The Chair for Computational Design in 2000-2005

Five reflective years

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1. Introduction: end of an era?

2000, the year of the last symposium on Design Research in The Netherlands, was a turning point for the Chair for Computational Design (*Bouwinformatica*) at the Faculty of Architecture, Delft University of Technology. Administrative changes in the Faculty gave us the opportunity to modify the character and orientation of the Chair. These modifications were not merely the effect of the administrative changes but a conscious response to ongoing socio-technological developments. The democratization and popularization of the computer that characterized the last years of the previous century had a profound effect on the purpose and role of specializations such as computer-aided architectural design (CAAD), i.e. specializations that link computer science and technology with a particular application area. As an academic and technological elite CAAD has been the custodian of the rare, expensive and poorly understood computer technology in architecture and building. When computers became affordable and widely available CAAD was no longer required to provide computer literacy in teaching or to develop applications on behalf other architectural specializations, which could select from a wider range of available applications or even do their own customization and development.

Unfortunately the democratization and popularization of the computer were poorly understood in CAAD. In a climate of light panic many CAAD specialists approached the computer as a media machine or attempted hybrid solutions involving analogue media. Others concentrated on CAAD literacy and accepted a support role in the background of other specializations. Digital studios became less a tour de force of design computing and more a conventional studio with computers used for presentations and visualizations, frequently with little reference to the theoretical and methodical underpinnings of techniques used. Even efficiency could suffer, as the use of the computer became more cosmetic, unfocused and chaotic, paying lip-service to vague ideas and irrelevant principles.

By doing so many CAAD specialists focused on the technological side of their field and ignored the other, probably more significant side that developed theory and methods through a combination of domain analyses with general computational principles. In the genealogy of CAAD (Figure 1) the theoretical / methodical side is firmly based on late modernist design thinking and predates the introduction of the computer. Similarly to other areas the computer was arguably brought in to serve the analytical thinking and the complex, information-intensive methods that were developed in order to achieve rationalization, transparency and efficiency in architecture and building.

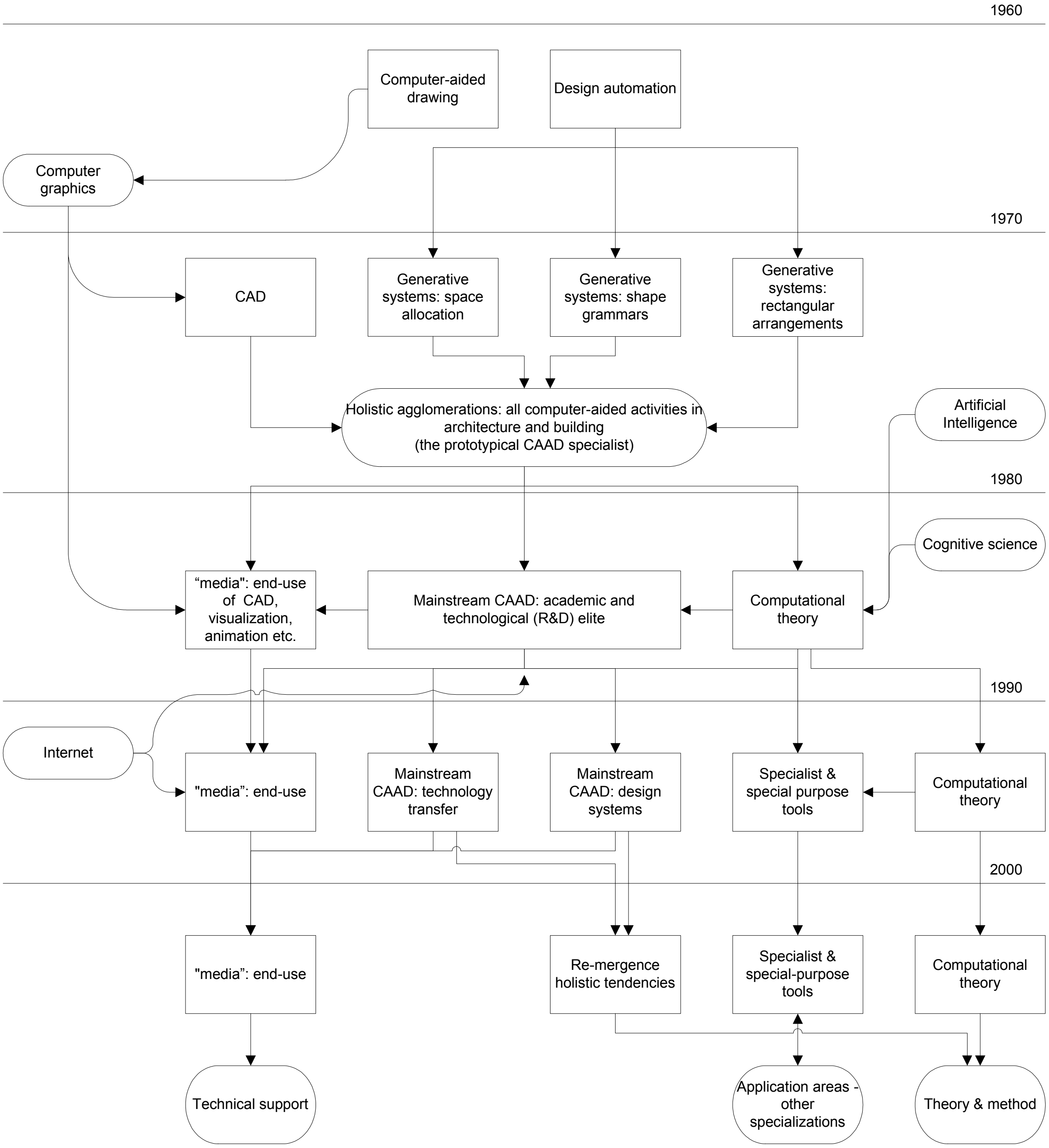


Figure 1: A genealogy of CAAD.

2. Changes at the Faculty of Architecture, Delft University of Technology

The main change that took place at the Faculty of Architecture, Delft University of Technology, in 2000 was the dissolution of the Computing Group (administrative unit *Vakgroep Informatica*) and the reallocation of the two chairs comprising the group to other administrative units. The Chair for Computational Design moved to the Group Building Management and Real Estate Management, which (following further administrative changes) later became the Department of Real Estate & Housing (RE&H). RE&H is one of the four departments of the Faculty (together with Architecture, Urbanism and Building Technology) and focuses on the management of products and processes.

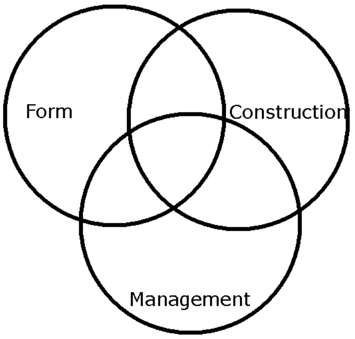


Figure 2: The domain and subdomains of architecture and building.

As Figure 2 illustrates, the four departments represent different, complementary views on the domain of architecture and building. The role of RE&H is arguably unique within this framework, as it not only covers the entire lifecycle of the built environment but also provides integration of aspects in every stage and continuity between stages (Figure 3).

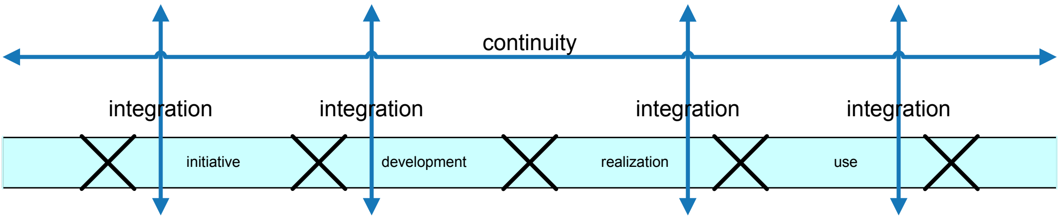


Figure 3: The lifecycle of the built environment.

The advantage of RE&H as the immediate context of the Chair for Computational Design lies in its broad, generalist character that allows for retaining the extensive profile of CAAD. In fact, most approaches to integration and continuity are closely related to or firmly based on computing and automation as a means of ensuring a consistent yet unobtrusive infrastructure for information management and communication. This also means a significant reduction of work in the areas of computer and CAAD literacy, in favour of more focused research and teaching. This does not necessarily imply that the other specializations in RE&H have already achieved a higher level with respect to design and building automation. It simply denotes different priorities, which have to do more with the utility and propagation of information and less with the actual production of information. This is also a fundamental weakness of most management approaches: the production of information is largely left to the designer who is left to his own devices, conventions and representations and yet expected to cater not only for the majority of information in a project but also for the integration of information. However, the designer has only indirect benefits from such tasks, while the manager who should be responsible for at least coordinating production and dissemination of information is generally restricted to issuing guidelines and directives. New specializations and subjects like design management and information management attempt to redress this conflict of interests and priorities but with variable results.

In general, the contribution of computational design to RE&H is dual (Figure 4):

- Methodical analysis of domain problems – methodical development of solutions (indicated by links marked “1”).
- Propagation of solutions to other areas and activities (links marked “2”).

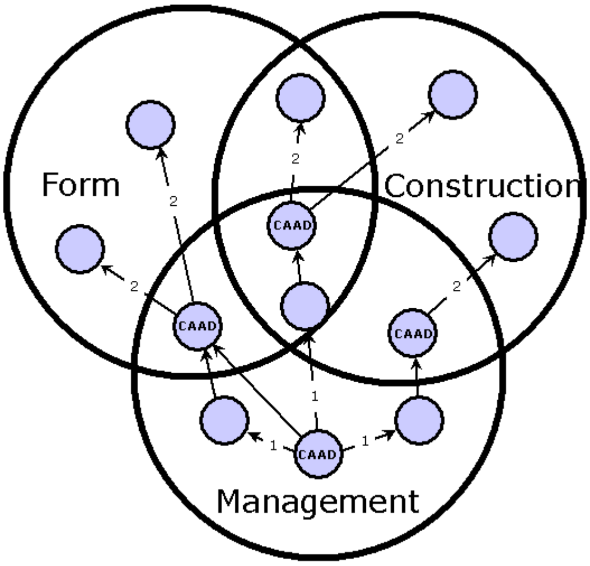


Figure 4: Contributions of computational design.

This duality makes computational design an exception within RE&H but is consistent with the character of CAAD and the wider reasoning behind automation in professional areas. In practical terms it allows for influence on the theoretical and methodical levels, as well as for control of practical aspects (primarily information management, including representation, communication and constraint propagation).

3. Research foci

Shortly after 2000 the research of the Chair for Computational Design was reorganized in accordance with its new position and corresponding roles /priorities. It became structured around three main projects:

1. *Design technology*: technology transfer from computer science and other disciplines. The technologies are selected on the basis of general potential (e.g. judging from outside architecture and building) or applicability to specific domain problems. Technology transfer invariably involves adaptation to the purposes and frameworks of the domain (from customization to prototyping). The subjects and goals of technology transfer tend to vary in time. This is the result of technological innovation as well as of adoption of earlier technologies by the application area. An important observation is that adoption does not necessarily mean that the technologies have been applied to the advantage of the area. On the contrary, quite a few technologies return higher costs and no significant improvement of performance. Design automation in practice is characterized by a number of such failures. One of the reasons (which also exonerates CAAD) is that the influence of general socio-technological patterns and developments in related areas can

be much greater than that of academic research and development. For example, the democratization of the computer has had a deeper and more lasting influence on the computerization of architectural practices than CAAD education.

2. *Design methods*: the application of general computational principles and methods may be preceded or followed by a thorough analysis of domain phenomena and problems. In either case the correlation of the two makes it possible to reformulate domain knowledge in ways that offer deeper insights or operational advantages. The subjects of design methods research also evolve with time but a large share of the basic principles and general theory has remained largely unchanged. This makes us assume that despite the constant irritation of vogues computational design methods are reaching maturity.
3. *Design information management*: this project is not on the same level as the previous two, which represent the two basic components of computational design. It was conceived as a way of making the correlation and application of these two components explicit and relevant to the management of architectural products and processes. Our expectation is that in the near future attention will shift from the production of digital information to its utility and dissemination. This does not preclude that the digital information produced fails to meet structural and semantic requirements – on the contrary, uncertainty or vagueness concerning its utility and value conspire to reduce the specificity and coherence of such requirements. As a result, we expect that the consumption of information will not only occupy a higher place on the priority list of the domain but also provide significant insights into the nature and structure of design information (the users' point of view).

The demarcation between these projects could be considered purely academic and conceptual. Activities clustered under different projects can be closely related, even causally. For example, technology transfer in the first project depends on theoretical and methodical underpinnings, structured analyses and reformulation of domain knowledge – subjects that fall under the second project. Nevertheless, the projects indicate differences in the departure, goals and means of related activities. Scientific thinking requires cohesive and consistent networks, common methods and sound reasoning but, as Terry Pratchett has suggested in *Pyramids,* one of his *Discworld* parodies, "*either the universe is more full of wonders than we can hope to understand or, more probably, … scientists make things up as they go along.*" In our case, even though we tend to (post)rationalize our choices, directions and findings, it is not uncommon that a research starts because of mere fascination with a problem, a viewpoint or a technology. Obviously one needs a few more substantial arguments in order to go ahead with a research beyond the early stages but the fact remains that departures can be more intuitive and more opaque than research proposals suggest.

4. Design technology

Initially research into design technology continued along the lines of earlier research, including the application of automated recognition and multilevel hierarchical representations to analyses of complex aspects and complex building types (Koutamanis 2001b). Of particular interest in this line has been the interaction between people and the built environment, as in pedestrian circulation and fire safety (Koutamanis, van Leusen and Mitossi 2001).

Another line involves the application and adaptation of simulation techniques to architectural situations. In this line we worked with computational fluid dynamics in order to make explicit air quality and air flow (Den Hartog, Koutamanis and Luscuere 2001; Den Hartog 2004). Two significant conclusions from this research are:

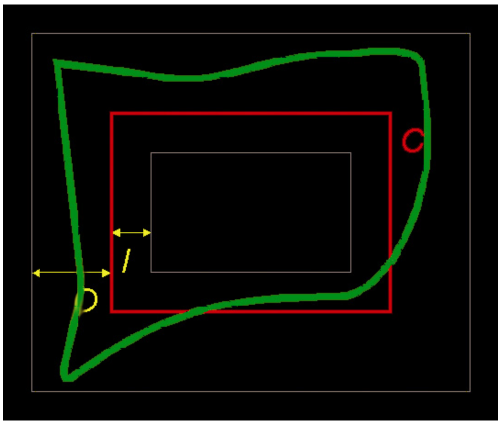
- Simulation and scientific visualization are capable of making explicit not only complex phenomena but also specialist domain knowledge.
- Communication and interaction between different aspects benefits more from analysis and focused queries than from information exchange.

Experimental applications of the results of the research in teaching were encouraging. Students seemed to appreciate the challenge and learning potential of such technologies and invested significantly more time in them than in more common tasks such as the production of photorealistic imagery. The two main limitations were that the technology is still computationally time-consuming and that effective feedback to the design decisions may require extensive consultation with specialists.

A third line relates to the exploration of the potential of autonomous mechanisms in analysis, synthesis and communication. This exploration ranges from the use of virtual users in simulations of pedestrian circulation to quality control in design representations to information retrieval (Koutamanis 2001e, 2002a). Under the principle of local autonomy quite a few design problems can be resolved automatically through knowledgeable autonomous mechanisms with a restricted scope but extensive understanding of both local and global constraints.

Closely related to issues of autonomy is the representation of complex and irregular forms. In many cases local variations and modifications can be delegated to autonomous local structures that cooperate in order to establish global consistency and coherence (Koutamanis 2001d, 2004a). Probably the most significant development in this respect is the notion of fuzzy modeling (Koutamanis 2001c).

Fuzzy modelling emerged from a comparison between architectural sketching on paper and computer modelling. The vagueness of sketching offers possibilities for e.g. introducing tolerances, expressing relationships and deferring decision to later stages that are practically prohibited by the crispness of most computer modelling systems. More ambitious systems involve advanced techniques such as parameterization (almost always geometric; topological parameterization is severely neglected) to achieve a higher degree of precision and flexibility. However, the costs of developing and maintaining such models can be too high for the performance and support they offer. Fuzzy modelling has a much lower overhead, especially in combination with autonomous mechanisms that regulate object behaviour within the local constraints of fuzziness.



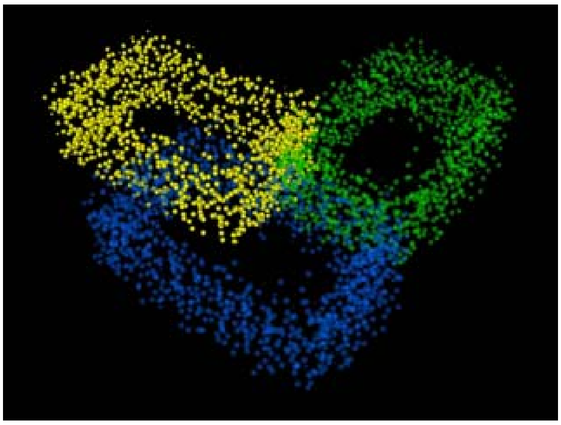


Figure 5 (left): Adaptation of a fuzzy form. Figure 6 (right): Fuzzy forms as particle clouds.

More recently we have started concentrating on mobile tools as a simple, unobtrusive means of achieving our goals. Such tools are often dismissed as mere gadgets but this simply reflects the way technologies are marketed. In terms of connectivity mobile tools offer significant advantages through the proliferation of GPRS, Wi-Fi and Bluetooth, while their portability and ergonomics have become acceptable for most practical purposes. Moreover, they are widely, affordable, familiar and available also for professional applications. Our research focuses primarily on:

- Mobile information processing with palmtops and smartphones: this has significant advantages for physically distributed processes of architecture and building, especially on construction sites and site visits.
- Digital sketching on analogue media: as most design documentation is produced with computers but presented, communicated and discussed on analogue reproductions, this technology presents possibilities for feedback from the analogue to the digital world (Koutamanis 2005).

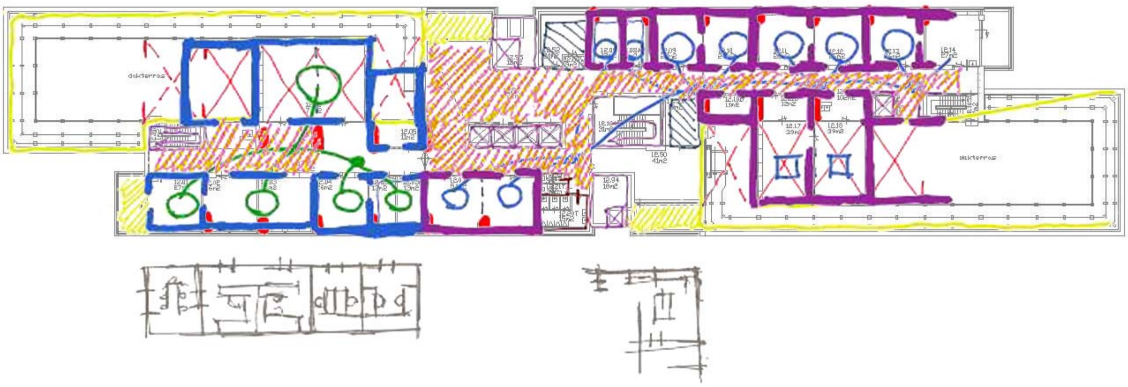


Figure 7: Digital sketch on analogue drawing (computer print).

5. Design methods

Our research into design methods, their principles and applicability, related primarily to two issues that could be considered permanent and dominant preoccupations. The first is design representation and has been the target or carrier of many projects, from fuzzy modelling to route analysis. In the period 2000-2005 much of the work in representation has been subsumed by other projects, primarily in the areas of design technology and design information management. The second issue is decision support, especially in multi-actor contexts. Extensive attention to group processes and their significance for management and coordination has been a logical consequence of the integration into RE&H. The main characteristics of the approach developed under the name “open design” have been optimization, process and product innovation, collaboration between stakeholders, and correlation of management with decision-taking (Van Gunsteren 2003, 2004; Van Gunsteren and Van Loon 2002; Van Loon 2001).

In earlier research case-based reasoning and the use of design precedents have been closely related to representation. More recently these subjects have been linked to empirical knowledge and architectural typologies as means of encapsulating and ordering formal and functional patterns that support design analysis and guidance (Koutamanis and Steijns 2003).

Another consequence of the new position of the chair has been the tendency to look back the historical and conceptual development of CAAD as a scientific area (Figure 1). The absence of real historical analyses and overviews of the area encourages our amateur musings, which nevertheless help with the refinement of our viewpoints (Koutamanis 2004b).

6. Design information management

The main thrust of our research into design information management has been integration: on the one hand integration of the chair in its new context and on the other integration of design computing into the wider framework of architectural and building processes (Figure 2). In many cases this amounts to an extension of established approaches and techniques to managerial tasks (Koutamanis 2002c, 2003). Through this extension we have attempted to make management approaches more operational and practical, better attuned to information production and dissemination. This leads to a clear preference for descriptive rather than proscriptive or prescriptive approaches which may be more appealing at too high strategic levels (Koutamanis 2001a).

The practical challenge of design information management is the development of systems specific to particular types of problems or activities, such as school buildings and real-estate management (Martens and Koutamanis 2003; Steijns and Koutamanis 2004, 2004). These systems give a good measure of the applicability and efficiency of the proposed methods and techniques. They also provide valuable feedback concerning the structure of existing processes, the usability of domain knowledge and possibilities for innovation. This feedback has reinforced our belief in the necessity for transition from design information management to virtual design prototyping: an integral environment for the representation, analysis and communication of form, function, behaviour and performance (Koutamanis 2002b).

7. Future plans

The main characteristic of the period 2000-2005 is reflection. The combination of local administrative changes and wider socio-technological developments led to a reconsideration of the roles and targets of computational design. The main conclusion is that simple computer use (even when it concerns design tools) is currently beyond the scope of the specialist. While effectiveness, reliability and performance in computer-aided design practice may be well below the envisaged level, there is no practical possibility for academic research to compete with commercial development. There are fundamental differences that work against academic research. For example, scientific publication is a slow, controlled and time-consuming process, while commercial products appear at a rapid pace and frequently in a very early version so as to claim a market share early. Quite a few commercial products rely on user feedback for final testing and further development.

This allows us to concentrate on theoretical and methodical aspects. It should be stressed, however, that practice makes little use of academic understanding of these aspects. User dissatisfaction with the current performance of computerization in practice is rising but attempts to improve performance by changing tools and approaches usually rely on introspection and empirical arguments. Academic achievements in the analysis and reformulation of domain knowledge are unknown, misunderstood or mistrusted. It turns out that considerable effort, thorough understanding of new problems and good timing are required in order to propagate computational knowledge in practice. It is also important that we try to comprehend the various dimensions of the problem, including the viewpoints of different actors: architects, managers, engineers, clients and users.

In this framework our research in 2000-2005 aimed consciously at the augmentation of theoretical foundations, the exploration of new technologies and the analysis of current computerization solutions. In particular we enjoyed the challenge of new decision-taking approaches and techniques, the still rapid development of cognitive science, the attention paid to computerization in the social sciences and the occasional innovations in related design and engineering fields. The proliferation of mobile technologies is also refreshing, as it requires a deep reconsideration of human interaction with information and information-processing devices. Less enthusing have been the results of analyses of current computerization in architecture and building. We are still lagging behind other industries to a worrying degree. The combination of poor industrial structure and over-reliance on prescriptive and proscriptive approaches has detrimental effects on performance and domain knowledge. Moreover, the role of the designer is frequently underrated in favour of new specializations (mostly managerial), despite the central function of designing in decision-taking and information processing.

In the coming years we see little reason to change our research subjects and approach. The only exception is our hope that our analyses of computerization might lead to synthesis, i.e. redesign of existing instruments and patterns of use. We expect however that any synthesis will be local and sharply focused on specific tough problems. In general lines the planning retains the three main projects as general clusters and departures. In design technology the focus remains on technologies outside the CAAD mainstream and in particular on mobile information processing and robotics. In design methods the emphasis is on fundamental development through the exploration of cognitive subjects such as affordances and figural goodness. Group processes remain a central issue, as does representation. Dynamic aspects such as continuity and abstraction take priority, as well as computational reformulations of domain knowledge (e.g. typology).

Design information management continues to form the convergence of our research. In practice it is already in danger of becoming a superficial technology race, characterized by the usual attempts to establish an early market share with preliminary versions and a limited integration of domain knowledge. This makes integration of knowledge from as many subdomains as possible a clear research priority. The evolution of virtual design prototyping should also take into account the emerging building information standards, not from a technical viewpoint but with respect to information supply and demand from every aspect in a design process. The context of such analyses and exploration is the Group Design Room (GDR) that is currently under development. In the GDR group process support is complemented with virtual design prototyping and background domain information systems towards an integrated environment for brainstorming, communicating and benchmarking.