but it has also an Opening class. The Opening class contains the Window and Door.

Annex Figure 12: CityGML schema of Building LoD1, LoD2, LoD3



E. The last LoD4 building models has all the features of LoD3 model but it contains also a navigable building interior. The features of LoD4 are seen in VIOLET. The Room class represents the interior of the building. The Room can have furniture. More than one room can be grouped together as GroupOfRooms class.

Annex Figure 13: CityGML schema of Building LoD1 to LoD4



4 Annex: Sample survey questionnaires

A. 'Survey 1': The functionalities of geo-VE

Reference to Chapter 6

The Participating Municipalities, housing agencies participated to validate the required functionalities of geo-VE. The survey population was asked to fill in all the answers and in case of no data '0' was used, as it doesn't help come to a decision. **Total survey population = 30.**

Annex Table 2: Virtual environment for interaction with actors in urban planning

Introducing an Internet based 'Virtueel Environment' can be used for many purposes. Through such a system designers and decision-makers in the Municipality can be able to communicate with the public and related organizations (like *welstandscommissie*, housing associations, architectural firms, etc) about urban projects. This can lead to better acceptance of the municipality decisions by the involved users.

Amsterdam is available in Google Earth. Municipalities of Helmond and Tilburg already have such virtual cities available via the Internet.

See Virtueel Helmond at http://www.virtueelhelmond.nl/
See Virtueel Tilburg at http://www.virtueeltilburg.nl/
See Virtueel Apeldoorn at http://www.virtueelapeldoorn.nl/

Agreeability/Necessity Index

Uw Naam: Joris Bak
Uw Functie: Projectleider Stadmodel Rotterdam
Uw bedrijf: GW, Gemeente Rotterdam

Index	Necessity
5	Absolutely Necessary
4	Necessary
3	Desirable
2	Not Necessary
1	Absolutely Not Necessary
0	Don't Know/No Answer

How to fill up the form:

If you work at a municipality you are requested to answer for both Citizens (burgers) and for the Municipality (*Medewerker*). Needs for Citizens according to Municipality means the functionalities Municipality will provide for citizens. Needs of Municipality's Internal Staff: means functionalities Municipality wants to have for internal use. If you are not working for a municipality please fill up the functionalities you think are necessary for the citizen and your own organization by filling your organization name. (Need of Organization Name).

It follows an Index of 5 to 0 as seen above right. Where '5' is the highest and '1' is the lowest in the rank. Fill '0' if you do not have an answer.

Example

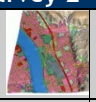
Chart 1: Design Communication	Needs of citizens according to Municipality	Needs of Municipality's Internal Staff	Needs of…….
	Necessity Index (5-0) See above right corner	Necessity Index (5-0) See above right corner	
System should be built preferably with Open Source Software.	2	4	
User should be able to measure the objects like building height, streets width, etc.	1	0	

B. 'Survey 2': The visual materials of geo-VE

Reference to Chapter 6

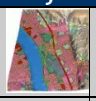
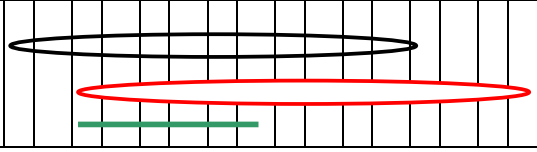
Survey 2' has three types of questions and they are as seen in sample questionnaire as below. It is assumed that the use of the visual material to each of these types of questions is not certain. With firm certainty, it cannot be declared that a certain design phase is best suitable only in 2D or 3D visual material. The participants are given a free choice (3 block as seen below) to answer the specific questions. Ellipses or straight lines are used to answer these questions. When a block is filled up, it gets a number '1'. All the numbers on the single block (or point) is added up to find how many people agreed on the certain decision point. This is called the added agreeability (Annex Table 4, 5). **Total survey participants= 30.**

Annex Table 3: Sample of designed questionnaire 'Survey 2'

						
Visual Material>	Text, graphs & images	Plan and Maps	Volumetric block models	Volumetric envelope model	Detailed architectural model	Detailed model with interior
Parameter X	1D	2D	3D	3D	3D	3D
Parameter Y, etc	NA	NA	LOD1	LOD2	LOD3	LOD4
A. How does human beings perceive design through the use of visual materials (VM) in the virtual environments?						
B. How the visual materials represent different urban design phases (in various dimensionality and LoD)?						
C. Which visual material in the 3D scene is suitable for friendly navigation, guided orientation, to show difference between designed and existing situation, spatial analysis, etc?						

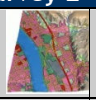
Let us say three people answered that for Master plan the following type of visual materials should be used. The results are in black, red eclipse and green line.

Annex Table 4: Sample of designed questionnaire 'Survey 2'

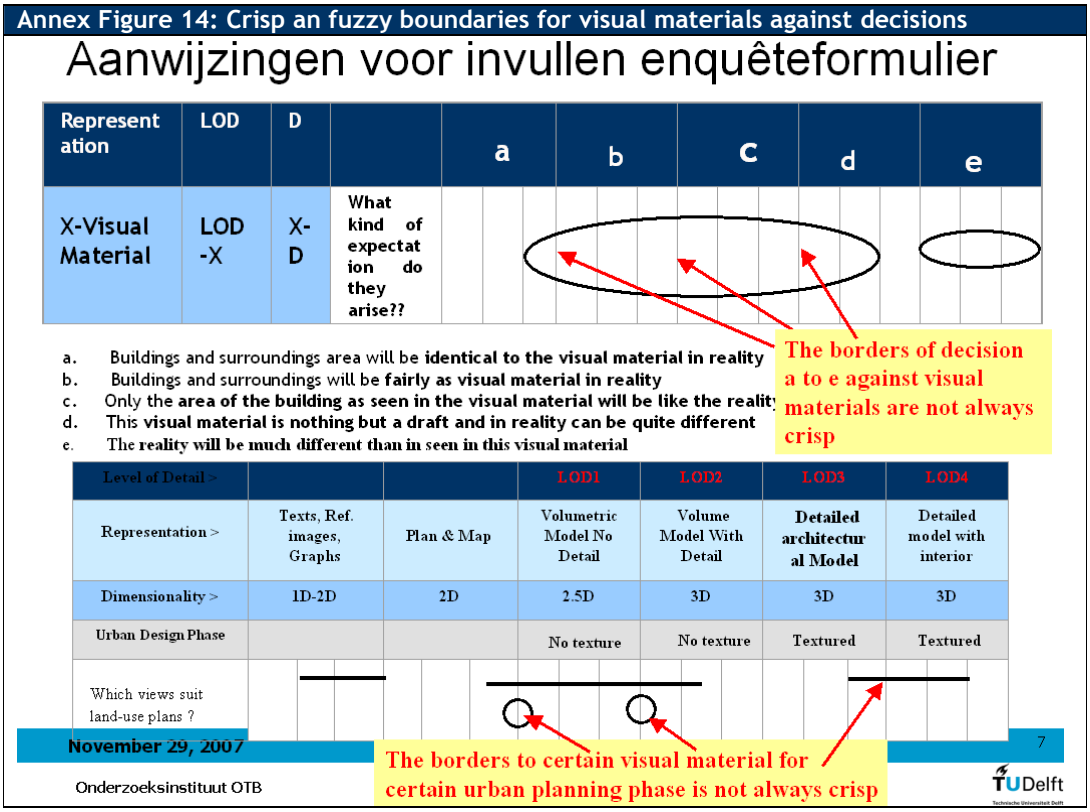
						
Visual Material>	Text, graphs & images	Plan and Maps	Volumetric block models	Volumetric envelope model	Detailed architectural model	Detailed model with interior
Parameter X	1D	2D	3D	3D	3D	3D
Parameter Y, etc	NA	NA	LOD1	LOD2	LOD3	LOD4
Which visual material is best suitable for the representation of the master plan phase?						

The total added agreeability of the survey population in this case will be as followed. From the results it can be seen that at least 3 people agreed that 2D plan and map and 3D LoD1 models are best suitable for the representation. These values are regarded as the points where the most people agreed upon a certain decision.

Annex Table 5: Sample of designed questionnaire 'Survey 2'

						
Visual Material>	Text, graphs & images	Plan and Maps	Volumetric block models	Volumetric envelope model	Detailed architectural model	Detailed model with interior
Parameter X	1D	2D	3D	3D	3D	3D
Parameter Y, etc	NA	NA	LOD1	LOD2	LOD3	LOD4
Which visual material is best suitable for the representation of the master plan phase?	1 1	3 3 3	3 3 3	2 2 2	2 2 1	1 1

Annex Figure 14: Crisp an fuzzy boundaries for visual materials against decisions



The three blocks for each of the visual materials represents the degree of freedom to answer the questions.

5 Annex: Interview results on the software components to build *Stadmodel Rotterdam* (according to Rotterdam Municipality)

Reference to Chapter 6

The Municipality of Rotterdam has inclination about implementing the CityGML specification (OGC 07-062, Candidate) for 3D data exchange and storage for the final stage of 'Stadmodel Rotterdam' for multiple purposes. They want to visualize urban design and architecture for interaction with the citizens in web based geo-virtual environments. At the same time the municipality wants to use the 3D models for other purposes like cadastre, disaster management, tourism, facility management, traffic, augmented reality visualization of utility pipes, etc. Implementing CityGML LoD for urban objects can help to use 3D data in various applications. The spatial information for '*3D Stadmodel Rotterdam*' at the initial state is not stored in database but they are file based LoD1 and LoD2 models in KML 2.1 format.

ArcGIS is widely used in the Dutch municipalities and a well-defined approach to generate 3D LoD1 base models in ArcGIS environment can aid the municipalities to create parametric base models in LoD1. Applying the same technique will keep the quality and integrity of models comparable. The base models for *Virtueel Tilburg* are generated from height information and GBK(T) and Cyclomedia images are used to texture them. A specific method for generating parametric 3D models from 2D footprints and LIDAR height information is discussed in Annex 6. (The prototype models are used during interviews) Using editing tools these LoD1 base model can be converted to higher LoD models.

The interviews revealed the choice of data and software for the construction of '*Virtueel Rotterdam*'. For constructing the initial version of VE (Virtueel Rotterdam: Stadmodel versie 1.0) for Rotterdam Municipality has the following choices:

Annex Table 6: Data components for Stadmodel Rotterdam

Choice	Motivation	
File based	Version 1.0 for the VR model is file based, shapes from KBK, GBK, raster from AHN, 2.5 D and 3D objects and models.	
Choice GBK/KBK	Basic LoD1 models are made from GBK(N),(R), KBK (N), (R) footprints	
Choice AHN	AHN is the only large-scale datasets, which the Municipality has at this moment to get height information of all the footprints for the VR model. ANH needs to be filtered to get the best results. AHN without buildings can be used for the DTM, which can be draped with land-use 2D maps. Other height information like TopHoogteMD, NAP etc are not feasible.	
Choice Cyclomedia	The textures of the buildings can be found from Cyclomedia.	
Choice Height	The method of taking average or median height from AHN+GBK/KBK data can be found in Annex 6 for generating base models in LoD1.	
Choice 3D objects/landmarks	Many 3D models of landmarks can be found in Google's 3D Warehouse. *Hogeschool Rotterdam* made the Rotterdam Landmarks. The LoD1 models made in ArcGIS environment can be further worked out in SketchUp 6.	
Choice new urban areas	Architecture and urban design firms to which the municipality out sources development projects should be consulted for detailed 3D models of newly designed urban areas.	
Choice Software/ Plug-in	**Editors/Developers**	**Viewers**
	ArcGIS (ArcScene)	Google Earth (Software)- KML
	SketchUp 6, Autocad 2007	Bitmanagement (Plug-in)-X3D
	3D Geo, 3D Max	LandXplorer/Aristotle (Software)-CityGML
	Flux Studio 2, X3D editor	Virtuocity Cebra B.V. (Plug-in)- X3D

As CityGML is based on the GML 3 schema, it is possible to index and manage it within spatial databases. It will be possible to store information in a spatial DBMS visualizing this information on the fly in KML or X3D. CityGML can be a rich information source for the generation of 3D visualization in X3D and KML. Online streaming of CityGML is a problem due to large datasets[1] and therefore, both X3D and KML are preferable for 3D visualization. The software like Google Earth, Bitmanagement plug-in, LandXplorer and Cebra BV's VirtuoCity (*Virtueel Tilburg, Apeldoorn, Helmond*), etc virtual environments are rich in one to many of the functionalities regarding controlling, experiencing, interacting, exploring, elaborating but there are fundamental differences how these interfaces work. The functionalities of these environments are depended on how their respective data formats are defined.

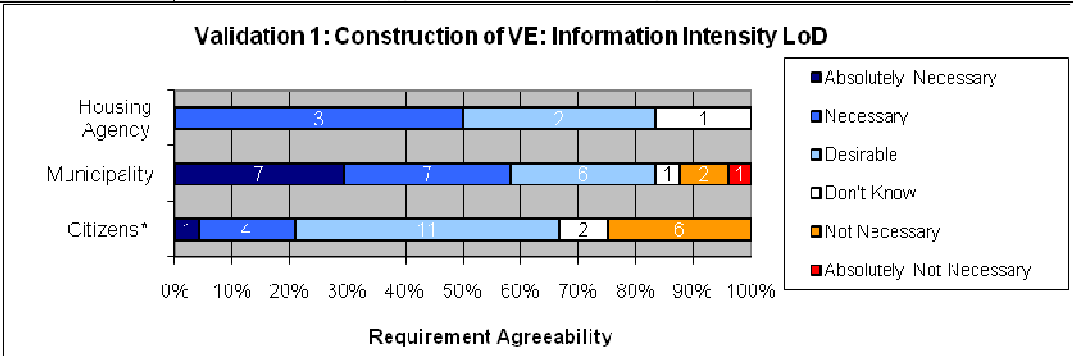
With the development of feature converters like Safe Software FME, data conversion between CityGML, KML, X3D/VRML, etc will be facilitated. FME 7 beta can read CityGML and export to VRML. The VRML files can be converted back and forth to X3D (and other 3D formats, like KML, dgn, dwg, 3ds, etc) in data fusion software like Flux Studio 2, Blender and Google's SketchUp. Besides XML conversion engines like XSLT can be used to convert CityGML to KML or X3D for visualization purpose. The '3D Geo Creator for Google Earth' is commercially available software that can convert CityGML data to KML.

[1] GML based data can be uploaded in the client only when the whole information is transferred through the Web Feature Service (WFS). Streaming is not possible in GML based 3D information models like CityGML.

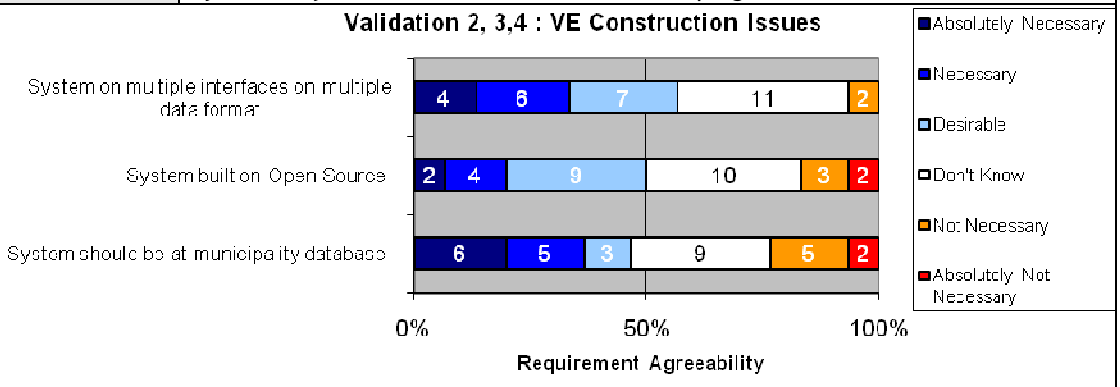
6 Annex: 'Survey 1' graphs on Required Functionalities of geo-VE

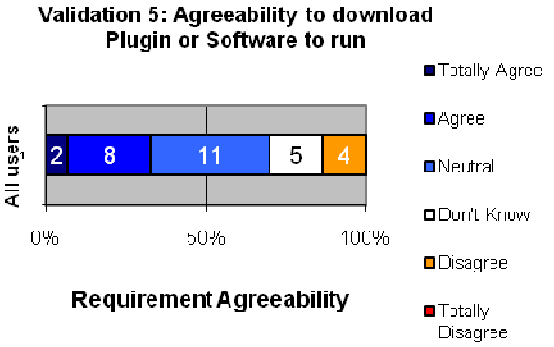
Reference Chapter 7 section 7.1
A total of **30 participants** participated in the survey.

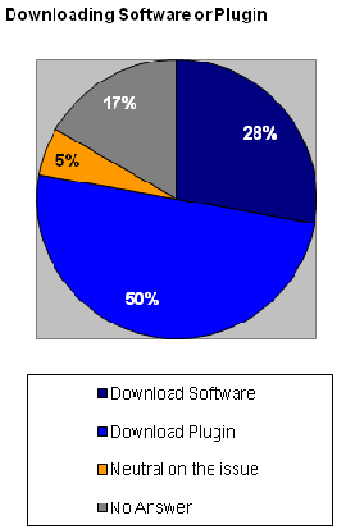
Domain	**Construction of 3D Scene (Also validation 30-33)**
Functionality	***Information Intensity LoD***
Validation 1	System should allow the visualization of various design phases (*masterplan, stedenbouwkundig plan, beeldskwaliteitsplan*, etc) in various LoD models.



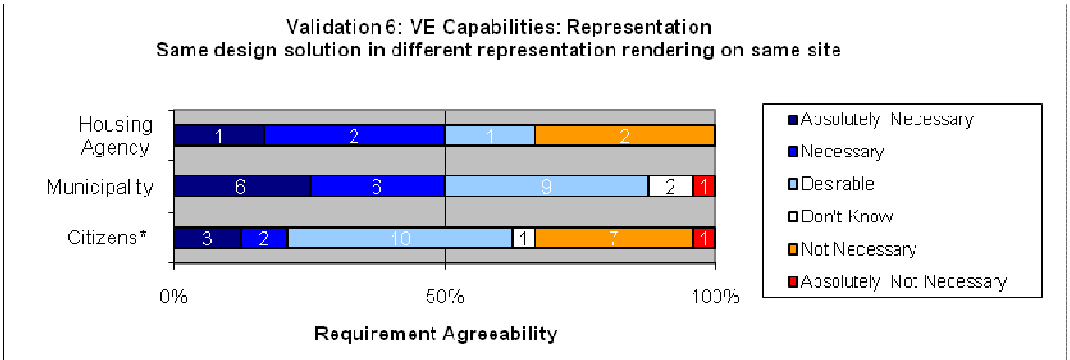
Domain	**Construction of VE System**
Functionality	Location of Datasets
Validation 2	System should be situated in a central database at municipality & not at an external party.
Functionality	Open Source
Validation 3	System should be built preferably with Open Source Software
Functionality	Different Data types and Interface
Validation 4	System should have more than one front-end Interface using various data-formats (like KML, X3D, VRML, GML, CityGML (WFS), etc) to decrease software dependency
Functionality	Plug-in and Software Download
Validation 5	System may have to download a software or plug-in to run on the Internet.

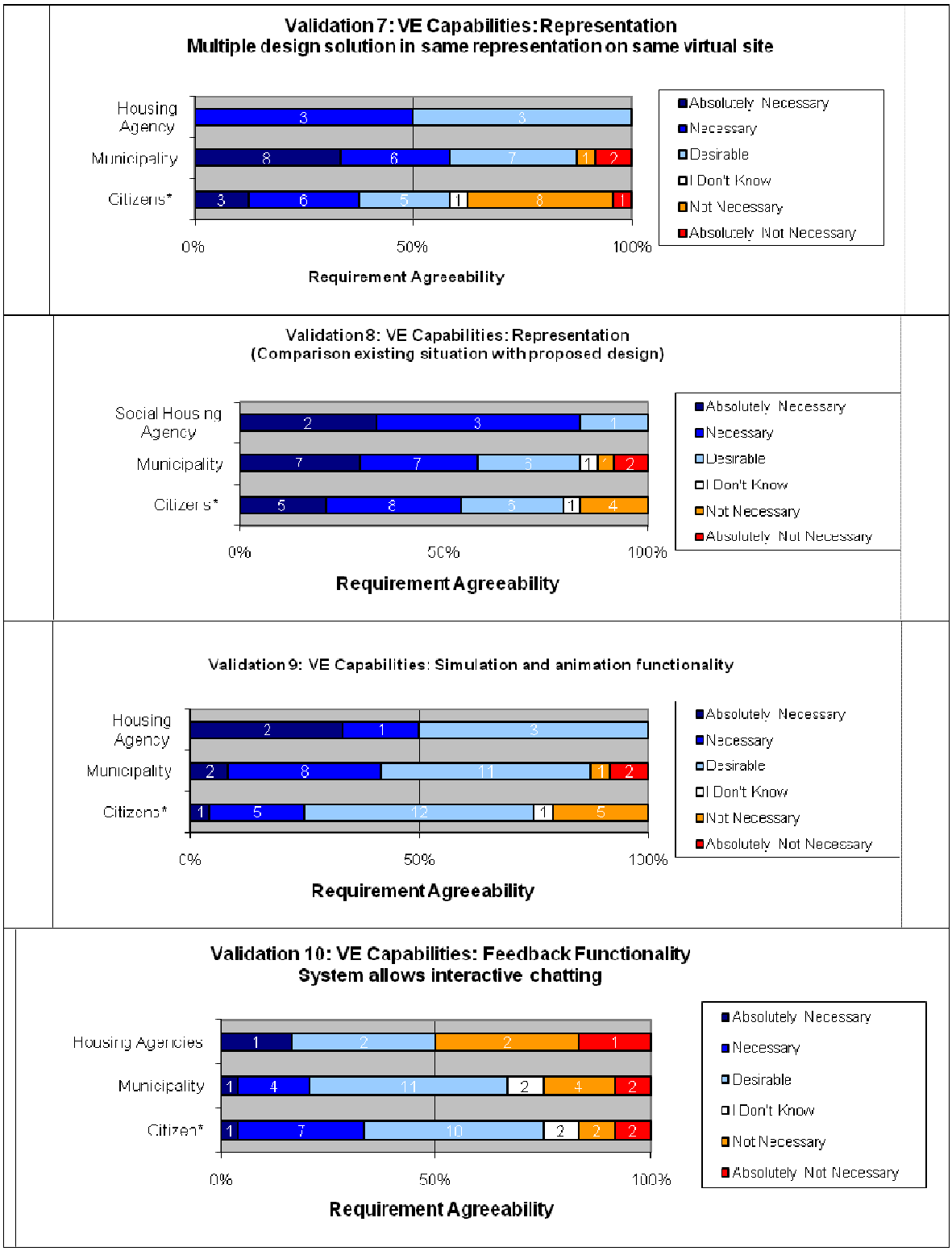


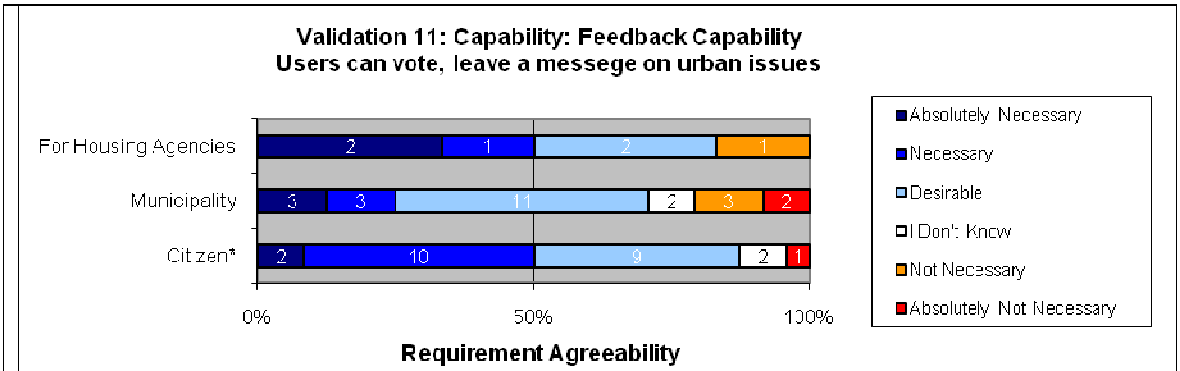


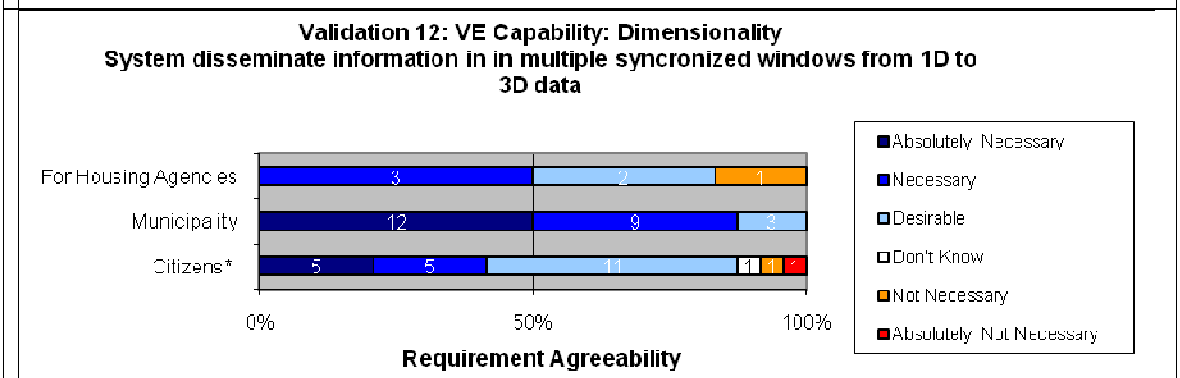


Domain	Capabilities of 3D Scene
Functionality	***Representation***
Validation 6	System should allow the visualization of more than one design solution on same virtual site in order to make a judgment (different geometry models in same rendering representation on same site).
Validation 7	System should allow the visualization of same design solution in various representations and rendering on same virtual site to make a judgment (same geometry different rendering representation on same site).
Validation 8	System should present comparison between the old situation and the new design of an urban project.
Functionality	***Animation and Simulation***
Validation 9	System should be able to make simulation (time & other parameters) and animation (movies) for presentation.
Functionality	***Feedback***
Validation 10	System should allow the users to interactively chat with each on urban design issues (Same time different place).
Validation 11	System should allow the users to leave a leave message, vote or email (feedback) on certain urban issues. (Different time-different place).
Functionality	***Multi-Dimensionality/Viewpoints***
Validation 12	System should allow the visualization of urban design projects in multiple dimensions (1D, 2D, 2.5D, 3D) in multiple synchronized windows using multiple viewpoints.

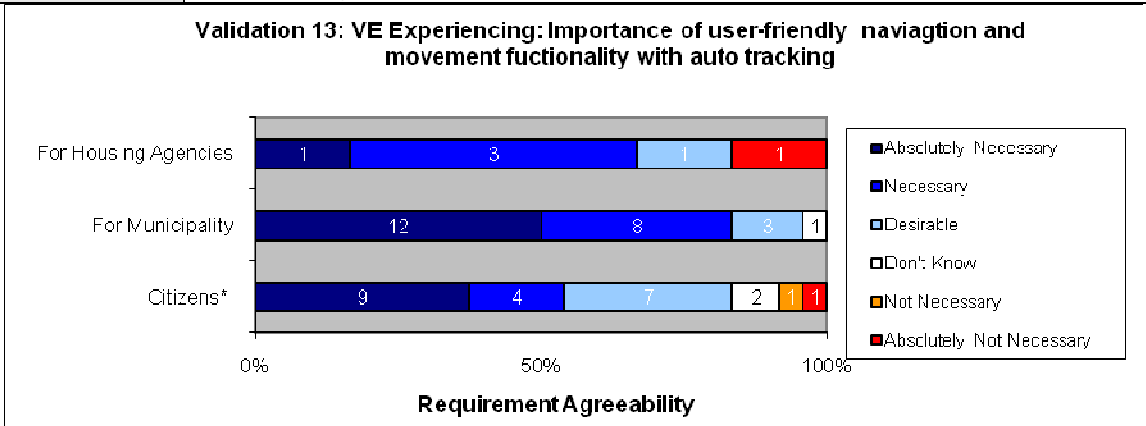


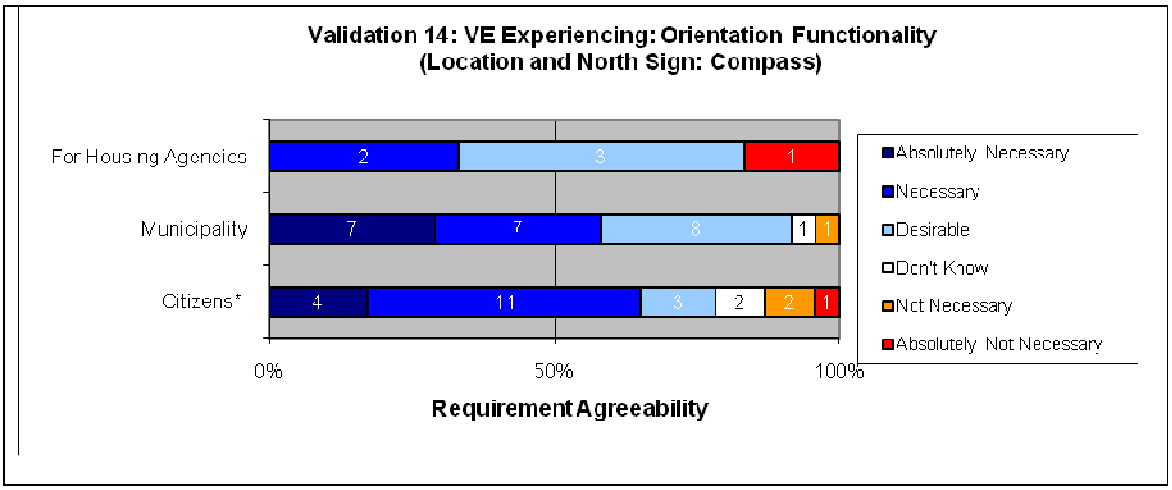

Validation 7: VE Capabilities: Representation
Multiple design solution in same representation on same virtual site
Housing Agency
Municipality
Citizens*
3
3
8
6
7
1
2
3
6
5
1
8
1
0%
50%
100%
Requirement Agreeability
Absolutely Necessary
Necessary
Desirable
I Don't Know
Not Necessary
Absolutely Not Necessary
Validation 8: VE Capabilities: Representation
(Comparison existing situation with proposed design)
Social Housing Agency
Municipality
Citizens*
2
3
1
7
7
1
2
5
8
1
4
0%
50%
100%
Requirement Agreeability
Absolutely Necessary
Necessary
Desirable
I Don't Know
Not Necessary
Absolutely Not Necessary
Validation 9: VE Capabilities: Simulation and animation functionality
Housing Agency
Municipality
Citizens*
2
1
3
2
8
11
1
2
1
5
12
1
5
0%
50%
100%
Requirement Agreeability
Absolutely Necessary
Necessary
Desirable
I Don't Know
Not Necessary
Absolutely Not Necessary
Validation 10: VE Capabilities: Feedback Functionality
System allows interactive chatting
Housing Agencies
Municipality
Citizen*
1
2
2
1
1
4
11
2
4
2
1
7
10
2
2
2
0%
50%
100%
Requirement Agreeability
Absolutely Necessary
Necessary
Desirable
I Don't Know
Not Necessary
Absolutely Not Necessary



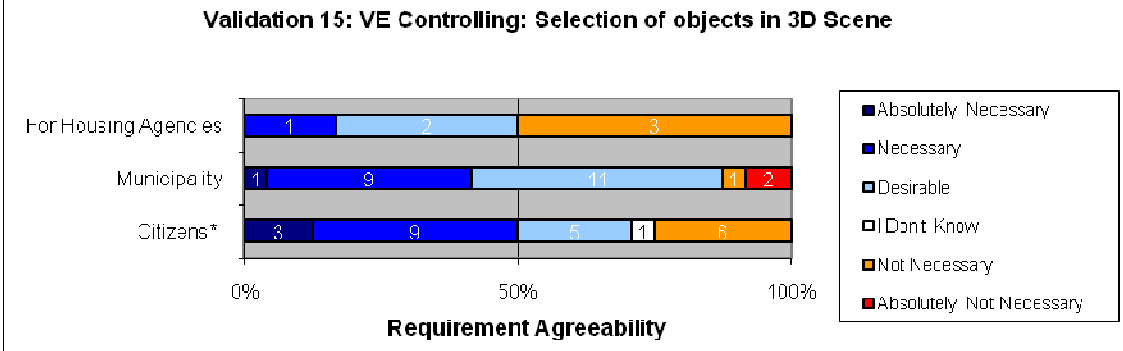


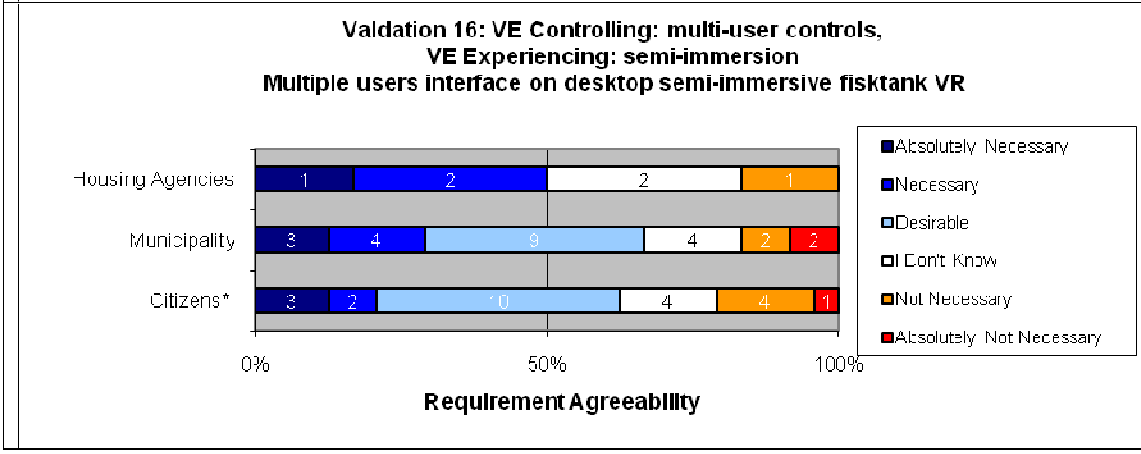
Domain	Experience of 3D scene
Functionality	***Navigation & movement aids***
Validation 13	System should have user-friendly navigation and movements in the 3D environment (zoom, pan, jump, walk, crawl to, look at, fly, etc) with the help of automatic focus and tracking.
Functionality	***Orientation Aids***
Validation 14	System should show the user's location on screen (in separate 2D map view) and the 'north sign' for better orientation.



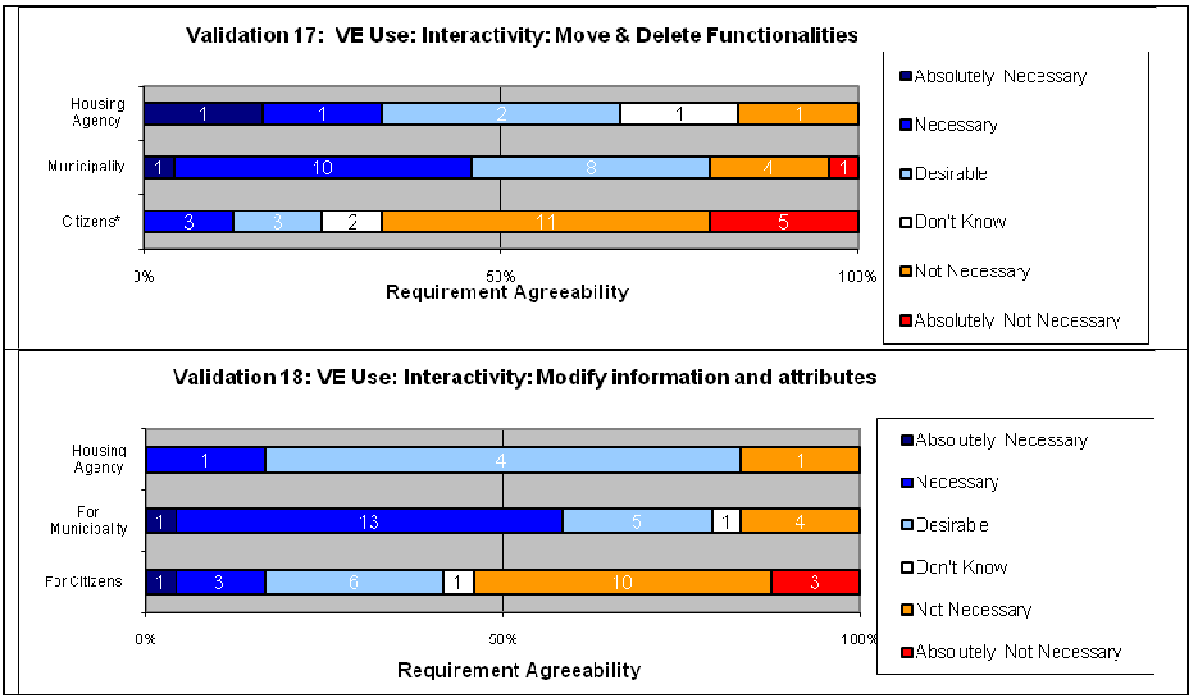


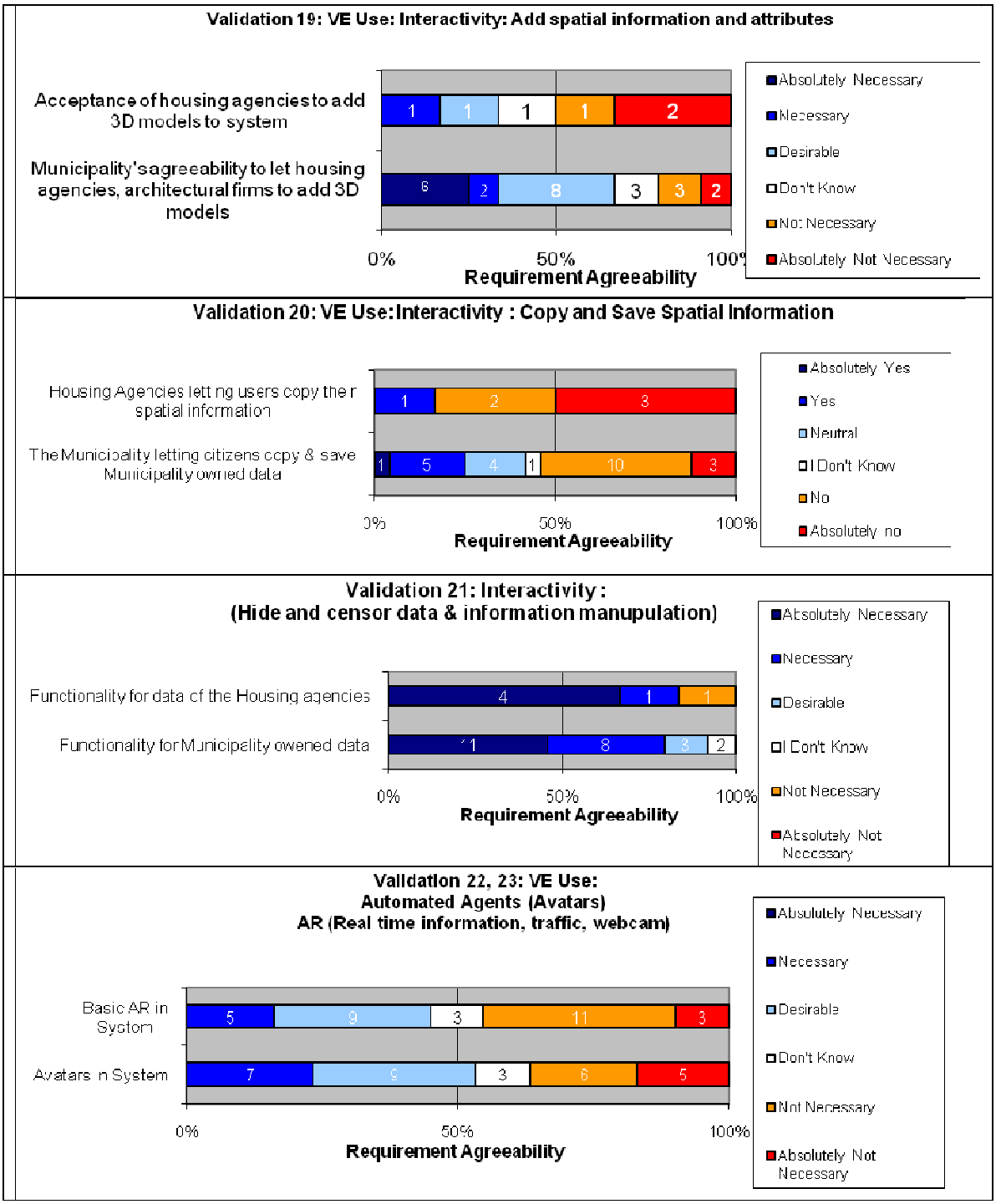
Domain	Controlling of 3D Scene
Functionality	***Selection of scenes***
Validation 15	*System should let the users click & select 2D plans & 3D models in the 3D scene through direct keyboard/mouse control*
Functionality	***Multi-user, Semi- Immersion***
Validation 16	*System should be built on multi-use interface on desktop semi-immersive VR (meaning more than one user can use the system and immersion on Fisk Tank VR)*



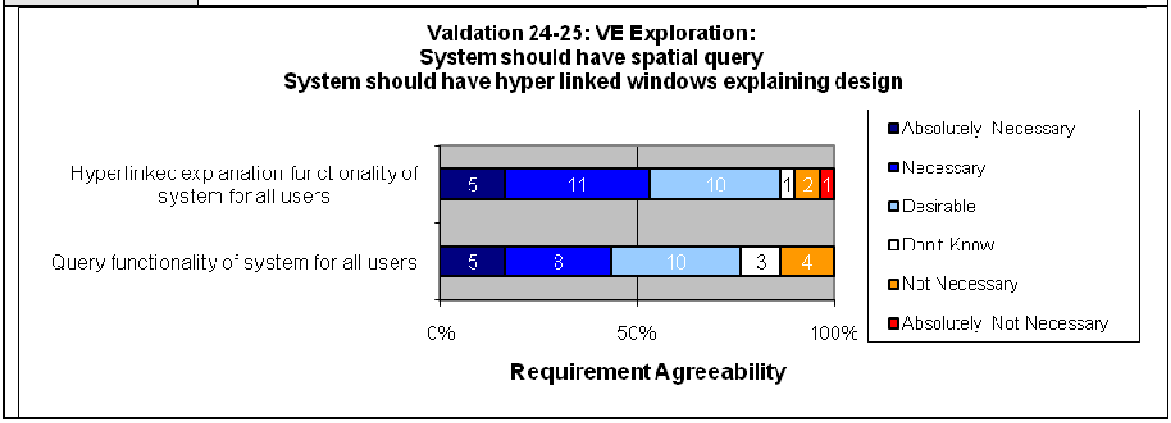


Domain	Use of VE
Functionality	***Interactivity (move, delete, attribute change, hide)***
Validation 17	System should let user move and delete 2D plans & 3D models temporarily in the local computer (to see various design options).
Validation 18	System should let user modify colors, transparency, size and information of 2Dplans/3D models temporarily in the local computer (to see various design options).
Validation 19	System should let users add own 3D models on empty-land parcels (for external actors like citizen or real estates through authorization from the Municipality).
Validation 20	System should let users copy and save 2D plans & 3D models (municipality owned) from the system to own local hard disk.
Validation 21	System should give the Municipality/Housing agency the possibility to stop/hide/censor sensitive or undecided design projects from viewing.
Functionality	***Augmented Reality***
Validation 22	System should have real-time information (traffic, webcam connections, web feeds, other information, etc) needed for the appropriate users).
Functionality	***Automated Agents (Avatars)***
Validation 23	System should allow the user to enter virtual environment system logging in as Avatar (humanoid object), representing user in real life (name, age, location).

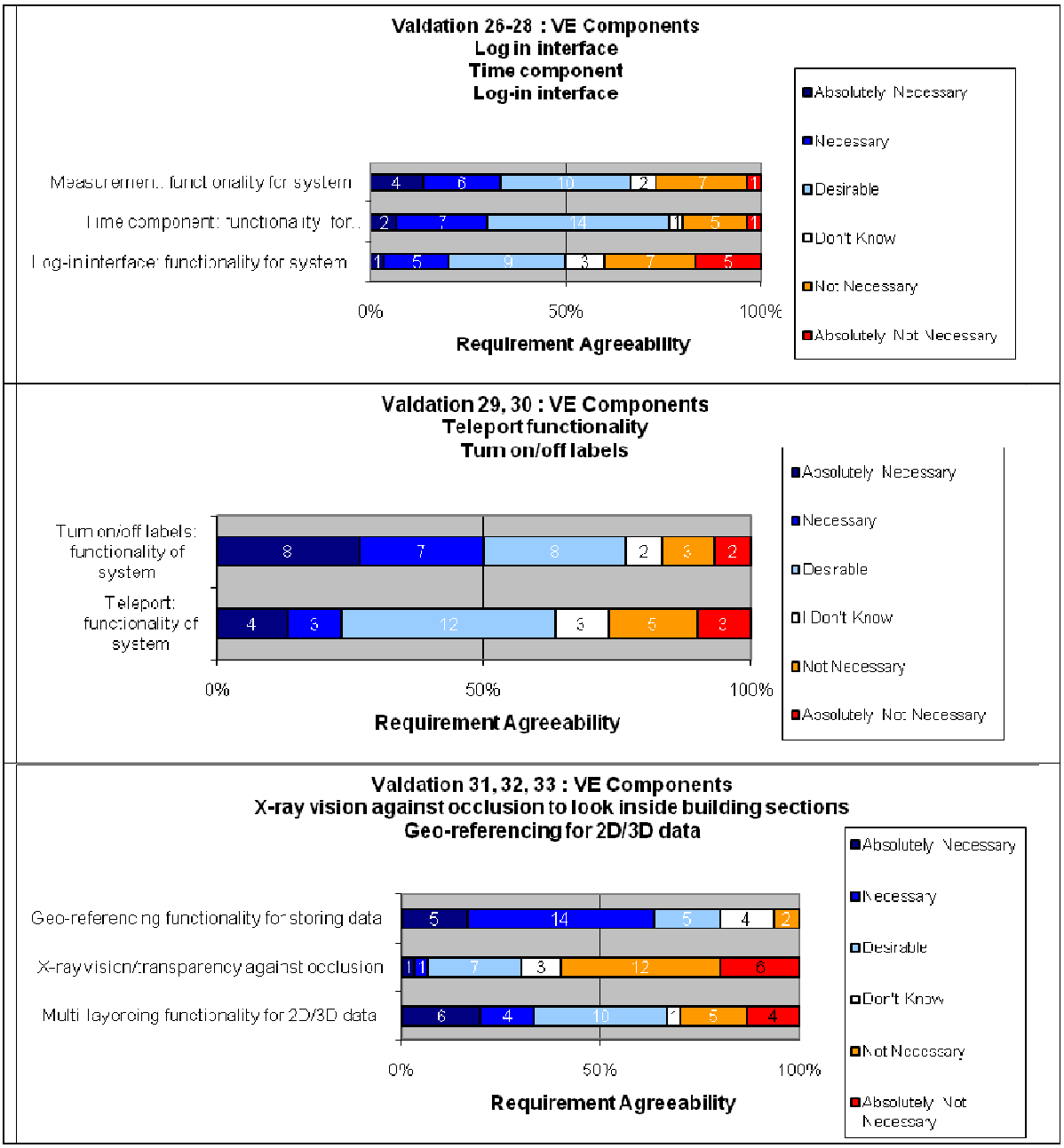



Validation 19: VE Use: Interactivity: Add spatial information and attributes
Acceptance of housing agencies to add 3D models to system
Municipality's agreeability to let housing agencies, architectural firms to add 3D models
1 1 1 1 2
6 2 8 3 3 2
0%
50%
100%
Requirement Agreeability
Absolutely Necessary
Necessary
Desirable
Don't Know
Not Necessary
Absolutely Not Necessary
Validation 20: VE Use: Interactivity : Copy and Save Spatial Information
Housing Agencies letting users copy their spatial information
The Municipality letting citizens copy & save Municipality owned data
1 2 3
1 5 4 1 10 3
0%
50%
100%
Requirement Agreeability
Absolutely Yes
Yes
Neutral
I Don't Know
No
Absolutely no
Validation 21: Interactivity :
(Hide and censor data & information manupulation)
Functionality for data of the Housing agencies
Functionality for Municipality owened data
4 1 1
1 8 3 2
0%
50%
100%
Requirement Agreeability
Absolutely Necessary
Necessary
Desirable
I Don't Know
Not Necessary
Absolutely Not Necessary
Validation 22, 23: VE Use:
Automated Agents (Avatars)
AR (Real time information, traffic, webcam)
Basic AR in System
Avatars in System
5 9 3 11 3
7 9 3 6 5
0%
50%
100%
Requirement Agreeability
Absolutely Necessary
Necessary
Desirable
Don't Know
Not Necessary
Absolutely Not Necessary

Domain	Exploration of VE
Functionality	***Spatial Query***
Validation 24	System should allow online search to find a street, area (*wijk*) postcode, etc for the users.
Functionality	***Hyper Links, Linked Windows***
Validation 25	System should have hyper linked windows to other websites, datasets, WMS/WFS, reference pictures, panoramic photos, textual and oral for elaboration of 2D/3d models

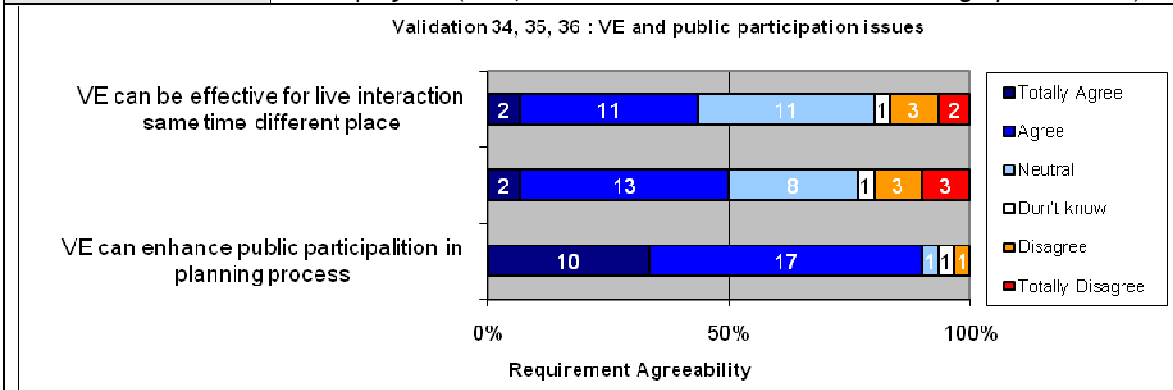


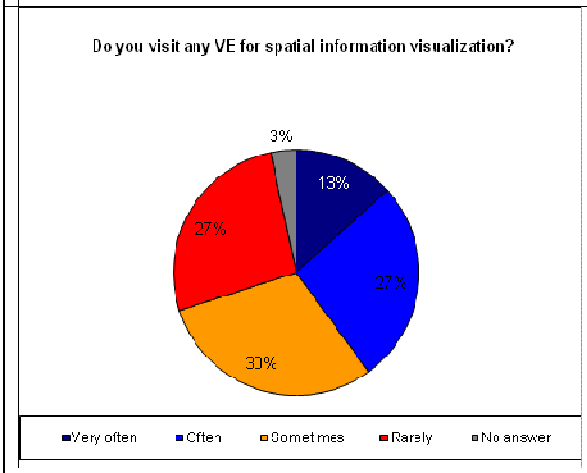
Domain	Components of VE
Functionality	***Log-in interface***
Validation 26	System should have an user-log in interface
Functionality	***Time component***
Validation 27	System should have a time component showing the development phases of the urban design project in time.
Functionality	***Measurement tools***
Validation 28	User should be able to measure the objects like building height, streets width, etc
Functionality	***Teleport tool***
Validation 29	System should have ***teleport*** function for the user to navigate from one point to another on the instant
Functionality	***Labeling object***
Validation 30	User should be able to turn on/off labels of building name, street name, etc.
Functionality	***Multi-layers***
Validation 31	Users should be able to turn on & off various layers of 2D plans & 3D models.
Functionality	***X-Ray Vision and Transparency***
Validation 32	System should allow 'X-ray vision' to look inside building's interiors
Functionality	***Geo-referencing***
Validation 33	System should contain spatially referenced data with high accuracy

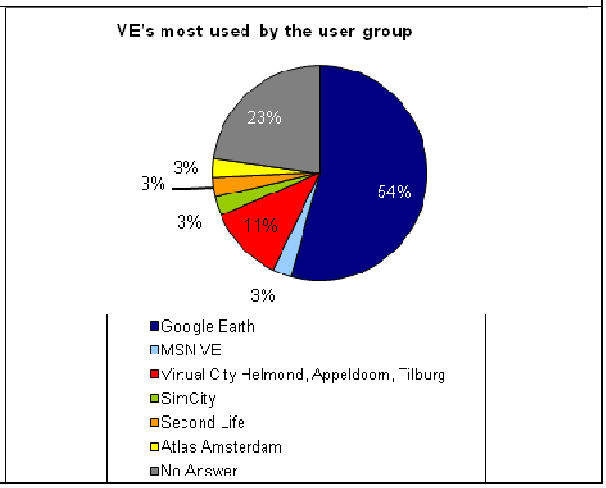

Validation 26-28 : VE Components
Log in interface
Time component
Log-in interface
Measurement.. functionality for system
Time component: functionality for..
Log-in interface: functionality for system
4 6 10 2 7 1
2 7 14 1 5 1
1 5 9 3 7 5
0%
50%
100%
Requirement Agreeability
Absolutely Necessary
Necessary
Desirable
Don't Know
Not Necessary
Absolutely Not Necessary
Validation 29, 30 : VE Components
Teleport functionality
Turn on/off labels
Turn on/off labels: functionality of system
Teleport: functionality of system
8 7 8 2 3 2
4 3 12 3 5 3
0%
50%
100%
Requirement Agreeability
Absolutely Necessary
Necessary
Desirable
I Don't Know
Not Necessary
Absolutely Not Necessary
Validation 31, 32, 33 : VE Components
X-ray vision against occlusion to look inside building sections
Geo-referencing for 2D/3D data
Geo-referencing functionality for storing data
X-ray vision/transparency against occlusion
Multi layoring functionality for 2D/3D data
5 14 5 4 2
1 1 7 3 12 6
6 4 10 1 5 4
0%
50%
100%
Requirement Agreeability
Absolutely Necessary
Necessary
Desirable
Don't Know
Not Necessary
Absolutely Not Necessary

Interaction and Public Participation through VE

Validation 34	*3D Virtual Environment* can enhance public participation and inform the public about urban projects
Validation 35	*3D Virtual Environment* can help the general public understand the municipality decisions better and help to supplement (and not replace) the existing methods of communication
Validation 36	*3D Virtual Environment* can act as medium to have live conference with the actors like the general public, architectural firms, *welstandscommissie* about urban projects (chat, online virtual-conference or '*virtueel gespreksavond*').







7 Annex: 'Survey 2' values for visual materials of geo-VE

Reference to Chapter 7 Section 7.2

How can Visual Materials in geo-VE be used in urban design phases:

In this phase only three parameters are used in the results of this thesis. They are dimensionality, reality axis and LoD. Choice of the points where the most survey population agreed on the use of visual materials. Overlapping ellipses are used to give the users the freedom to choose between the visual materials and the certainty of design in the human perception. Only the highest five values are visualized in deep blue.

Question A: Visual material and human perception

	Name of visual materials	Graphical Modular	LOD	Dim	Reality Axis	Visual regime	Abstraction Realism	Experience	A	B	C	D	E
1	Text, ref images & graphs	Graphical	--	1D 2D	Language Symbolic	--	Abstract	User Perception	4 4 4	5 6 5	5 6 7	**11** **12** **11**	6 5 2
2	Plan and maps	Modular	--	2D	Symbolic	PV	Abstract	User Perception	1 5 6	10 **15** **16**	**13** **13** **12**	9 6 7	3 2
3	Volumetric block model (no detail)	Modular	LOD1	2.5D 3D	Iconic	MV	Abstract	User Perception	1 1 2	3 3 4	7 8 10	**16** **15** **15**	8 7 5
4	Volumetric envelope model	Modular	LOD2	3D	Iconic Indexed	MV	Semi-abstract	User Perception	4 4 5	8 **15** **16**	**16** 12 9	6 5 2	2 1
5	Detailed architectural model	Modular	LOD3	3D	Indexed Verisimilar	WV	Realistic	User Perception	8 14 **18**	**22** **19** 12	8 7 4	2 2	
6	Detailed model with interior	Modular	LOD4	3D	Verisimilar	WV	Highly realistic	User Perception	9 **16** **18**	13 11 6	5 5 4	3 3 3	3 3 2

Types of user perception		
	A	Building and surrounding area will be completely identical to visual material
	B	Building and surrounding area will be fairly identical to visual material
	C	Only the building and building parts as seen in visual material will be realized
	D	Visual material is a draft and in reality the building can be quite different
	E	Reality will be much different than seen in visual material

Question B: Visual material and urban planning tasks (highest values in blue)

Visual Materials	Text, graphs & images			Plan and Maps			Volumetric block models (no detail)			Volumetric envelope model (some detail)			Detailed architectural model			Detailed model with interior		
Parameters																		
Gra/Mod	Graphical			Modular			Modular			Modular			Modular			Modular		
Scalability	Not scalable			Scalable			Scalable			Scalable			Scalable			Scalable		
Dimensionality	1D-2D			2D			2.5D			3D			3D			3D		
Visual regime				PV			MV			MV			WV			WV		
Abstraction & Realism	Abstract			Abstract to Realistic			Abstract			Semi-Abstract			Realistic			Highly realistic		
Reality Axis	Language-Symbolic			Symbolic			Iconic			Iconic			Indexed to Verisimilar			Verisimilar		
Photorealism							Non textured*			Non textured*			Textured			Textured		
Level of Detail							LoD1			LoD2			LoD3			LoD4		
Planning phases																		
Land-use & zoning plans	10	19	21	22	21	18	11	8	5	3	3	1	1	1	1	1	1	1
Structure plan *Stedelijkevisie*	9	17	20	20	19	19	16	13	6	2	4	2						
Master plans	6	12	16	16	21	23	22	18	16	7	4	3	2	1	1	1	1	1
Regional plans	4	11	13	14	21	21	19	17	13	9	8	4	2	1	1			
Urban plan	8	9	14	15	16	18	17	16	16	18	15	10	4	4	4			
SpvE	5	8	11	11	14	9	15	15	13	9	9	9	4	4	3	3	2	2
Beeldkwaliteitsplan	8	11	12	5	8	8	9	10	11	16	17	15	15	12	10			
Architecture designs	6	9	9	7	5	7	4	5	5	9	13	17	21	21	18	17	9	7
Navigable landscapes design	3	8	10	8	8	8	5	5	6	11	12	13	20	17	16	15	14	11

Question C: Visual material and urban related tasks (highest values in deep blue)																		
Visual Materials	Text, graphs & images			Plan and Maps			Volumetric block models (no detail)			Volumetric envelope model (some detail)			Detailed architectural model			Detailed model with interior		
Parameters																		
Gra/Mod	Graphical			Modular			Modular			Modular			Modular			Modular		
Scalability	Not scalable			Scalable			Scalable			Scalable			Scalable			Scalable		
Dimensionality	1D-2D			2D			2.5D			3D			3D			3D		
Visual regime				PV			MV			MV			WV			WV		
Abstraction & Realism	Abstract			Abstract to Realistic			Abstract			Semi-Abstract			Realistic			Highly realistic		
Reality Axis	Language-Symbolic			Symbolic			Iconic			Iconic to indexed			Indexed to Verisimilar			Verisimilar		
Photorealism							Non textured*			Non textured*			Textured			Textured		
Level of Detail							LoD1			LoD2			LoD3			LoD4		
Shade shadow analysis					1	3	11	14	15	15	16	16	6	6	4			
Volumetric analysis	1	3	3	1	9	10	19	20	18	9	9	7	1	1	1	1	1	1
Comparison present with designed	5	7	6	9	11	11	7	8	7	15	19	20	20	17	13	12	8	7
Triggers misunderstanding	7	9	9	8	9	10	16	17	17	16	12	12	13	14	12	12	9	9
Information, navigation & orientation supportive	1	4	4	7	10	9	10	10	11	12	16	17	16	14	10	9	8	6
Most attractive for visualization	3	5	5	6	6	6	3	3	3	10	11	13	18	16	13	10	5	6

8 Annex: Comparison of geo-VEs according to Section 7.3.1

Reference to Chapter 7 (Section 7.3.1)

The researcher tested the four geo-VEs based on the Table 34. Each of geo-VE is extensively explored and the functionalities listed. The following Annex Table 7 shows the comparison:

Annex Table 7: Comparison of Google Earth, LandXplorer, Bitmanagement plug-in and VirtuoCity

		Virtual Reality Software	Google Earth	LandXplorer	Bitmanagement	VirtuoCity
	Construction functionalities					
1	V1	Information Intensity (LoD)	Yes but based on distance	Yes based on geometry and thematic attributes	Yes but based on distance	Can have various LoD models.
2	V2	Data fusion& integration: Dissemination from database	Yes	Yes	Yes	Yes
3	V3	Data fusion& integration: Open Source solutions	Propitiatory	Open Source	Open Source	Propitiatory
4	V4	Data integration: Different Data types & Interface	NA	NA	NA	NA
5	V5	Plug-in Software	Software	Software	Plug-in	Plug-in
6	N1	Toolboxes: Control, Experiencing, Navigating & Movement tool	Yes present	Yes present	Yes present	Yes present
	Capabilities functionalities					
7	V6	Representation: Multiple Representation in different rendering	Yes possible and settings can be changed by user	Yes possible and settings can be changed by user	Yes possible and settings can be changed by user	Yes possible but noting cannot be changed
8	V7	Representation: Multiple representation in different geometry	Yes	Yes	Yes	Yes
9	V8	Representation: Comparison of old and new situation	Yes but not for interior space	Yes successfully	Yes successfully	Yes successfully
10	V9	Animation and Simulation capabilities	Yes	No	No but can be built externally	No
11	V10	Feedback: Interactive chat (online *gespreksavond)*	No	No	No but can be built externally	Yes these functionalities are already built-in
12	V11	Feedback: Leave a message, email, vote	No, not on Google Earth	No	No but can be built externally	Yes these functionalities are built-in
13	V12	Dimensionality/Viewpoints	Yes	Yes	Yes	Eye level
	Experiencing functionalities					
14	V13	Navigational and movement aid	Easy smooth& advanced	Slow for huge datasets	Difficult navigation	Easy smooth& advanced
15	V14	Orientation aid	Yes compass	Yes compass	No built in	None
16	N2	Manipulation, exploration and élaboration	Present	Present	Present	Present
17	N3	Immersion: mental semi-immersive environnent	Semi and mental	Semi and mental	Semi and mental	Semi and mental

Table1:Comparison of Google Earth, LandXplorer, Bitmanagement plug-in and VirtuoCity						
		Virtual Reality Software	Google Earth	LandXplorer	Bitmanagement plug-in	VirtuoCity (Cebra B.V)
		Controlling functionalities				
18	V15	Selection of Scene/Objects: Click & Select	No click and select unless given the option	Yes click and select	No click and select	No click and select unless the option is given
19	V16	VR Accessories: Fisk tank VR / User mode: Multiple & Single	Runs on Fishtank VR. Multiple users can see the models	It runs on Fishtank VR. Multiple users can see the models	Runs on Fishtank VR. Multiple users can see the models	Fishtank VR. Multiple users can see the models
		Use (Interaction) functionalities				
20	V17	Interactivity: move & delete	Yes possible	Not possible in viewer but in editor	Yes possible but through editor	No not available
21	V18	Interactivity: modify and change 2D/3D information	Yes possible	Yes possible	Yes possible	No not available
22	V19	Interactivity: copy & save	Yes dynamically	Yes possible	Yes possible	No not available
23	V20	Interactivity: add own 2D and 3D data	Yes dynamically	Yes possible	No not possible must be built	No not available
24	V21	Interactivity: stop, hide, sensor information	Yes dynamically	Not investigated	Not investigated	Not investigated
25	V22	Primitive AR like webcams, RSS feeds etc	Not investigated	Not investigated	Not investigated	Not investigated
26	V23	Avatars	No	No	Yes	Yes
27	N 4	Intelligent objects	No	No	Must be built	Yes
		Exploration functionalities				
28	V24	Spatial Query functionality	Yes both geometrical and thematic	Yes both geometrical and thematic	Yes both geometrical and thematic	Not found
29	V25	Hyper links, linked windows	Yes possible	Yes possible but needs to be built	Possible but must be built	Available
30	N5	Re-expression functionalities (3D Editing)	Not possible on Google Terrain (through SketchUp)	Not investigated	Through editing software like Flux Studio	Not possible directly.
		Component aided functionalities				
31	V26	Log-in interface	No	No	No but can be built	Yes
32	V27	Time component	Yes	No	No	No
33	V28	Measurement tool component	Yes	No	No but can be built	No
34	V29	Teleportation component	No	No	No but can be built	Yes
35	V30	Labeling & icons	Yes	Yes	Yes	Yes
36	V31	Multiple layering	Yes	Probably yes	Not investigated	Yes
37	V32	X-Ray Vision	No	No	No	No
38	V33	Geo-referencing	Yes	Yes	No	Probably yes

Table2:Comparison of Google Earth, LandXplorer, Bitmanagement plug-in and VirtuoCity						
		Virtual Reality Software	Google Earth	LandXplorer	Bitmanagement plug-in	VirtuoCity (Cebra B.V)
	General components					
39	N6	Lighting, angle change (on/off)	No lighting, angle change possible	No lighting change but angle change possible	Lighting and angle change possible	No lighting change but angle change possible
40	N7	Camera and viewpoints change, tilt, range etc.	Camera and view point change is possible	Camera and view point change is possible	Camera and view point change is possible	Not found in the toolbox
41	N8	Transparency and shading (on/off)	Transparency can be adjusted	Transparency can be adjusted	Transparency can be adjusted	Transparency cannot be adjusted
42	N9	Atmosphere and visibility	Yes available	Yes available	Yes available	Yes
43	N10	Screenshots and save image	Yes available	Yes available	Yes available	No not possible
44	N11	Automatic focus and tracking	No	No	Not found	Not found
45	N12	Basic drawing tool (mark and draw)	Yes	No not in the viewer (editor)	No	Not found
46	N13	Highlight landmarks, nodes, districts	Yes possible	Yes	Yes	Yes available
47	N14	Add floating labels	Yes	Yes	Yes	Not by the user
48	N15	Reference points (Home button, back and forward)	Yes possible	Yes possible	Yes possible	Yes
49	N16	Audio sound support	No	No	Yes but needs to be built	Yes available
50	N17	Distance function from highlighted 3D object, from ground	Yes available	Not found	No but can be built	No
51	N18	Velocity: fast, medium, slow & Acceleration	Yes possible to adjust	Not found	Yes possible to adjust	Not found
52	N19	Gravity and collision (on/off)	None	None	Yes possible to turn on/off	Yes
53	N20	Vector and raster data support	Yes	Yes	Yes	Yes
54	N21	Defined and closed boundaries	Yes	Yes	Yes	Yes
55	N22	History keeping (undoing, replaying)	Not found	Not found	Not found	Possibly on log file
56	N23	Ions and arrows (to indicate design and 3D objects)	Yes	Not found	Yes can be possible	Yes

9 Annex: List of participating organizations

Participating Municipalities (Field survey and Workshop)

1. Municipality of Rotterdam (dS+V, GW, RO) cooperation with TNO
2. Municipality of Den Haag (Afdeling Stedenbouw)
3. Municipality of Delft (Afdeling Stedenbouw)
4. Municipality of Oldebroek (Afdeling Stedenbouw)
5. Municipality of Amsterdam
6. Municipality of Groningen
7. Municipality of Landgraaf

Participating Housing Agencies

1. Vestia, Delft
2. INBO Amsterdam, 2 personnel
3. BUR Adviseurs
4. De Seyster Veste- Corporatie
5. Bergopwaarts@BOW

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