On the Relation of Full-scale Simulation and Virtual Reality

Bob Martens

Vienna University of Technology, Austria

Introduction: What is VR?
Simulation or in other words, the illusion of reality aims at predicting the impact of an object to be built. The accuracy to be achieved depends on the respective possibilities of use of the simulation media chosen. Great hope is pinned on the phenomena of virtual reality in this context. Regarding definition of term we want to point out that virtual reality refers to the reality. The reality is what man meets upon and what he faces whiles planning and designing. Thus a real condition is to be regarded as the pendent to the unreal or ideal condition. Prototyping and modeling are used as working steps throughout the planning activities in order to check the reproduction and the operating execution of an object to be built, of city quarters or of space in planning. The virtual-digital and physical-analogous working levels are of great importance. The physical model in full scale acts as substitute for the original and is to outline the proximity to reality. The virtual model has the capacity of “acting”, e.g. the reality appears by virtue even in absence of physical matter.

Fig. 1 - 1:1 performance area (digital representation).
Full-scale Lab
Practically every design and planning activity aims at its specific realization in the built reality. Any decisions could and should be made on the basis of original substitutes. The actual dimensions and proportions of space can be grasped in 1:1 scale without any “mental detours”. Furthermore, the interaction of light, color and surface can be illustrated best in the 1:1 model. The experience of “space” is a multiple experience involving not only the visual sense, but also all other senses (touching, smelling, hearing and feeling). It is, however, common sense, that the perception of visual events predominates in our culture due to our “one-way conditioning” and cultivation of situations requiring different sensual involvement are grossly neglected. Man and space are always interacting. Spatial perception as such relies on innumerable pieces of information: the three-dimensional architectural-constructional urban space is complex and amounts to more than the mere accumulation of modeled polygons. Integration of spatial dimensions, proportions and properties thus considerably adds to spatial realizations and planning work.

The term “full-scale lab” is made up of the components full-scale and laboratory. Though complicated to integrate the future environment completely the full-scale representation can illustrate the (inter-)action of light, color and material and surface in architectural space in an optimum manner. Therefore the question arises what full-scale simulation can convey in the course of design work. Is it focussed at making for the independent investigation of architectural space and thus furnishing reasonings for decisions throughout the confrontation with “space”? Or should the one structuring space rather rely on his own imaginative power? Every design activity is finally directed towards its realization in the built environment. Essence and purpose of simulations in full scale is to recognize any shortcomings. The 1:1 model lends itself to the representation of and experimenting with various arrangements.

VR-Kit
Once input of the 3D-computer model in a specific system environment (Dos-PC, Mac, Unix, etc.) has been completed it can be stored by means of a data exchange formatted and imported into a virtual reality kit. In reproducing the stereoscopic real time representation including the reaction to the constantly changing angle of view and the position of the viewer in Cyberspace becomes possible. The cybernaut thus has the impression of moving in virtual space determining his way through space by his own actions. If the viewer turns his head to the right - 360 degree movements are possible - the environment picture changes likewise as any of his movements are received by a sensor and processed accordingly. A VR-installation provides of one or more sophisticated graphic computers. Periphery tools such as data gloves, eyephone-
helmets equipped with color-LCDs and head-tracking sensors can be added. Even though several cybernauts can walk simultaneously through the virtual model the motional radius is limited in VR-work. It seems wise to provide certain limitations. The viewer could e.g. have the option of “only” walking across the floor thus sensing gravitation and not viewing the virtual model from the bird’s eye view. Space cutoffs are not experienced as “real” borderlines provided one can walk through a wall. Regarding its limitations in performance representation of e.g. textures by means of texture mapping are somewhat confined.

Fig. 2 Cybernaut in the Capella Speciosa (Image: E. Schmidinger).

**VR-Light: Stereo-display**

This equipment is also known as *LCD-glasses*. The screen format of the left and right single frame matches the screen frequency, the left and the right LCD alternating in turning not transparent. The quick change makes for the stereoscopic impression. The sequence is located in front of the screen, the viewer, however, being able to “experience” his model individually by means of mouse movements; depending on the efficiency of hardware also “walk-throughs” can be generated in real time. The affinity to the computer-generated stereo-picture is obvious and connections to virtual reality become evident, as adapted stereo-displays are used in the *Eyephone-Helmet* in the VR-kit. Provided the cooperation of hard- and software is optimized in future also in the “low-end-area”, various implementations of this application will arise.
Exemplification I - Housing Space in Vienna

Large-scale virtually generated housing space was illustrated by means of video-projections in a building cover specifically designed therefore. Housing projects of the Municipality of Vienna being built at present or being in the planning stage are shown. The four screens are drawn up alongside the sides of a square the projection of real time animations providing a kind of pseudo-panoramic reality. The stereoscopic representation is not considered on account of practical and technical reasons.

Drawing attention to the building forms is achieved efficiently in the illustration, the environment only being globally suggested (with a few trees). People are not shown in this technically perfect presentation, being a basic matter of abstraction of “level of detail”. What is remarkable is that the demands of the users are constantly increasing. The installation of a joystick in the center of the room like on an altar is to invite to interact. “I am to contribute in determining” the navigating visitor is supposed to think. This representation of the world shows clear analogies to numerous computer games and stresses the “I-perspective”. The environment is seen by the eyes of the hero. The possible narrowing down of human perceptions has already been pointed out. What possibilities does VR provide for perceiving an electronically created world not as cold computer graphics, but as a cosy computer-art world. Not only the representation as such, but also the atmosphere conveyed by this representation makes for the full “immersion”.

Virtual Reality Modeling Language (VRML)

VRML makes for the interactive exploring of three-dimensional models and individual interfering regarding the source code. The three-dimensional VRML-scene lends itself thus to spatial draft- and planning work and can be composed using e.g. a text editor. Compact files without unnecessary information are issued, complex forms, however, can not be described by means of a “indexed face set”. For those finding editing work from scratch too complicated available objects by means of other applications (3D-studio, lightwave 3D, etc.) can be exported. As the converted objects are mostly not developed for real time rendering they normally have to be optimized, i.e. superfluous information is to be eliminated, as the consume computer capacity.

Principally, VRML-implementations aim at dealing with new concepts. Agglomerated structures require that objects can be connected via transformations with one another. The infinity issue calls for great skills concerning navigation: by means of Anchor a “new world” can be entered. A single world origin does not exist any longer: local systems of coordinates serve as reference point for so-called Inline-models. A VRML-models are transported into other VRML-models. Two different models interact, the problem of being hard to follow up is coped with by means of modular representations.

Fig. 4 Front page of http://fbra.tuwien.ac.at/ vrml/ (Image: Borislav Petrov).
The full-scale lab opened in 1992 at the Vienna University enabled the students to translate their spatial ideas into reality. Not conventional building materials, such as concrete, bricks and plaster are used, but rather a multitude of building elements, such as Mero-rods, Brik-stones, scaffolding poles and the like. Due to the space simulations in full-scale performed hitherto computer-generated space simulations have proved handy as preparation in lab work. The main goal of the recently issued thesis of Lubomir Kulisev was the development of a digital building brick system called “Lubolego” on the basis of the present state of appearance of the full-scale lab and the building elements available to be used for computer-assisted space simulations. The ArchiCAD 4.55 (by Graphisoft TM) program was selected for generating and optimizing the 3D-computer model. Those objects making up the set installation of the full-scale lab (working platform, wall girders, etc.) as well as the building elements were generated authentically and stored as individual library elements. Some of these elements were unique parts to be implemented several times in space installations. On completion of input work the Archicad-documents were stored in the so-called Wavefront-format and transmitted for viewing purposes to the field computer SGI-Onyx RE II of the Department for Urban and Regional Planning and Architecture at the Vienna University of Technology. This also resulted in the transformation into a VRML-model.

Connection of spatial simulation in full-scale and computer-assisted space simulation was advanced in the course of this work. The advantages of this integration are obviously as follows: in digital space simulation the size proportions of the individual building parts of a spatial arrangement can be efficiently investigated. Drawing-up of a three-dimensional project proceeds at a rate unmatched - provided sufficient CAD-skills - compared to the building of the same project in full-scale. The technical problems occurring by placing in the 1:1 scale can be neglected. The ease of illustrating ideas on the screen might lead to the impression that the real building work of the planned object might be as easily accomplished. Here, however, one is greatly mistaking. The positioning of a 3D-Mero triangular girder only requires a mere mouse click in the groundplan window in comparison to the actual 30-minutes of work of three individuals. The great advantage of a computer simulation surely is that a single person can simulate complicated spatial configurations even on his own, which, on the other hand might also amount to a disadvantage, loosing practically unintentionally the relation to reality, due to his moving in “completely different dimensions”. Many possibilities being “feasible” on the screen cannot or only hardly be translated into reality (e.g. suspended ceiling members, etc.)
The practical use of VRML for architecture can be hardly estimated. Principally, there is the possibility of offering a lecture at the Vienna University of Technology “remote”, thus making it accessible to students of other departments and universities - such as the Graz University of Technology - this also being in line with the intention of the project. VRML-models occur as by-product as it were of modeling work. What is of great advantage is that it is a language not being platform-bound. VRML is not restricted to transmitting three-dimensional geometric information, but also makes for the implementation of various characteristics (e.g. collision protection), i.e. a vast range of perceptive possibilities of space. The independent navigation in real time calls for the investigation of a spatial situation. Adequate viewing possibilities, however, are presently only provided by high-speed computers.

![Image](image.png)

Fig. 6 Practical work with Lubolego (Image: L. Kulisev).

**Upshot**

To which extent is this of interest for the architect’s office? In this context two essential working steps are to be differentiated. First of all, modeling work can be performed on any available platform. Regarding a number of tasks the demands as to computer performance are not too great in this phase. A model can also be split up into part models. Secondly, an adequate computer performance is required depending on the extent and complexity of data to be represented, especially in real time representations. VR thus offers an additional viewing possibility of an already generated 3D-model in architectural production without having to build an extravagant physical model using additional materials.
The required VR-equipment must not be available at the working site, but can be purchased on demand as available service. The problem of conversion is to be treated individually within these considerations. Practically all architect’s programs provide of more than a single DXF-interface. It is to be pointed out that this interface though pretty popular does not always work faultlessly and may require awkward re-editing afterwards. Thorough and careful preparation in the modeling phase is a must saving unnecessary re-processing and annoyance. Accordingly, trial runs will prove wise in between. More and more projects are being subjected to CAD three-dimensional modeling featuring differing degrees of detailing. Last, but not least, a pragmatic argument in favor of VR is to be mentioned. VR-models are not only “en vogue”, but also are to be regarded as “ecologically compatible”, as they are not built.

The unfavorable economic relation regarding effort and benefit often is one of the reasons why (complete) physical 1:1 models are only rarely built. Therefore, representation by means of the less costly virtual models are strongly preferred, also because they can be used simultaneously at many locations due to their digital nature (no loss of information when duplicated). It lends itself particularly well to spatial planning and design work regarding the fields of urban development planning and urban and regional planning. A well-balanced combination of physical and virtual (existing and planned) models in full scale accounting for the field- and problem type, the degree of detailing and scale might gain in importance in the future (“Real Realities - Virtual Realities” (R.R.-V.R). Generating visions and utopias (“Virtual Virtualities V.V.) may also contribute to spatial development and design.