Illusion, Frustration and Vision in Computer-Aided Project Planning: A Reflection and Outlook on the Use of Computing in Architecture

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Abstract

This paper examines the progressive and pragmatic use of computers and CAAD systems in the architectural practice. With the aid of three scenarios, this paper will illustrate gainful implementation of computer aided project planning in architecture. The first scenario describes an actual situation of implementation and describes conceptual abortive developments in office organization as well as in software technology. Scenario two outlines the essential features of an integrated building design system and the efforts involved in its implementation in the architectural practice. It clearly defines preconditions for implementation and focuses on feasible concepts for the integration of different database management systems. A glance at paradigms of conceptual work currently under development will be taken. The third scenario deals with the structure and integration of innovative concepts and the responsibility the architect will bear with regard to necessary alterations in office and workgroup organization. A future-oriented building design system will be described that distinguishes itself from existing programs because of its modular, net-based structure. With reference to today's situation in architectural offices and according to realizable improvements, this article will demonstrate courses for future IT-support on the basis of an ongoing research project. The presented project is part of the special research area 524 "Materials and Constructions for the Revitalization of Existing Buildings" which is funded by the Deutsche Forschungsgemeinschaft. It deals with the integration of various parties that are involved in the revitalization process of existing buildings as well as with the provision of adequate information within the planning process resting upon the survey of existing building substance.

Additional concepts that might change the way an architect's work is organized will also be presented. "Case-based-reasoning" methods will make informal knowledge available, leading to a digital memory of preservable solutions.

1 Introduction

Starting with an assessment of today's use of computers in architectural practice, we have to admit that architects use a great variety of software and hardware components that do not fit together well. Even if the software industry tries to make us believe that architects' demands find fulfillment in the newest release of their software packages, we should confess that unimpeded exchange of data for instance is still not possible. Who has not experienced a system crash in conjunction with loss of data while importing? Who has ever been able to perfectly import dxf-data from the structural engineer without having to cope with hatching or text that appears distorted, enlarged or incomplete?

Nonetheless, after the decision is made to use computers in architectural practice and after experiencing the advantages and disadvantages of stand-alone applications, the architect desires an integrated information basis to exchange data (product model). Interfaces exist and most CAAD-packages deliver functionalities to import / export files and to convert them into other formats - but have you ever tried to import dxf-data from the surveyor? Usually, the exchange of data involves heavy losses (Haas 1998). Do you use an integrated information system in your office that administers simple items like geometric information of the proposed building, details, building costs, load bearing behavior, type and degree of building and land use or addresses of the people involved in the building process? Common systems available on the market do not fulfill most of these general demands and demonstrate that they do not meet the requirements of the architect's duties. However, the development of integrated systems is making progress. In the text that follows, three scenarios will be given to describe an ordinary, a possible and a visionary – yet feasible - situation in computer aided project planning. Besides the exclusive use of a CAAD-system as a design and construction tool, Scenario Three will glance at the future use of CAAD-databases as being part of an overall spatial expression within architecture.

2 Scenario One – The Ordinary Situation

Most software and hardware used in building design begins with so called "stand-alone" applications. These programs serve a single specific task, are used in an isolated manner from other programs, and the generated data is stored individually. In general, the structure of these programs relates to the way the architect's work is organized. Conventionally the architect uses the CAD-system to draw 2-dimensional plans, elevations and sections, each of which will be stored separately. Site plans will be adapted manually, by redrawing them in the CAD-system. The architectural functionality of the system is more or less limited to the use of predefined symbols from CAD libraries. In Germany, drawings of the project will usually be sent by postal mail to the structural engineer. In some cases, more future-oriented offices use modem-connections to deliver the drawings. The "bill of quantities" (BOQ) and project documents are created manually, based on printed plans and sections. In most cases, spreadsheets and, sometimes, specific stand-alone applications are used to generate the BOQ but usually without making use of the digital CAD-data. Changes that occur during the building process are recorded in revised plans, sections and elevations that very often follow no filename-convention. In most cases, the files will be renamed into filename-old, filename-1, etc., leading to a variety of different planning stages, which are not catalogued or documented. After several changes to the building design, the architect is no longer able to reproduce which drawings represent which planning stage. In addition, data might be stored in arbitrary directories on a central server, the local hard disk or possibly on floppy disk, depending on the users' needs or conventions and preferences of the operating system the office uses. In specific cases, the software used by the architect mandates a specific filename convention and determines in which directories the user has to store his or her data, thus making it nearly impossible to archive the project or even worse - recover a specific planning stage of the project at a later point in time.

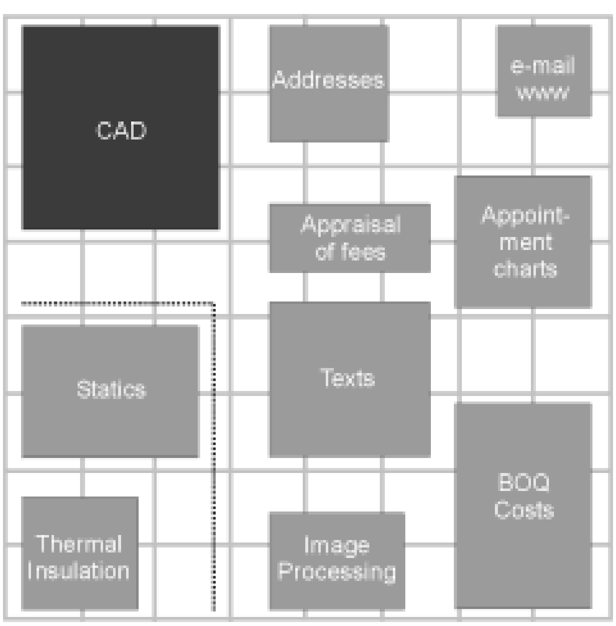

Figure 1. The ordinary situation

Nonetheless, this way of working has some advantages in comparison to a consistent data-model. If any one of the system components fails, the remaining components are unaffected and continue to work. The various programs can provide a quantity of features that justify expenditures of costs and training period. The demands made to the system performance are less than those made to a system with a consistent data-model. These applications provide the architect with the flexibility to equip his office with exactly the stand-alone tools and the staff that meet his demands. (Figure 1 – The ordinary situation).

3 Scenario Two – The Possible Situation

With today's software applications, processes in building design could be reformed and improved, reaching an effectiveness that is not possible to achieve with stand-alone applications and the methods described in Scenario One. To utilize these applications, the architect has to assume a certain risk and expenditure in training that should not be underestimated. Software specialists and system administrators are required to maintain an integrated information processing system in the architect's office. New and specialized systems expand the architect's capabilities and range of duties. An example of such a system would be a digital survey of an existing building that provides accurate CAD data directly from the survey on the building site (Donath and Maye 1996). In this and other cases, i.e. facility management, the architect can adopt new fields of activity, which provide him with increasing competence, improved sales potential on the market and in the end, new clients. Several processes depend on each other and were made consistent with each other by utilizing standardized data exchange formats. With this type of system, project documents could be generated automatically by the use of the 3-dimensional CAD model. An integrated information processing system could consist of specific building elements, providing the architect with the required data. Without doubt, the architect has to ensure that the masses generated and exchanged between the CAD and the BOQ system are appropriate and consistent. It is an essential precondition that both systems make use of the same data specification; otherwise the data-exchange could cause a surprise. STEP (Standard for the Exchange of Product Model Data), for instance, lays claim to map consistent information about a specific product, i.e. material characteristics or the expansion of a building. In the near future ProSTEP will be an interface with which data exchange will be further improved. However, in light of the diversity of existing systems in building planning, this step is comparable to the exchange of a single carburetor between various automobile manufacturers. (Figure 2 – The possible situation).

Single processes in building planning are better supported and more efficient and logical because information can be used in another module, transformed or further developed. Object-oriented database management systems (OODBMS) do not allow one to administer a consistent data model containing interwoven modules, whereas Scenario Two requires consistent models within each aspect of the planning to ensure unrestricted data exchange. A possible solution, such as active relationships or the adaptation of the "event-condition-action-paradigm," is not ideal either because they are often specified for particular cases only (Bergmann et al. 1994; Kolender 1997; Olbrich 1998). The main criteria and characteristics of Scenario Two that current systems are capable of meeting will be described in the following:

- Digital survey as a basis for planning with CAAD in the revitalization and conservation process of existing buildings:
- Beginning with digital building surveys, the architect faces an urgent need for the development of a software concept that delivers a structured way of collecting and organizing information about existing buildings.

Before the actual planning task begins, a comprehensive consideration of the existing built situation has to be undertaken. The results of this complicated process are a variety of individual aspects relating to the building. The building's geometry and structure express themselves in the form of single "drawings" - plans, sections, elevations, details, it's documentation in the form of analyses, log books, statistical information, project descriptions, photographs or expert reports. It is then up to the architect, not just to "read" the information, but also to find connections specific to the situation.

On the basis of an in-depth analysis of traditional methods and processes involved in architectural surveying, a system is required to allow structured surveying, preparation, organization and use of digital information about existing architectural objects. The information gathered has to be stored in an integrated building information system, which provides the basis for further development of the building project with the aid of CAAD-systems. Particular emphasis should be given to the systematic breakdown of a building into its component parts, information relevant to its use and planning, and to the integration of different methods of capture and presentation of this information.

- Availability of complex CAD-systems which provide specific architectural functionality (CAAD).
- Links between CAAD-data and databases (DBMS) providing information for room-books and administration of utilization.
- Links between CAAD-data and BOQ and tender-documents for the exchange of quantities and masses.
- Data exchange capabilities to deliver CAAD-data directly to other professionals.
- Architectural visualization, presentation and simulation derived directly from the CAAD-package.

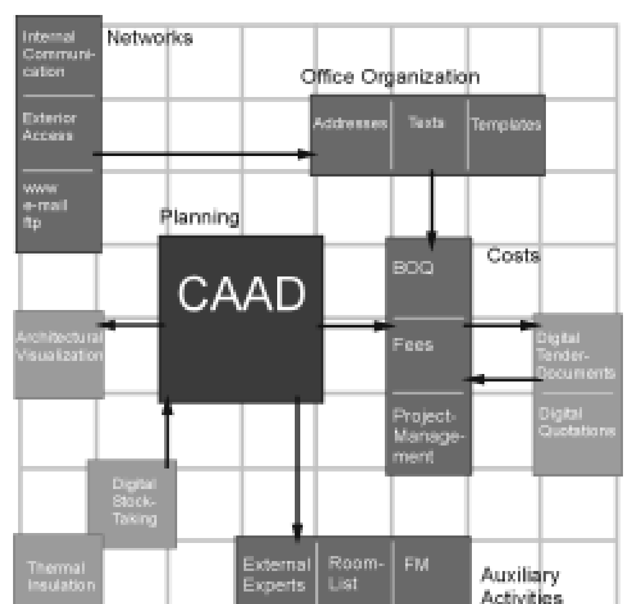

Figure 2. The possible situation

- Structured and classified office-organization, including a standardized filing and archive system.
  Well-defined, standardized office organization is still one of the most important factors in a viable architectural practice. The use of electronic data processing doesn't take away the staffs' responsibility to adopt specific rules and organizational structures within the office. On the contrary, the use of computers forces the architect to clearly organize the electronic work-environment. Management of user-access, software versions, document patterns, central databases and the use of standardized, up-to-date binding forms for correspondence and planning applications are indispensable.
- Integration of programs to create and exchange digital BOQ and project documents as well as price indices.
- Establishment of networked computing equipment, i.e. client-server architecture with appropriate input/output devices, power failure and backup systems, hierarchical control mechanisms observing user access and an intranet.
- An intranet with standardized access to global networks and net-services (www, e-mail, telnet, ftp, fax-server, etc.). Problems affiliated with these demands derive from incompatibilities between various input / output devices and the net-traffic that is to be expected to increase on the Internet. A peculiarity to German Internet users is the high fee charged by domain providers making it difficult to intensely use net-services.
- An intranet providing access for external temporary users, such as freelancers, partners or external specialists, who need to obtain data stored on the architects' server. Implementation of these structures requires tremendous security mechanisms, which the architect is usually not able to establish on his own. Therefore, external service providers must be engaged in providing the appropriate hardware and software solutions to ensure the highest security for the network. Always it is wise to employ a systems administrator who can fix bugs or problems that occur in everyday use of the network and its components.

4 Scenario Three – The Visionary Situation

It seems that today's situation in computer aided planning is unsatisfactory for the architectural profession. Various factors contribute to this situation. On the one hand, there is often a misunderstanding between the architect's demands and the actual ascendancy these demands have on software developers – thus onto the conversion of these demands into commercial software packages. On the other hand, the use of electronic data processing in architectural practice requires the architect to rethink and reorganize his or her work environment. Today's systems are not capable of providing a work environment that can adopt the methods and strategies used in older established work environments. And if they would, the intention to establish computer aided architectural design would demonstrate absurdity. However, to benefit from new ideas in CAAD, the architect has to be receptive to new ideas and he has to be able to clearly define his objectives, requirements and goals that he hopes to gain from the use of computers in his practice.

Will the increasing integration and complexity of CAD tools provide a detectable benefit? Yes, the benefit will exist, but not through the use of small, specialized products. These specialized applications separate themselves from each other, whereas the planning and realization process of a building inevitably requires loss-less and consistent exchange of data between numerous branches that are involved. At present time, data exchange works in principle only. Single pieces of information can be processed, but it is based on arbitrary standards. The planning process itself is characterized by high loss of information. For a long time, computer science tried to create a complete, yet classical mapping of our world, i.e. an object-oriented model. Sufficient research and theoretical foundations exist to map such complex issues. At first glance, these basic approaches are possible. But looking at them more closely, they are complex, but not hopeless. There has been noticeable progress in the development of complex, unified data interfaces. Great hope could be laid in the Industrial Foundation Classes (IFC), even if their implementation and development is slow and inflexible. With the IFC, the industry tries to provide unified data exchange and a consistent model for a variety of CAAD-systems. Therefore the IFC offers individually definable objects relating to specific branches, which contain information about building elements as well as about design, building and administration. (Industrie Allianz für Interoperabilität 1995, http://www.opb.de/iai/)

The central idea of innovative and future-oriented CAAD-systems will lay in a modular conception. The performance of the system will be controlled by the specific user, dependent on his current tasks and necessities. Centralized or de-centralized stored integrative building models will be standard (EDBMS – Engineering Database Management System), which will be accessed on request by individual tools the user defines on the basis of his specific needs. These queries will be realized through CAAD-functionality made available on the Internet, passing through continuous improvement by the developer. Instead of complex and isolated CAAD-programs provided by different suppliers, architects will make use of a variety of functions they could assemble arbitrarily. Thus the architect who has no need to draw 3-dimensionally could concentrate on the functions that allow him to draw, sketch and render 2-dimensionally. To provide experts from other fields, i.e. heating, ventilation, structural engineering, etc. with the functionality they need, the system is always ready to be expanded with the appropriate functions. Thus, troublesome conversion, data exchange as well as internal and external binding do not apply. The user models for instance the 3-dimensional external structure of the building and calculates the verification for heat insulation later on. New plans are no longer necessary for this project. If the user needs to work solely on the digital survey of complex data of the buildings surroundings in the next few weeks, then this function will be added. The user is able to lease this function for a specific time. There is no need to buy a specific product. If the architect uses specific functions more often (e.g. wall modules) he could subscribe to them for a longer period. The biggest advantage is that the architect always has access to the most up to date software, and he will be billed for it based on his usage. Today, applications in building planning exist that demonstrate this paradigm. BOQ-programs are stored on a central server and with the aid of software that works at close range to the operating system (e.g. ZITRIX), the content of the screen as well as mouse and keyboard entries will be transferred to the personal computer in the office. By this method, the amount of data sent through the Internet remains within the realms of acceptability. (Figure 3 – The expected situation). Building information systems will be established which support digital survey. All aspects related to the building project will be captured, evaluated and structured on the building site. As far as possible, mapping of planning conditions will correlate to our natural perception. (Bauhaus Universität Weimar 1999). This means that a downspout for example, will be mapped as a complex object with its origin and natural characteristics like material, delivery time, complexion and dimensions. Each object modeled in the CAAD-system enacts geometric properties and representation as well as a connection to an object management system. This modular system could be extended, depending on the diversity of the planning task. If the architect needs voluminous analysis of the objects, the administrative system would be extended by the requested items. Each specialist could access specific modules, which relate to his or her profession. To describe building objects, the various modules make use of the technical terms the professional is used to. The modules themselves belong to domains, characterized by a superordinated communication / information interface, that mediates between the domains (Huhnt and Grosche 2000). The system allows interpreting building data according to its technical terminology and pertinence. (Figure 4 – The visionary situation). The basis of our vision of an integrated planning model as mentioned above will be built by a digital building model. In terms of a "virtual building" this model represents an existing building to be revitalized or a building that has to be newly designed. It constitutes itself through abstraction of attributes and properties of a commemorated / real building.

Consequently it represents a system of ordering of the totality of belonging data. The main task and functionality of a building model alike is the administration of all information necessary and the exchange of data between the specialists involved. This information and data interchange takes place on the basis of universally valid, formalized data structures.

Accordingly planning actions are temporal and spatially distributed cooperative processes, whose coordinating platform is the modeled representation of the planned object. The domain models reflect a relevant dynamically modifiable clipping at a time, i.e. survey, the architectural model, the load bearing model of the disposable data of the building (SFB 524, 1999). Further information about the research project is available at the following address:

http://www.uni-weimar.de/architektur/InfAR/forschung/GebIS/index.html

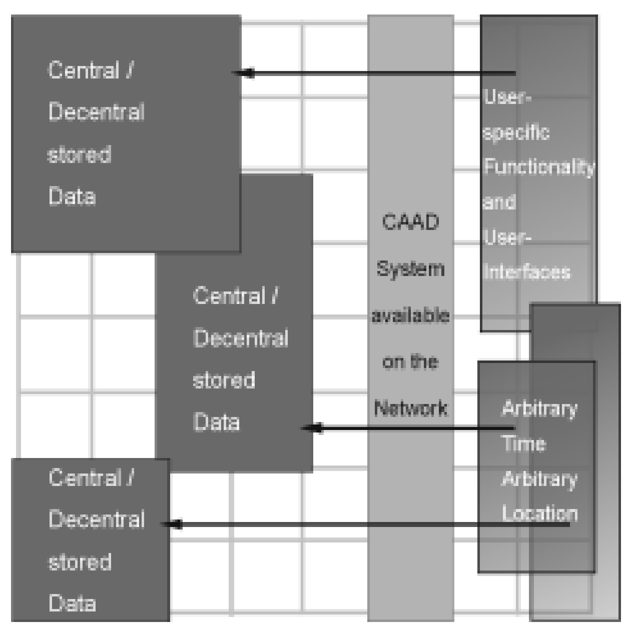

Figure 3. The expected situation

The intuitive and creative phases of architectural design work will also be supported. The architect could make use of functions like virtual reality or rapid prototyping – (possible today in well equipped universities and institutes) (Donath and Regenbrecht 1998, 1999; Streich and Weisgerber 1996). With the aid of these tools, the architect generates visualizations and appraisals that will further be edited in the net-based CAAD-system. Classic design techniques like sketching and model building will find their counterparts in new communication techniques like sketch recognition, gesture recognition and 3D scanning. The use of digital images and animations as "beautiful pictures only" will change. Complex product presentations, showing different aspects of the building, will become relevant, making good economic sense: the visual model of the building costs, the load bearing model, the model related to building physics – immersive, multi-sensorial, possible to be experienced, discussed and explored in its original size simultaneously with others.

Informal components will assist the architect in every occasion, at each planning stage. Your personal software agent informs you of the norms and standards your building has to comply with. It delivers information about a specific brick you'd like to use, it's common and fast-selling formats, delivery times, as well as addresses of potential manufacturers within the periphery of the building site. In accordance to the quantities derived from the digital CAAD-model, the agent contacts these manufacturers, asking them to submit an offer. Information about building regulations is stored on the system, or could be queried through the agent who automatically contacts online representatives of building authorities. The delivered appropriate standards or norms will find entry into the modules you hired for this dedicated architecture project. The norms will assist the architect in his design work by suggesting solutions and providing information he usually obtains from books or encyclopedia. Without depriving the architect of his creativity that is an essential and indispensable component of architectural design work, this will provide a specific set of rules the building has to adapt to. Imagine the massive amount of information dependent on primary and secondary grids and sub grids the architect has to co-ordinate when designing an office building. The general layout of the building, its load-bearing structure, its room structure, its network of pipes and conducts, the arrangement of the facade down to the layout of tiles in the restrooms – they all follow binding principles. Within future systems, these tasks could be performed by your personal agent, reminding you - while designing - that the grid of the facade you've chosen is disharmonious with the size of the parquet flooring, and possibly suggesting a better solution that is even cheaper.

Case-based-reasoning methods allow the architect to look up and examine proven solutions for design or construction severities and adjust and transfer them to his planning situation – leading to a digital memory of preservable solutions. (Steinmann 1997).

The place where the design-work was actually done or where it is stored is not a crucial factor anymore. To save the whole project in a central place, storage facilities will be leased, including services for maintenance, archival and conversion. Office networks are - apart from security mechanisms - no longer distinguishable from global networks. Wherever you are, security and access mechanisms occur and it is of no importance whether your workplace is still in the local office or anywhere else in the world. (Donath et al. 1999). Traditional data communication will become an item of the past. (Figure 4 – The visionary situation).

Accordingly, architecture will find new means of expression by the use of digital space. Not in the form of built objects, but by cultivating its digital representation in networked computer environments and virtual communities. Architecture will turn into an interface, a designed virtual communication space. Without making this thesis the focus of the discussion one could indicate that we have to face developments in the near future that might distort our traditional way of looking at things. The implications for architecture will be beyond our imagination and experiences (Anders 1998; Mitchell 1995)

5 Conclusion

The computer aided planning process will influence automated building processes as long as it takes human peculiarities and attributes into consideration. Highly effective, automated prefabrication exists and its usage will be increased in the future. But it seems that there will always be the sewerage gully located somewhere on the street, not known by any computer program, but by the caretaker.

The future of computing in architecture has to be invented before it becomes real. Therefore it is essential to reconsider existing technologies and to develop visions to become an indispensable component of the gainful use of IT in the architectural practice.

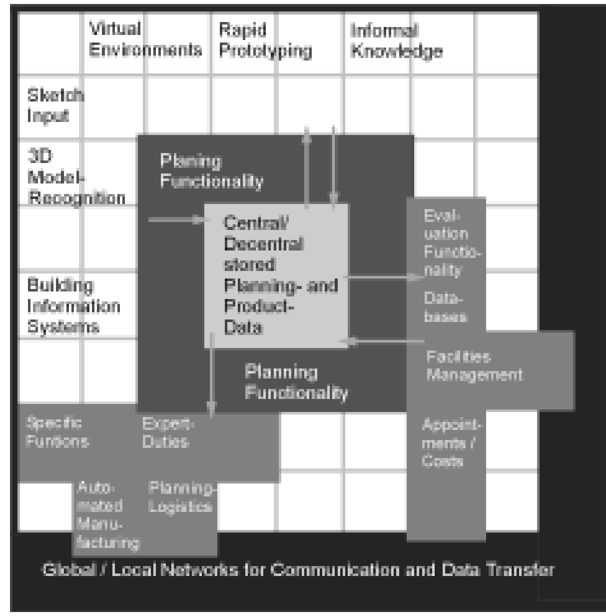

Figure 4. The visionary situation

References

Anders, P. (1998) *Envisioning Cyberspace.* McGraw Hill, 1998

Bauhaus Universität Weimar. (1999) *Revitalisierung von Bauwerken.* Sonderforschungsbereich Nr. 524, DFG, 1999

Bergmann, A., Bode, Th., Cremers, A.B., Reddig, W. (1994) *Modelling Civil Engineering Constraints with Inter-Object Relationships.* Proceedings of the European Conference on Product and Process Modelling in the Building Industry, Dresden, 1994

Donath, D., Kruijff E., Regenbrecht H., Hirschberg U. (ETH), Johnson B. (Univ. of. W. ,Seattle), Kolarevic B. (Univ. of Honkong). Wojtowicz J. (Univ. of BC, Vancouver). (1999) *Virtual Design Studio 1998 – a Place2Wait – using a VRAD system in a Virtual Design Studio.* eCAADe 99, International Conference, Liverpool, 9/99

Donath, D., Maye H.G. (1996). *Computergestützte Verfahren der Bestandaufnahme, Techniken, praktische Erfahrungen und Trends.* bausubstanz, Meininger Verlag Neustadt, 1996, Teil 1: pp. 49-54, 3/96, Teil 2: pp40-43, 4/96

Donath, D., Regenbrecht H. (1998). *Using an Immersive Virtual Reality System for Spatial Design.* First International Workshop on Usability Evaluation for Virtual Environments: Methods, Results and Future Directions. Leicester, UK, 17th December 1998

Donath, D., Regenbrecht H. (1999) *Der Bleistift im 21. Jahrhundert. Das architektonische Entwerfen in interaktiven VR Umgebungen.* IAO Forum Architektur im Informationszeitalter FhG Stuttgart, 1999, proceedings chap. 7, p 10

Haas, D. (1998) *Datenaustausch bei CAD-Anwendungen im Bauwesen – Wunsch und Wirklichkeit.* VDI-Bericht Nr.700.4 VDI-Verlag, Düsseldorf, 1998

Huhnt,W., Grosche,A. (2000) *Information models as a basis for communication in A/E/C projects*. Courses at Summer Academy 2000, Weimar, July 2000

Industrie Allianz für Interoperabilität. (1995). *Industry Foundation Classes***.** Management Overview, November 1995, http://www.iai.org

Kolender, U. (1997) *Qualitätssteigernde Maßnahmen bei der Entwicklung von Software-Systemen im Bauwesen durch Objektrelationen.* Dissertation, Technisch wissenschaftliche Mitteilungen TWM, Mitteilung 97-4, Institut für Konstruktiven Ingenieurbau, Ruhr-Universität Bochum, 1997

Mitchell, W. (1995) *The city of bits.* MIT Press, 1995

Olbrich, M. (1998) *Relationenorientiertes Modellieren mit Objekten in der Bauinformatik.* Dissertation, VDI-Berichte Reihe 4 Nr. 150, Düsseldorf 1998

Steinmann F. (1997) *Modellbildung und computergestütztes Modellieren in frühen Phasen des architektonischen Entwurfs.* Dissertation, Bauhaus Universität Weimar, 1997

Streich B., Weisgerber W. (1996) *Computergestützter Architekturmodellbau.* Birkhäuser Verlag, Basel, 1996