Proceedings of a Roundtable Discussion on Advanced Technology in the Construction Industry

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PROCEEDINGS OF A ROUNDTABLE DISCUSSION ON ADVANCED TECHNOLOGY IN THE CONSTRUCTION INDUSTRY

Tim Kehoe and Kalev Ruberg

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PREFACE

On October 3, 1986, industry leaders in CAD, architecture and facilities management arenas participated in an NRC roundtable for defining future research directions. A spectrum of directions and topics were discussed, ranging from CAD standards, to research of human factors issues in buildings. This input from private industry and invited government bodies has proved invaluable in our definition of research paths.

Each participant has left his mark on our research direction. Their thoughtful and well-aimed comments form the content of the proceedings. The structure was provided by Dr. Esmail Baniassad of the Royal Architectural Institute of Canada (RAIC). Special thanks are extended to Mr. Timothy Kehoe who is a co-author of these proceedings and helped organize this roundtable.

Dr. R.C. Biggs
Institute for Research
in Construction

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A G E N D A

THE NATIONAL RESEARCH COUNCIL OF CANADA
INSTITUTE FOR RESEARCH IN CONSTRUCTION
ROUNDTABLE ON ADVANCED TECHNOLOGY
Montréal Road Labs
Ottawa, Ontario

FRIDAY
OCTOBER 3, 1986

9:00	Coffee and informal introductions
9:30	Welcome by Dr. Ron Biggs - Director of Research, Institute for Research in Construction (IRC/NRC)
9:35	Opening Remarks by Chairman - Dr. Esmail Baniassad (Royal Architectural Institute of Canada)
9:40	Introduction of Roundtable Participants
10:00	Introduction to Advanced Technology in the Construction Industry - Kalev Ruberg (IRC Advanced Technology Group)
10:15	Option 1, "Facilities Management": presentation and discussion
10:45	Coffee
11:00	Option 2, "Standards and Codes": presentation and discussion
11:30	Option 3, "Design Tools Development": presentation and discussion
12:00	Lunch
13:00	Option 4, "Guidelines for Automated Office Design and Specification": presentation and discussion
13:30	Defining research directions
14:45	Coffee
15:00	Defining research directions (cont'd)
15:30	Futures Discussion
16:00	Adjournment

EXECUTIVE SUMMARY

Participants at an IRC-sponsored roundtable, convened in early October, 1986, discussed research priorities for IRC's Advanced Technology Group. Four general areas were highlighted:

- facilities management support;
- codes and standards development and support;
- integration of electronic hardware with the building fabric and occupancy;
- research of occupant performance criteria in buildings.

In each area, both general directions and specific industry needs were identified. Participants included building-industry and computer-industry representatives. Their views on research directions differed, with the building-industry representatives focusing on pragmatic technology questions, while computer-industry representatives focused on research of data structures. Representatives from research bodies tended to bridge this gap.

Participants from the building industry identified the following priorities:

- facilities management research and development;
- development of an integrated building database;
- establishment of standards for graphic and building data exchange formats in the CAD industry;
- development of a library of standard details to be evolved for machines;
- IRC technical expertise to be made more accessible to the architectural industry;
- the need for standard EMCS interfaces and protocols.

Participants from the computer industry identified the following priorities:

- the need for a common structuring of the building design and facility management database;
- development of standard protocols for drawing and information transfer;
- establishment of standard taxonomy for terms used - particularly in facilities management.

The breadth of topics discussed precluded detailed definition of any single project. Discussions pointed to the lack of definition, information and knowledge in all of the above areas.

More importantly, many of the issues of electronic hardware applications in buildings resulted in discussion of occupant behaviour and lack of criteria for measuring the performance of buildings in support of occupant productivity and welfare. This has led to a commercial environment where rental costs determine all aspects of building design.

Because it is not currently possible to measure the monetary value of properly designed workstations, or more generally, work environments, any movement to increase knowledge in this area and define criteria would be fruitful and ultimately profitable.

Actions

- Develop better mechanisms using advanced technology to get IRC research into practice. Knowledge-based systems were identified as one mechanism. Other methods included laser disk systems (similar to Sweet's own distribution method) and industry roundtables.
- Develop reliable benchmarks to measure the efficiency of drawing and building data transfer between systems.
- Establish protocols for transferring data and drawings between systems.

- Establish a research program to develop criteria for measuring the use and operation of buildings.

- Develop an integrated database structure to support transfer of building-related information during conception, design, construction and management.

These issues are pertinent to both the building industry and the supporting sector of the computer industry.

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Phillippe Davidson - NRC/Division of Electrical Engineering

Jim McEhinley - ACDS

Dr. Mark Rea - IRC, Lighting

Mr. Wayne Webster - Canada Mortgage & Housing Corporation

1.1 Welcome by Dr. Ron Biggs

Dr. Ron Biggs, Head of Research for IRC, welcomed the participants to the roundtable discussion and extended greetings from George Seaden, Director of IRC, who was unable attend. By way of introduction, he noted that for some time IRC has recognized the potential role for advanced technology in the construction industry, and that recently the Institute assembled a team of young scientists (Advanced Technology Group) to develop a concerted research program in this area.

Dr. Biggs underlined that the term "advanced technology" connotes more than simply 'computer technology', and expressed the hope that the roundtable discussion might go some way toward giving a more rigorous definition to the term.

IRC's AT program must be developed within the context of federal government policies directed toward job creation in the private sector. However, this is consistent with the original mandate given to NRC to undertake research in support of private industry in Canada. This is not to say, though, that NRC is unwilling to invest significant sums of front-end resources to get technologies to the point where they are of direct use in the industry and can find real clients. In this spirit, IRC's mandate is to serve the construction industry by performing research that will find application within that industry.

Dr. Biggs concluded his remarks by thanking the participants for accepting the invitation to assist IRC in identifying promising areas of research related to advanced technology in construction.

1.2 Chairman's Opening Remarks

Dr. Esmail Baniassad (School of Architecture, TUNS) thanked those present for the contribution of their time and asked for their cooperation in making the day a success. He encouraged the members of IRC's AT Group to join in the discussion and, in particular, to remind those present of the real concerns facing the development of this program. He emphasized that the discussion must be rooted in a sense of reality of what actually lies before IRC.

Dr. Baniassad stressed the importance of IRC's relevance as a research instrument in support of industry. The issue of relevance must be examined with a view to its long-term implications: **it can be misunderstood to impede original research, or it can be used to maintain a sensible course of events.**

Therefore, he invited the main participants to give some attention to the dilemma facing any group of researchers: on one hand, they must avoid going way off base, and on the other, they must ensure that they are not operating within some sort of straitjacket. This is not an easy question since researchers must work within disciplined guidelines, but not without a sense of freedom. Fundamentally, it is an issue of judgment, initiative, and imagination. The very idea, then, of setting up the AT Group and letting it work with a degree of autonomy is commendable. The task now, he concluded, is to assist IRC in identifying what the AT Group can and should do.

The Chairman indicated that the discussion has been organized into two parts, beginning with an introduction to the AT group's work and the four potential directions they have identified for their research, and moving from there to a substantive analysis and discussion of these options. He went on to invite each of the participants to briefly introduce themselves.

2.1 Overview of IRC Advanced Technology Program

Kalev Ruberg, Head of the Advanced Technology Group (IRC), initiated the discussion by way of a basic introduction to advanced technology in the construction industry (Appendix 1). The fundamental question that must be addressed, he said, is "Where's the Research?". In the advanced technology area, because of the integration across many fields, it is often difficult to find a focus for basic research.

(1) Roundtable Structure

In capsule, it is intended that the discussion focus on electronic and computer technologies, including, for example, artificial intelligence, CAD, control theories, ergonomics, psychology, architecture, and systems analysis. Part of the problem is the scope of this field. The point, therefore, is to establish, from industry's perspective, where the priorities are for research assistance and research knowledge, and to get some indication of industry's experience in developing and implementing these technolgies in the real world. This exercise provides the building and computer industries with a unique opportunity to input their ideas to the development of IRC's AT program and, in turn, to target research.

After reviewing the role of NRC and the mandate of the AT Group, the participants will be asked to examine the following potential research directions:

- Facilities Management;
- Testing, Standards and Benchmarks;
- Computer Software Development;
- Architectural Research: office ergonomics, communications.

(2) Building Industry Research Roles

In broad terms, the field of building research can be divided into three categories: basic research, development, and implementation (practice). In each of these areas the level of knowledge attained and applied varies considerably.

Basic research has found many of the answers in the so-called "hard sciences" (structures, materials, geophysics, building thermodynamics, etc.). However, very little is known in the field of occupant response and behaviour.

In the transfer of basic knowledge into product **development** we actually lose part of this knowledge because not all of it is used. Therefore, the knowledge that gets used in development is actually less than what is available.

This knowledge is further diluted in **implementation (architectural practice)** for two reasons. First, there is a lag in the application of developments in industry; and, secondly, those involved in implementation have to integrate across a number of fields, usually without expert knowledge in any specific field. The implementors also assume the liability by practicing with this knowledge - something to think hard about before applying new concepts.

(3) IRC Roles

Since the Institute for Research in Construction (formerly the Division of Building Research) was opened in 1947, its building research program has addressed a wide variety of issues ranging from fire research, through to structures, noise and vibration, and research into human factors (primarily acoustics and lighting). IRC plays a role in each of the three areas outlined above in a number of operational modes.

In **basic research,** IRC has an established international presence in materials, heat transfer, structures, fire safety, acoustics, geotecnique, and lighting. As for **development,** IRC has been involved in design of a digitial thermostat (ENERSTAT) and HOTCAN (a computer program). On the **implementation** side, IRC acts as an information transfer agent, publishing the Canadian Building Digest and the Building Practice Notes.

(4) AT Group Work

IRC formed the Advanced Technology Group in response to a growing demand by industry to clarify the role of electronics in the design, delivery, construction and operation of buildings. Currently consisting of five research officers (4 engineers and 1 architect), the Group's work has focused on the following areas:

- Knowledge-based diagnostics systems (Kalev Ruberg, Dan Sander, Steve Cornick):
  - development of a prototype window diagnostician;
  - some examination of knowledge based expert systems (KBES) embodying the National Building Code.

- CAD benchmarks, symbols standards, and integrated CAD databases (Dana Vanier).

- Simulation of building thermal performance and control systems (Dan Sanders).

- Exploration of issues in the "Intelligent Building" field (Alan McKinley).

The AT Group is part of a growing number of researchers undertaking work in the computer field. However, to ensure maximum benefit of their work, researchers must face two fundamental questions:

- Why and how is this technology of use to industry? and
- What kind of information is/is not being transferred?

(5) Potential Research in AT for Industry

Research in AT for industry would potentially concentrate on the following areas:

- Facilities management;
- Standards, Benchmarks and Interfaces;

- Development of Software Tools for the Industry;
- Basic Research of Occupant Activity;
- Use and Usefulness of Computation Equipment in Office Environments.

With five research officers, the AT Group can address only a small part of this agenda. The task facing roundtable participants, then, is to assist in defining priority areas within this field which would warrant the attention of the AT Group.

2.2 Contextual Constraints

A number of questions were asked by participants seeking clarification as to what constraints (programmatic, budgetary, institutional) the IRC Research program actually operates under.

(1) Basic Research vs. Applied Research

Peter Smeallie of the National Academy of Sciences Building Research Board inquired as to whether IRC was doing **basic** research (i.e. scientific creation of new knowledge) or **applied** research (i.e. taking applications and merging them in order to come up with some new findings).

Mark Rea, Head of IRC's Lighting Group, responded that IRC attempts to bridge basic research to application, only carrying out research where a need has been identified - not simply to develop new knowledge. This sometimes entails laboratory work as, for example, in the area of visual performance where the knowledge base is rather low. IRC is now working with a private sector company to transfer this research into a form that will enable practitioners to evaluate lighting systems.

Ron Biggs suggested that IRC's research might best be characterized as "strategic research" - research which, though on the basic end of things, leads in a strategic way to something very applied. Because of the nature of the subject area and the unique expertise residing in IRC, more basic research has been done in lighting than in other areas.

Kalev Ruberg added that the overriding goal of IRC's research is to provide information to the Canadian construction industry which would enable it to build more efficiently and cost-effectively and to give the occupants a better building.

(2) Construction Research versus Buildings Research

Ted Newman, of Public Works Canada, asked whether IRC is targeting its research at the residential market or, rather, whether it is concentrating on the commercial buildings sector. Kalev Ruberg responded that there is no bias toward either area; much of the research undertaken by IRC is, in fact, used by both markets. He added that IRC has longstanding agreements for cooperative research with the Canada Mortgage and Housing Corporation (CMHC) in the residential field and Public Works Canada (PWC) in the commercial field.

Ron Biggs suggested that there may be an even broader answer to Mr. Newmann's question in that, in principle, IRC's focus is not confined to the building sector but, rather, is directed at research into general construction in all its dimensions, including dams, bridges, geotechnical work, and so on. This orientation is reflected in the recent change in name from the "Division of Building Research" to the "Institute for Research in Construction". The new title is intended to articulate more clearly the goals and scope of interest of the Institute rather than to signal any shift in philosophy.

Some work is currently being carried out in the general construction area: for example, dynamic response of structures, avalanche research, perma-frost engineering, soils, etc. However, much of the Institute's activity has been constrained to the building sector because it is here that its expertise primarily lies. Dr. Biggs concluded his remarks by stressing that the scope is entirely open to move more into the general construction area based on new opportunities identified by industry representatives.

(3) Budgetary Constraints

Don Coggan of Coggan Douserv inquired as to why the AT Group was being required to limit the scope of its work. Was it due to limited manpower within IRC or was it because budgetary constraints prevented this work from being done on an in-house basis? Kalev Ruberg replied that, in fact, it was due to both of these factors: there are only a limited number of people within IRC who can engage in this work, and the competition for research dollars is quite strong. He added that one could argue that funding should be allocated not only in support of the work of the AT Group, but as well for research initiatives to be carried out in concert with private sector firms.

(4) Institutional Constraints

Peter Smeallie asked what institutional constraints IRC is operating under. For example, are there policies which would preclude IRC from competing with private industry? Ron Biggs responded that the institutional constraints are evolving. NRC in general is being encouraged to depend less on tax dollars and to become more closely related to the private sector by doing more work on a fee for service basis. IRC's objective is to complement, rather than compete with, the work of private sector and provincial government research laboratories. Treasury Board guidelines stipulate that NRC's research is to be carried out on a "full cost recovery" basis in order to avoid undercutting private industry by competing on the basis of price. In fact, IRC is seeking to move more and more into collaborative research with private industry and other research agencies.

Though IRC operates under some bureaucratic constraints and there are a number of regulations which constrain its actions, in general, Council is becoming more imaginative in what it permits the Institute to do. Further, as a Crown agency, NRC is less regulated than the typical Government Department. Dr. Biggs concluded, therefore, that roundtable participants need not be overly-concerned about institutional constraints. If private industry can assist in defining some directions for the AT Group's work, then IRC can be flexible as to how these should be implemented.

3.1 Introduction to Facilities Management (Kalev Ruberg)

Given that 80% of current building stock will still be in existence by the turn of the century, the load on facilities managers to diagnose and remedy problems will steadily increase. There is, therefore, a clear need to provide tools for the industry to help diagnose building problems, to develop energy management control systems for existing as well as new HVAC systems, and to be able to access "as built" building data for refit and rehabilitation.

Potential research in this area could involve:

- identifying KBES representations to support diagnosis, and advising managers;
- hypothesizing and testing database structures that would support facilities managers in their tasks;
- developing control strategies for energy management and control systems (EMCS) for HVAC control.

Possible directions for development would include:

- software for KBES and database interfaces;
- interface design for facilities managers (i.e. screen and keyboard design);
- choice of systems for development and distribution of systems;
- choice of vendors for dissemination/marketing.

3.2 Overview of IFMA Research Framework

Discussion of facilities management was initiated by Steve Parshall of CRS Sirrine who gave a brief synopsis of research activities sponsored by the International Facilities Management Association (IFMA). Mr. Parshall took over chairmanship of the IFMA Research Committee in January, 1986. Prior to that time, much of the research carried out concentrated on attempting to define the nature of facilities management as a profession. Early research studies carried out by the Facilities Management Institute, a sub-part of the Herman Miller Corporation, established that facilities management was indeed a distinct discipline with functional areas that could be defined and addressed.

The research committee then shifted its focus to examining what the knowledge of this discipline is. It decided to develop a research framework in order that each year IFMA might determine its priorities and allocation of resources within specific research areas (Appendix 2). Ranked from top priority down for 1986-87, the programs are as follows.

(1) External Comparisions

Similar to a competitive benchmarking study, this program will compare members' facilities by industry, size of company, and geographic location. It will investigate all aspects of facility operating costs and organizational staffing.

(2) Performance Improvement

This program will examine how the facilities manager can improve performance in a number of areas. Topics to be studied include cost reductions, energy retrofit, product and service assessments, quality and performance evaluation of those products and services, and the impact of new technology.

(3) Expertise Referral

Within the Association there is a great demand for information regarding who has expertise related to, for example, lighting, CAD systems, expert systems, and so on. A profile of IFMA members will therefore be developed through an annual census of the membership, indicating their experience and areas of expertise. In so doing, it is hoped that IFMA will be able to put in place the necessary resources to meet the growing demand for such expertise referral.

(4) Standard Language and Measures

While carrying out the early benchmark studies, researchers found considerable discrepancies among standard language, terminology, and measurements.

Therefore, in an effort to achieve greater standardization, this program will look at the definition of facility areas and calculation procedures, financial and accounting practices for capital expenditures and operating costs, and the definition and measurement of workload indicators. This is an area for collaboration with others because of the need for consensus-building among many disciplines, associations and practices regarding standards.

(5) Internal Practices

This program will look at how to set up a facilities management organization, examining such issues as facilities management functions, organizational roles and responsibilities, job classifications and salaries, computer tools and techniques, management styles and processes, and workloads and staffing.

(6) Roles, Relationships, and Alliances

This program will examine relationships of facilities managers with other design, manufacturing and professional communities and, in particular, will examine new (non-traditional) types of delivery arrangements for services.

3.3 Related FM Developments in the U.S. (Harry Mileaf, Peter Smeallie)

Harry Mileaf of McGraw-Hill Information Systems Co. (New York) commented that the situation in the U.S. is quite complex in that the governmental and military sectors are also very involved in facilities management and CAD/FM development - and taking a very different approach to these issues from that of the IFMA. And the fact that each branch within the military goes off in its own direction only adds to the confusion. He cautioned that Canada should avoid repeating the mistake made in the United States where the private and public sectors did not act jointly in evaluating what can be done in this field.

Peter Smeallie agreed that the public sector has traditionally taken the lead in this area. Representatives of the fifteen federal government agencies mandated to design, construct and manage facilities formed the Federal Construction Council which is housed under the National Academy of Sciences Building Research Board.

As a cooperative effort, these agencies are now looking at a whole range of questions related to advanced technology and facilities management. It is true that many federal agencies have been pursuing diametrically opposed approaches to this question in terms of the procurement of systems. But with respect to computer applications in the building industry, 4 or 5 of the agencies led private industry in the application of building-related computer technology, though it is generally recognized that private industry has now caught up.

As an example of federal government pre-eminence in this area, Mr. Smeallie cited the CAEADS project (Computer-Aided Engineering and Architectural Design System) sponsored by the Army Corps of Engineers Laboratory. This project, which has been underway since the 1970's, represents the first attempt to include all the disciplines in the design process on a computer and to integrate them. Never before has an agency responsible for a building from conceptualization to operation attempted to introduce computers in a manner other than drafting (i.e. mimicking the manual process). Though the project has not been totally successful, it has pushed the state of the art.

However, exhibits at the AEC Systems show in Chicago this past June would indicate that private industry has now taken up that lead. Nonetheless, it is important to recognize that in the U.S., government agencies with building programs have traditionally been on the leading edge in advanced technology for the construction industry.

3.4 Facilities Management in the Canadian Context

To illustrate the extent of Canada's impact in the facilities management field, Dana Vanier of the AT Group (IRC) cited statistics from the September 1985 issue of The Facilities Manager which indicated that three Canadian developers (Olympia & York, Cadillac Fairview, and Trisak) had holdings in excess of 50 million square feet and were listed among the top 14 development and property management firms in North America. Among the top 50 firms, Royal Lepage and Campeau Corporation would also be included.

On the government side, the Canadian impact is astonishing: the largest holder of office space in North America is Treasury Board Canada (258 million square feet), followed by the Postal Service, the New York State Government, and the New York City Housing Corporation. Among the top 50 public sector property holders, we note every provincial government and major university in Canada.

Ted Newman suggested that a misunderstanding of what facilities management actually is often leads to a blurring of expectations. By way of analogy, he contrasted the role of the plant engineer in the production industry and the design consultant in the construction industry. In the production industry, the plant engineer is involved not only in the design and construction of product equipment, but in its maintenance as well. Once the equipment is handed over to the production manager, the plant engineer and his staff are available to troubleshoot should problems arise. Therefore, in the production industry, the respective roles of the plant engineer and the production manager are quite well understood, and expectations are clear.

In the building industry, this is not the norm. Designers generally do not operate the building and therefore only rarely do they have any idea of what the building is like after construction. As a result, the capacity to mass-produce the same mistakes is systemic within that industry.

To counter this tendency, a plant engineering function is beginning to emerge within the construction industry, particularly on the government side where officials are often responsible for operating entire facilities including the sewage systems, power distribution, and so on. In fact, NRC has developed a plant engineering organization which operates under its own charter. Since many of the engineering institutes do not encourage the practical skills requisite to carrying out this function, Public Works Canada has begun to recruit students, offering them plant engineering training during the summer with the promise of a clear career progression after graduation.

Dave Scott of Bregman and Hamann Architects commented that in Canada over 40% of prime commercial office space over 100,000 square feet is held by the six largest Canadian developers. The balance of the market breaks down into single building owners and multiple developers of single buildings. Mr. Scott questioned how many of the latter group have the resources to get into sophisticated buildings and facilities management systems. Though huge developers like Olympia and York have considerable management expertise, most individual building owners have none.

Though it is true that designers do not generally get involved in the operation of buildings, there are signs that this is beginning to change. For example, an increasing number of mechanical and electrical engineering firms run buildings from the facilities point of view (including some government buildings).

Alex McCallum of ACDS remarked that, from his experience in developing CAD/FM tools, he has been struck by the lack of definition and the confusion in terminology. But, in his view, the FM discipline is beginning to mature and there is a now a good deal of research going on in a number of isolated spots (e.g. NRC, Public Works Canada, and some private sector firms). As a discipline, facilities management provides the industry with a better idea of the continuous occupation, costing, and goals of the building. Various players in the building delivery process are now being provided with new electronic tools (e.g. databases and digital copies of buildings) which enable them to better relate the original intention to the operation of the final product. In short, by keeping information generated in the delivery of the building, we can learn from our experience in a shorter cycle and hopefully avoid making the same mistakes.

Jim McEhinley took the position that facilities management is really only an issue for clients responsible for managing a great deal of space. Among these one must differentiate between public and private sector clients as well as between corporate clients who build and occupy facilities and those who simply build facilities but rent out that space to others. It tends to work best in government where the people who build the facility also occupy and operate it, and communicate with each other rather well. These roles tend to break down in the traditional construction industry where the person who owns the facility, designs it, and operates it may be all different people. This often leads to a number of problems in information-transfer, particularly for the facility manager who frequently cannot access initial design data.

3.5 Potential Research Directions

The Chairman asked participants to consider what research could be undertaken by the AT Group to advance the emerging discipline of facilities management. Mark Rea suggested that one way to pose the question might be, "Do participants see NRC's role primarily in taking existing information and putting it into a useable form, or should it be generating new information which would expand the current knowledge base?".

Ernie Chang of the Alberta Research Council disagreed with Jim McEhinley's earlier statement that facilities management is only relevant for large clients. He argued that any dwelling is based on a model for occupancy and life cycle and that it would be ideal if the individual's environment could be designed after his own needs. Research in advanced technology (computers, real-time systems, moveable panels, etc.) should be moving in that direction and not be limited to improving the economics of management for large developers. That may be where the market is, but it is certainly not where the advanced technologies are. He therefore suggested that researchers should concentrate on developing an economic, cognitive, sociological model based on the goals for occupancy, and that the building should be run during its life cycle according to that model.

Peter Smeallie suggested that, because of its specific resources, IRC could potentially take a lead role in research related to integrated building database development. By way of background, he described the work of a committee sponsored by the Federal Construction Council which has been looking at how the building process might change if the full extent of the capabilities of the computer were employed. The way computers are currently being integrated into the building process simply mimicks the manual way of doing things - for instance, the ouput of CAD is working drawings.

The outcome of this process is that an integrated database for a building project from conception to operation is now technologically feasible. This development will provide enormous savings for owners at the operation and maintenance stage. The savings that would accrue to the owner will drive the development costs of this integrated database.

This past June, the committee sponsored a workshop involving 40 participants. During the workshop, a demonstration of the system was mounted keying in on a prototypical juncture between the design and construction phase. It became clear from the workshop/demonstration that what is currently missing is a precise determination of the facility manager's real data needs. The fundamental question facing researchers in this area is, "what data should be captured in the programming and design phases in order that one might avoid having to re-create it later on?". Participants grappled with this question during the week-long workshop but only managed to scratch the surface.

Mr. Smeallie suggested that when one considers the scale of Canadian involvement in facilities management as well as the research capabilities residing within NRC, IRC might well be in a unique position to begin addressing the development of such integrated design databases.

Ernie Chang expressed strong support for the research direction proposed by Mr. Smeallie. When one starts off with a database and moves into the idea of a knowledge base that describes a model that includes the functionality and purpose of the dwelling, then instead of merely worrying about diagnosis, one is able to model anticipation of the problems. This opens the possibility for detecting inconsistencies and conflicts in, for example, air flow or energy balance that even the structural engineers might not be able to identify due to the scale of the problem.

Dave Scott, however, commented that it is rare that his firm can sell CAD services (i.e. CAD-generated drawings) to a client. In cases where the firm has been successful in doing so, he said, it has usually been to government clients.

Ted Newmann expressed concern that though Public Works Canada contracts stipulate that the consultant must provide as-built drawings as well as operations and maintenance manuals, the quality of drawings received is generally quite poor. In fact, in many cases there is no record of the designer's intent, and technicians must be put to work deciphering what the architects and engineers intended. This provides enormous difficulties when it comes to maintenance and repair.

4.1 Introduction to Standards and Codes (Kalev Ruberg)

Developing standards for the electronics industry and providing tools for accessing the building code is another possible area of research and development. Within this domain, the database and KBES representations of the building code would occupy the AT Group's time as well as provide a fair amount of contractual work.

Potential **code research** would include:

- developing a building taxonomy that is agreed upon by all;
- developing a KBES representation that best handles access to the code heuristics;
- developing a method for re-defining the building code as rules, frames, or nets.

Possible directions for **development** work include:

- development of software to represent sections of the codes and references;
- development of an interface between the building representation (as a CAD image) and the code heuristics.

Standards development involves testing CAD and facilities management software, developing benchmarks for operation of the software, and developing standards for symbols used in the interface. The other side of standards would be in the development of energy management control systems (EMCS) interface protocols to HVAC equipment and developing networking standards for intra-building communications.

The **research and development** would include developing plausible models of CAD use in offices, hypothesizing tests that are representative of the tasks found in design or FM offices, and formalizing them as benchmarks. In terms of EMCS standards, the Group would undertake development of software translators and standards for interfacing control equipment and the mechanical hardware.

4.2 Are Standards Necessary?

The Chairman asked Harry Mileaf to lead off the discussion on standards and codes. Mr. Mileaf stated that he does not believe in the establishment of fixed standards for computers because of the highly dynamic nature of both the computer industry and the application of computers in the construction industry. In his view, standards would interfere with progress in the development and use of computers. Standards are more useful in the electronics, transportation and heavy equipment industries than in the construction industry. He has taken the position, along with many others in the United States, that over a period of time standards will take care of themselves by industry consensus, as has been the case with the IBM PC.

However, while defining standards often causes problems, guidelines in certain areas are necessary. For example, some kind of standards for communications protocols like MAP and TOP are indispensable.

Mr. Mileaf went on to illustrate some of the problems with the establishment of graphics standards in the construction industry. In the United States, graphic exchanges to be used by CAD systems were developed - initially for all industries. However, many in the construction industry did not want the standards, and so an AEC subcommittee was established to go over the standards for that industry. Nonetheless, the standards developed are not being used as much as the subcommittee would like.

Dana Vanier, who acts as Chairman of a Computer-Aided Design Standards Group, took issue with Mr. Mileaf and argued that architects and engineers want solid standards to work with. He differentiated among three levels of standards:

- hardware standards;
- transfer protocol standards;
- applications standards.

Of the three, industry has voiced greatest concern over the **transfer protocol standard** which has not been properly addressed yet. There is IGES (Initial Graphics Exchange Specification), which is an ANSI standard developed to address mechanical and printed circuit board requirements. It allows you to transfer graphical information from one CAD system through a processor into a common format; then from that common format other CAD vendors can read that data through their own host processors. In practice, at the present time, it is possible to pass lines and arcs from one CAD system to another - but not text and dimension information. Without text and dimension, this is of little use to the construction industry. So IGES is approaching what is needed, and everyone in the industry is clamoring for it.

The importance of graphics standards was re-iterated at a recent meeting of Working Group 78 (integrated computer-aided design) in Washington where Dan Reyak, a leading expert in the field of expert systems from Carnegie-Mellon, stated that the CAD industry would be in much better shape if it was enforcing standards the way the AI and KBES communities are. In the CAD field, standards for development are virtually non-existent: CAD systems are simply developed according to the arbitrary standards of the manufacturer. Ultimately, it is the practitioner, faced with a seemingly limitless array of choices, who suffers.

Dave Scott agreed with Dana Vanier as to the importance of transfer protocol standards. In his firm's experience, CAD has served as an excellent marketing tool and has enabled the firm to produce drawings more quickly. However, it has not proved cost-effective in terms of significant cost savings to the firm. Its functional value has been greatly diminished by the lack of compatibility between his firm's CAD system and that of the consulting engineer on any given project. This has been particularly the case on complex, larger projects where joint ventures are common due to the specific expertise required. Therefore, in terms of a research priority, the development of a translator between CAD systems would be of great value to the practising design professional.

Peter Smeallie supported Harry Mileaf's contention that, in the U.S., all sectors of the construction industry agree that it would be unwise now to establish standards since it would freeze the technology at a given point in time. When the industry is ready to embrace standards in a more encompassing manner, then they will develop through the voluntary consensus apparatus that currently exists.

Ernie Chang agreed that in the areas of computer graphics and computer communications we correctly perceive problems with prematurely establishing standards because we realize that as the technology grows the standards become inadequate and new protocols are developed which, for various technical reasons, are often incompatible with the previous ones. But this does not necessarily argue against the need to have those standards at a particular point because of the requirement of people to work together.

Dr. Chang then suggested that, beyond the question of communications standards, the issue of research into performance standards (minimum safety standards) must be addressed. He cited as a potential direction for research the development of a system to test the performance standards incorporated in the National Building Code in order to reveal any inconsistencies inherent in those standards.

Dick Peters of McGraw-Hill Information Sytems Co. (Toronto) voiced some concern with the notion of establishing communications standards for dissemination of electronic data. Sweets Canada has looked at various systems for data dissemination such as CD ROM and Videotext. But the industry has not yet consolidated to the point that unanimity could be achieved on how data should be disseminated and received. Though the IBM PC has become the industry standard for hardware, followed by the Apple computer, the problem of incompatibility remains. In this context, distribution of a database designed for equipment which may later become obsolete due to further technological change becomes problematic.

Wayne Webster of CMHC argued that one must distinguish between prescriptive standards and performance standards. He suggested that performance standards, by which guidelines and protocols are laid out, are essential. It is important to have standards for the small manufacturers, because otherwise the only firms that will be successful are the large ones such as IBM who, because of their influence, can make their product the industry standard.

4.3 Potential Research Directions

Peter Smeallie suggested that in terms of AT research that could be done at IRC in the codes and standards area, some attention could be given to examining the steps preceding the development of prescriptive performance-based standards and codes. Questions that could be addressed might include, "what are the basic requirements that are needed?" and "what are the criteria and test methods by which one can determine if those requirements are met?". Though standards are being developed for certain protocols and local area networking, in the area of graphics standards the field is open.

Ron Biggs suggested that some of the discussion was, in fact, muddying the difference between standards and interfaces and he requested clarification of the distinction between the two. Carey Mann of Dyonix Greentree responded that an interface is essentially a piece of software that facilitates transfer of data between systems by translating that data from one file format into a format acceptable to the second system. Standards are a necessary pre-requisite for development of an interface.

Mr. Mann agreed with Harry Mileaf that there is currently no consensus within the industry regarding definitive ways of handling the issue of communications standards. Every firm that has a CAD system has a proprietary approach to standards as well as a vested interest in maintaining its own standards. IBM has simply succeeded in establishing its approach as the industry standard. Therefore, the issue of integration is very difficult to resolve.

Jim McEhinley of ACDS commented that it is really not that important whether a standard is good or not; rather, it is important that there be one. The problem with prescriptive standards is that they become dated. In Mr. McEhinley's view, IGES, which is a prescribed standard in the sense that it was developed by a standardizing body, does not work that well.

He recommended that the IRC AT program consider undertaking research into techniques for designing standards and implementing them. By way of example, he suggested the AT Group look at the development of a KBES system that would check building plans for compliance with the National Building Code.

Dana Vanier commented that IGES is really only an interim standard and will, in fact, be replaced within 3-4 years by PDES (Product Description Exchange Specification) which will be an ISO standard. There are currently two ISO standards being developed - one looking at CAD general for technical drawings and another looking at CAD-specific for construction drawings. IGES is looking at both graphic and data transfer.

It is necessary to have a fairly good tie among a number of standards in order to make any one standard work. If you do not have your data organized in a logical fashion at the applications level, then it is very difficult to translate that data through IGES to other systems. Therefore, by having an applications standard which organizes data properly, and then by passing it in a logical sense through an IGES translator, one can end up with better information.

Kalev Ruberg closed off the morning's discussion with the comment that this option is a very wide one. It could include, for example, everything from constructing physical standards for communicating between ECMS's, to establishing standard protocols for CAD systems interfaces, and undertaking AT research into codes. Any one of these would represent a significant piece of work, he said, so choices must be made.

5.1 Introduction

Kalev Ruberg proposed that during the afternoon session the meeting direct its attention to the use of electronics and computers in buildings, and encouraged participants to describe the research needs they perceive in this area. Therefore, rather than looking at the effect of advanced technology on the construction process as had been done during the morning session, discussion would focus on hardware implications.

The Chairman then invited Tom Bowling of Bell Northern Research to lead off the discussion with a presentation of the "Smart House" project (Appendix 4).

5.2 Advanced Technology in Residential Buildings: Smart House Project (Tom Bowling)

Smart House is a multi-company project conceived by the National Association of Home Builders (NAHB) in the United States two years ago. Basically, it is directed toward integrating power and communications through the introduction of a new range of integrated power and communications wiring, wiring products and appliances designed to improve home safety and encourage new product innovation and sales.

The problem identified by the NAHB is two-fold. First, there has been no basic improvement in domestic wiring during the past 50 years and, secondly, the real capabilities of the equipment have not been realized: appliances should be able to talk one to another rather than simply stand alone.

The National Joint Ventures Act in the United States encourages firms to engage in joint R&D related to new products, devices and systems with considerable exclusivity of use of the resultant designs, having paid licensing fees to the venture capitalists supporting this research. Such activity is occurring in many U.S. industries, including the home construction field. Some 100 firms and organizations attended an NAHB-sponsored conference in Washington in November, 1984 to discuss the idea of a joint venture related to the smart house concept. 40 companies signed a confidential agreement to collaborate in the project's first phase to define the product, services and systems and some brief output specifications for the products. A complete product launch is planned within the next two years.

Smart house market penetration by 1990 is estimated at 300,000 units per year. To wire a basic smart house has been costed at approximately $500 more than an equivalent conventional home (4 bedrooms, 2 floors, no basement, $137.00 U.S. including land). The main features of such a house would be: improved home safety; integration of electrical distribution and control; and appliance and services innovation.

Mr. Bowling suggested that the confluence of the clout of the NAHB, the demand by the builders and users for this sort of house, and the adoption of national electrical code changes related to smart house technology present an unprecedented opportunity for the introduction of fibre optics into the house. He proposed that, given Canadian expertise in telecommunications and glass fibre manufacturing, this be considered as an opportunity for Canadian R&D. In order not to miss this window of opportunity, Canadian industry must vigorously advocate the development of a "glass-fibre-wired" house.

As for specific research requirements in the smart house field, Mr. Bowling replied that attention should be given to such issues as noise and interference, reliability, environmental control (e.g. distribution of HVAC control, optimization of cable routine designs, etc.), and human factors (e.g. input from the end-users, such as homemakers).

Mr. Bowling concluded his remarks with a brief status report on the project. Product specifications have been written, smart houses are being demonstrated, prototype houses are being constructed in Maryland and, shortly, Phase Two will be initiated involving agreements which will enable companies to begin working in concert in product development.

Peter Smeallie inquired as to whether any market research has been undertaken by NAHB regarding consumer acceptance of the smart house product - especially in view of the fact that the "smart commercial building" concept has not met with much enthusiasm in the United States. Mr. Bowling responded that the NAHB has an extensive economics and marketing department that has provided assistance to the project, and that surveys of builders across the U.S. indicate high interest in the product.

In response to Ernie Chang's request for information on the costs of retrofitting a conventional house, Mr. Bowling replied that to date the project has concentrated on the new-build market (single and 2-3 family occupancy dwellings), and that there is no data as yet on the retrofit costs. In many cases, he added, a complete retrofit will not be required, but only partial upgrading to smart house standards (e.g. for the media centre, nursery, study, and kitchen). In the NAHB's original projections, the retrofit market was underestimated by a factor of 4 to 1; current projections would indicate some 2.75 million smart houses being provided by the mid-1990's, incorporating one million miles of fibre optics per year.

5.3 Advanced Technology in Commercial and Industrial Buildings

Tom Bowling indicated that though the NAHB has not concentrated much attention on commercial and industrial buildings, the Intelligent Building Institute, formed in Washington by the National Electrical Manufacturers Association, is beginning to address these markets.

Don Coggan commented that, from his firm's experience in the commercial buildings sector, it would seem that there is considerable potential for reducing the cost of wiring in buildings. With new communications equipment going into buildings, many different types of wiring are required. Often the original wiring must be modified or replaced in order to accomodate the requirements of the new hardware. He suggested, then, that a worthwhile avenue of research might be to look at methods for overcoming wiring problems through introduction of either fibre optics or building cellular systems.

Dave Scott contended that, in the end, it all comes down to marketing. Generally speaking, in the commercial market of spec buildings, such technological developments only become viable when the developer can be convinced of their impact on revenue generation through extra rent. To Mr. Scott's knowledge, no "intelligent building" (in the strict sense of the term) yet exists in Toronto.

Don Coggan argued that this may be due to a very different regulatory environment in Canada when compared with the American market. In the United States, the intelligent building movement is driven by shared tenant services, where a third party provides the telecommunications services to the tenants in a building. In effect, this is being seen as a new distribution channel for telecommunications services that not only enables tenants to share features which they might not otherwise be able to afford, but also allows them to deal with one provider of services rather than going to a number of providers for equipment, local exchange services, long distance services, and so on.

The de-regulated environment in the U.S. makes it easier for new distribution channels to exist. This has led to greater market demand for information and data services, with the result that American developers have been much more inclined than their Canadian counterparts to move into the intelligent buildings area. At the recent Intelligent Buildings Conference in Atlanta, there was consensus among shared tenant services providers that the intelligent building market will continue to be viable because de-regulation offers many business opportunities to entrepreneurs. Mr. Coggan concluded that, **as long as the environment in Canada remains highly regulated, it is unlikely that much progress will be made toward intelligent buildings.**

Steve Parshall commented that, on the basis of its involvement in a number of studies during the past two years, his firm has concluded that much of the intelligent buildings movement is technology-driven rather than market-driven. Other than in the shared tenant services area, developers are reluctant to buy into an integrated package of appliances and standards. Before the developer will invest in new innovations, it must be demonstrated that the end-user perceives the value of such technology enhancement.

This may be easier to determine in the residential sector than in the commercial and industrial sectors. In the smart house context, the technology is addressing real needs perceived by the end-user (e.g. safe electrical outlets), and the cost benefits are more immediately realized because the owner and end user are the same person. However, with commercial and industrial buildings, the end user may not be the owner and so the structure of costs and savings may be quite different.

Where the commercial and industrial sectors can most benefit from the smart house movement is not so much in the technology itself but in the process of how that technology is adopted. Through demonstration models and prototypes in the marketplace, the smart house project has shown that it is possible to demonstrate the values and potential benefits of technology and therefore to get people to change their mindsets about how they use it. This is of enormous relevance to the commercial buildings sector: though technical feasibility is not a problem, until people begin to adopt new technologies and decide how they want to use them, smart commercial and industrial buildings will not become economically viable.

From a consumer standpoint, Ernie Chang expressed concern that economics appear to be a determining factor in commercial office development, often to the detriment of the end user. For example, area lighting and area air conditioning cause problems for many users, but the alternative offered through intelligent systems for micro-environment control is too costly. Neither the developer nor the user (tenant) is willing to absorb this cost and, as a result, innovation, though technologically feasible, may not occur. The Chairman asked whether there is not a possibility of every economy reaching a certain stage where it makes trade-offs for one way of doing things versus another without increasing the net cost to itself. If so, then one need not ask in every case who is going to pay for new innovations because somehow the economy as a whole is turning. He suggested that it might be useful to give some consideration to this.

Wayne Webster argued that in the residential market decisions are not always cost-justified. He cited as an example the purchase of an expensive painting for a living room wall. The smart house movement is primarily market-driven, with the result that cost justification becomes less of an issue if the new innovation is properly marketed. In the house of the future, communications and security will take on increasing importance and may not have to be cost justified because housing will not be considered to be quite the same kind of investment as a commercial building.

Carey Mann suggested that there is an interesting parallel in terms of market introduction between the smart house project and the R2000 program. The R2000 program started off as basic research, and then the Department of Energy, Mines and Resources approached the Canadian Home Builders Association to develop a joint program for dissemination of this technology to home builders through a grant subsidy. Now it is a very popular program in the marketplace. While the smart house project is more ambitious, the methodology being used will enable it to be diffused, perhaps slowly, but nonetheless successfully.

He also concurred with Wayne Webster on the need to differentiate economic criteria appropriate for the residential market from criteria more readily applicable to the commercial buildings market. The former may be characterized as 'quality of life tempered by some economic restraints' while the reverse is true for the latter.

Peter Smeallie remarked that in a way the situation resembles the proverbial 'boy with the hammer in search of a nail': the technology is overwhelming and its implementation is being stifled due to a number of factors such as cost and user acceptance. In the United States, because of the issue of building security, diplomatic posts have become the driver of the application of many of the technologies that go into intelligent buildings. The issue of building security may, then, open up a valid area of exploration for a research team such as the AT Group.

The Chairman posed the question as to what other technologies in their early stages could be similarly characterized. Tom Bowling suggested that, in fact, many technologies have been initially entertainment- and sport-driven such as the airplane, mass printing, cinema, and television.

Ted Newman commented that, as an institutional owner with costs paid by the taxpayer, one must deal with the political reality of whether public servants should be provided with a level of accomodation higher than that of the population as a whole. On the other hand, Public Works Canada could look at enhancing buildings to the extent of providing conditioned space designed to bring about lower operating costs and improved productivity. These qualifications would have to be dealt with before a significant investment would be made.

Dave Scott agreed with Carey Mann's comparison of the R2000 program to the development of intelligent buildings. On economics alone, he said, the R2000 house would not make it in the housing market. However, other factors, such as entertainment and "comfort level", make it quite viable. In the commercial buildings market, though, such technology innovations will only succeed where they can be justified on the basis of cost savings.

The Chairman asked participants to consider whether there might be any possibility that this new technology would bring about a simplification of current building operations rather than merely add the benefits of new technologies onto those operations. This could, in part, begin to mitigate some of the financial constraints placed on the introduction of innovative technolgies into buildings.

5.4 Electronic Offices: Human Factors

The Chairman then invited the group to shift direction in order to consider the issue of electronics in buildings from the human point of view, examining the need and potential for research into **occupant activity** in the office. The first half of the afternoon session had focused on the technological side, perhaps based on the implicit assumption that the human activity side is either totally understood or totally given. He therefore suggested that the group concentrate on the interaction between technology and human action.

Mark Rea led off the discussion with the comment that IRC is interested in developing new initiatives looking not at technology or human factors in isolation from one another, but **how they are used together** - i.e. the relationship between operation and occupancy. The occupant is not an add-on, he argued, but an integral part of the building; ignoring how the occupant fits into the system (building) may lead to technological solutions which do not respond to real occupant requirements.

Ron Biggs took the position that a distinction should be made between owner-occupied and tenant-occupied office buildings. Particularly in the case of owner-occupied office space, quality of life (i.e. occupant performance) becomes an issue with measurable cost implications. Roughly 90% of the cost of owning and operating a square metre of office space is the salary of the employee occupying that space. Of the remaining 10%, only 1/10th of the cost relates to energy consumption. In terms of cost savings, then, human factors issues take on increasing importance.

Ted Newman argued that productivity increases can be achieved more through improved management training than through modifications we can make to the building. Commitment to what the company is doing is far more important than the building environment employees occupy. Dave Scott concurred, adding that it is what the environment says about management concern for the employee, rather than the actual building environment itself, that is important.

The Chairman expressed the view that it is quite important to realize that, although in light of our experience we can speculate upon these issues, they have fine gradations of becoming effective or remaining sheer speculation and they do, in fact, represent some of the most fruitful areas for research. To be sure, the influence of the environment on the occupant is not something we understand very well, and the performance of many buildings underlines this fact. It would be imprudent to suggest, therefore, that there is not much to do by way of understanding people's expectations of buildings or how we could build them better. He concluded that there is great room for improvement, all things included (such as management).

Mark Rea agreed, adding that, more and more, quality of life is becoming an attractive economic issue. But the fact remains that very little research has been done on the real consequences of environment on productivity. Given the percentages pointed out earlier by Ron Biggs, it may be now the most important area requiring our attention. Ernie Chang supported this position. In general, he said, we want our structures to reflect and enhance the kinds of activities carried out in them, yet we understand very little about building ergonomics.

Steve Parshall suggested that the issue of employee productivity is really a management question related to the organization of the work itself rather than a technical question related to the tangible environment (e.g. lighting technology and standards). For this reason, his firm speaks of "officing", a concept which places great emphasis on understanding the work **process** (cf. Appendix 3). In this context, questions must be raised regarding what it is that the firm is trying to achieve, what work is required, what tooling is required to support that work, and then what facility it should be housed in.

In Mr. Parshall's view, the question on the research agenda is, "what is the nature of that work, and how do we challenge traditional standards, some of which are set on a work process that no longer exists?". Further, research into the process of adapting to technology is required: the management problem really is "how do we identify what our technology needs really are, and how do we get people to adapt to that technology?".

Kalev Ruberg expressed concern as to what tools can be used in order to measure how this actually works when you are doing basic research. Mr. Parshall replied that research into examples and models of good measurement is precisely what is needed. He suggested that the AT Group take a grounded research approach by, for example, carrying out occupant evaluations involving other federal government agencies and let the standards and research development come out of that. In fact, the methods for repeating these pilots will likely be of more value than the specific standards or guidelines developed.

Peter Smeallie concurred, adding that methodologies for post-occupancy evaluation (i.e. measurement of building performance from the occupants' point of view) have been rather ad hoc. He suggested that, given that IRC possesses excellent laboratory facilities as well as in-house social science expertise, it would be an ideal institution to examine a series of buildings over the long term in order to measure occupant behaviour. This fundamental research has not yet been attempted in the United States.

Mark Rea cautioned that the study of construction is not going to solve everything; it is part of a larger process that includes other dimensions such as the social environment. Also, we must seriously consider that science is not about discovering facts that can be plugged into an equation but, rather, is a collection of various methodologies. It is difficult to get a controlled setting in the strict scientific sense to study a building, so we must content ourselves with achieving reduction in uncertainty so that the client, designer or builder can make a wiser choice.

The Chairman commented that, because it is difficult to deal with questions that are somewhat intangible, we have a tendency to grab hold of one particular part which lends itself more easily to scientific examination. But the fact remains that many buildings are built to the detriment of their alleged purpose. It is therefore important for a group such as this to try to seek sharp directions for advancing knowledge and research related to these real problems. Technologically we can answer some of these; otherwise, maybe we can say that there is no way we can get at these problems - which would indeed be a very intriguing answer to give.

5.5 Potential Research Directions

Carey Mann suggested that the AT Group could have a significant impact on the market by placing greater emphasis on the dissemination of research results, ensuring that research is something tested and applied in the marketplace rather than information buried in the laboratory. He cited once again the R2000 program as an excellent example of an effective research program that is having a considerable market impact.

Ernie Chang pointed out that the Department of Communications has an extensive lab in Montréal - the Centre for Research in the Workplace - which looks at federal code methodologies and organizational protocols on many of these issues. He suggested that the Centre's work could be complementary to that carried out by the AT Group.

Peter Smeallie suggested that another important area of research that could be carried out by the AT Group relates to development of methods for effective building diagnostics. Unless people from within the building industry take hold of the area of building performance measurement, he said, it will be taken over by lawyers, which will no doubt lead to an increase in claims against building professionals.

Dave Scott concurred, remarking that **concerns about liability exposure cause architects and engineers to be wary of introducing leading edge technology into their designs. Consequently, there have been only marginal changes in building systems and technologies during the past 30 years.** The construction industry tends to take research carried out in other industries and adapt it to a given building operation. This provides quite a challenge, then, for the AT Group to find ways for overcoming this inertia.

The Chairman asked that during the final hour of the discussion the group address itself to identifying what forward-looking research should be done that is not currently being done, and what measures could be taken to help the industry carry out such research. In order to deal with this in an optimal fashion, he encouraged the group to bear in mind the total scope of the industry (i.e. from conception to completion and management). And to refresh the group's memory on this, he asked Peter Smeallie to briefly summarize the integrated database project discussed during the morning session (Appendix 5).

Mr. Smeallie indicated that research related to the building process spans all of the steps in that process, i.e. from the inception of a building through to its intent, programming, design and construction, fabrication, financing, beneficial occupancy, operations and maintenance, and, finally, the decision either to rehabilitate or demolish the building. This process can be enhanced (and changed somewhat) through the introduction of a project integrated database. The database will only contain essential information about that specific building that will be useful further on down the line to the contractor, financier, or facility manager.

It also has the additional benefit of being able to record the performance of the building because its original intent has been captured in the project database. The building performance evaluation can then be fed into the next building constructed by the owner or designed by the architect. This is particularly useful for institutions and larger companies that construct repetitive buildings with the same function. Integrated database development, Mr. Smeallie concluded, would provide an excellent research agenda for IRC - an area where it could have a significant impact.

6.1 Introduction

Following the final session, the Chairman invited participants to comment on what had been discussed and to identify relevant priority areas of research, regardless of what constraints may exist at present. He also encouraged the group to put forward any thoughts which may not have been given sufficient exposure. By way of summary, he suggested that although the discussion had addressed the issues of facilities management and advanced technology in buildings, the human side of the issues did not receive much attention (perhaps an indication of the urgent need for such research and the extent of work to be done). Further, he remarked that the discussion had focused almost exclusively on buildings research, rather than investigation into construction in general.

6.2 Recommendations of Roundtable Participants

(1) Ernie Chang, Alberta Research Council (Calgary)

One must keep in mind that construction does not refer only to buildings. Recent developments in KD (knock down) technology, such as KD furniture and houses, perhaps open up interesting opportunities for construction research. The whole area of new techniques in construction (methods, organization and tools) and the assembly of components into finished products might well be a valid area for advanced technology research. Finally, the smart facilities management problem may provide the means for integrating many of the concerns expressed during the course of the day's discussion.

(2) Dave Scott, Bregman & Hamann Architects (Toronto)

Three potential areas of work for the AT Group might be:

- To set up an electronic library of details and construction techniques for use by architects and engineers.
- To undertake research into development of interfaces which would facilitate transfer of data from one CAD system to another.

- To put together a team of specialists who could offer CAD training (on a consulting basis) to senior personnel in a design professional's office.

(3) Jim McEhinley, ACDS (Hull)

The importance of expertise dissemination cannot be underestimated: NRC does a great deal more good work than people are aware of. Therefore, ways of improving research dissemination, without adding complexity or extra costs, should be addressed. Secondly, IRC should do a great deal of basic, forward-looking research. The emphasis should be on technique demonstration rather than on producing finished products because private industry will do those things that are within the limits of commercial viability. It is research beyond the limits of commercial viability which is not getting done: this is the proper subject of research for an organization such as IRC.

(4) Alex McCallum, ACDS (Hull)

There is something wrong with the way the representation of buildings is handled in the commercial CAD industry: i.e. the abstractions which enable one to play within the building for management purposes or modify it for design purposes in the production of drawings. The models of the objects we work with really need to be descriptions of those objects plus rules for their use, modification and interaction with each other. The maintenance of this information is probably one of the more important areas for research, particularly the routing of that information from one group to another during the life cycle of the building.

There are very few examples of how that informaton can be packaged and transferred between various vendors' equipment and between different industries' techniques for representing it. IRC can play an important role in helping to keep private industry informed and to demonstrate techniques which might be used in future. The education of the private sector and the spirit of setting the path for future development in private industry are indispensable. Finally, the private sector would be interested in participating in cooperative, joint projects related to the implementation of such ideas.

(5) Steve Parshall, CRSS (Houston)

Other areas of consideration beyond those already discussed might include:

- Building Economics and Operations:
  - This area ties into the facilities management field and leads into addressing building renovation. The profiles of costs are going to be quite different in future because the emphasis will shift to putting equipment, rather than structures, into buildings. Tackling this area will lead to better building taxonomies and standardization of terminology.

- Robotics
  - Research into robotics is important, particularly in areas where hazard is concerned. Robotics may have real potential for the construction industry in Canada due to the harsh climatic conditions in many parts of the country.

- Construction Industry Performance
  - Another broad area of investigation would be research into improving the performance of the construction industry (i.e. questions of productivity and quality of life). Possible research topics might include examining different contracting structures and their impact on costs and productivity; or different methods of delivery leading to economics of building practice.

(6) Harry Mileaf, McGraw-Hill (New York)

Over the years, the changing role of computers has had considerable impact on the design professions and their ability to adapt to technological change. The industry is now in the process of moving toward "decision-oriented computers" (AI, KBES, etc.). Research should be directed toward the development and accumulation of various types of databases that can function with any one of these kinds of systems. This would involve both independent and transportable databases which would be accessed by the task-oriented computers that exist today and also function as knowledge databases with the decision-oriented computer systems that will be coming out during the next decade.

(7) Tom Bowling, Bell Northern Research (Ottawa)

North Americans are spending more and more time in the home and are consequently looking for something beyond the conventional house. Security and a cozy environment are becoming high priorities; hence, research into housing design must be undertaken with these factors in mind.

(8) Don Coggan, Coggan Douserv (Montréal)

The following areas would warrant some attention by IRC:

- Research Dissemination
  - Dissemination of information must be handled better if industry is to benefit from the research being carried out at NRC.

- Intelligent Buildings
  - This is an area sorely lacking in hard data. Databases on electronically-enhanced buildings must be developed in order to provide developers and building owners with a solid basis upon which to make rational decisions.

- Building Automation Systems
  - Since for some time control companies carried out their own research into building automation systems and EMCS's, there was not much need for outside agencies to get involved. However, this is beginning to change. One of the issues that consistently comes up in discussions at the HVAC committee of the National Academy of Sciences is the business of open protocols for allowing competing systems to communicate with one another. This is particularly important for the building owner who wants to avoid being tied exclusively into one vendor. This is a key issue about which something must be done.

- Global Whole-Building Strategies for EMCS's
  - There is not much being done by the control companies in the area of global whole-building strategies for control of energy systems within the building. These companies seem to have done a good job in developing specific stategies for specific systems, but not for the building as a whole. Maybe the reason for this is that each building is different from the next one. Some important research work could be done in this area.

- Use of Computers Relative to Building Codes
  - An area that did not receive much attention during the course of this roundtable is the use of computers relative to building codes. In Québec, the government put in place a standard for energy conservation in buildings, but accompanied it with a computer program aimed at simplifying the validation of designs to ensure code compliance. The AT Group might consider the development of similar tools for working with the National Building Code.

(9) Peter Smeallie, Building Research Board, NAS (Washington)

- One area that IRC could continue to be involved with is forums (such as this roundtable discussion) where the voluntary services of a group of people are mobilized toward bringing the construction industry to a greater degree of awareness about certain issues, many of which cannot be immediately resolved, such as building diagnostics, indoor air quality, energy conservation, and so on.

- IRC could offer assessments of the state-of-the-art through papers and booklets on such issues as artificial intelligence, expert systems, robotics, new construction management techniques, etc. Many of these technologies are being developed in universities, outside of the construction industry; as a result, there is a real need for unbiased assessments by an independent organization such as IRC.

- IRC should undertake R&D (basic research) in areas where the risk is too great or the benefit is not well-defined enough for private industry to get involved. This is an ideal area for cooperative public/private sector ventures.

- Research could be undertaken in areas relating to the national interest, whether that interest is defined in economic terms (strengthening the Canadian building industry against Japanese competition) or in terms of national security (building-related issues connected with making embassies more secure against terrorism).

- IRC could undertake to hold forums for consensus building among industry and federal agencies - if only to air out views on certain issues.

- IRC could provide technical expertise to the Federal Government in the area of policy issues affecting the building industry and, more widely, the built environment.

(10) Carey Mann, Dyonix Greentree (Kanata)

Areas warranting IRC attention would include:

- Investigation into Building Processes
  - This should be carried out along the lines described by Ernie Chang.

- Dissemination of IRC Research
  - Consideration should be given to establishing formal links with trade associations such as the Canadian Home Builders Association and the Canadian Construction Association in order to involve them more actively in IRC's work.

- Integrated database development:
  - Keeping in mind that the end user will want to tailor the database to his own requirements, there is no generic knowledge that is going to apply to everybody. Greater attention should therefore be placed on the database's format, methodologies and structure than on its content.

(11) Dick Peters, McGraw-Hill Information Systems Co. (Toronto)

If innovative technological developments like smart house, AI, KBES and integrated databases are to find a niche in the marketplace, it is important to determine where the real market demand for these products is. Though architects and contractors have a key role in deciding what goes into buildings, it is the owners and end users (tenants) who will bear the brunt of the costs related to such innovation. However, from the discussion today, it would seem that there is a gap in our knowledge regarding the precise requirements of these latter two groups. We need a clear understanding as to who decides, who buys, and what they need. Only then can we adequately determine which of these products (i.e. smart house, AI, KBES, integrated CAD, etc.) are the priorities and can be introduced into the marketplace.

(12) Wayne Webster, CMHC (Ottawa)

Like IRC, CMHC also faces the challenge of directing its research initiatives toward areas which are relevant to the needs of industry. Implicit in a number of comments made today is the question of what criteria should be used in evaluating the success of a building. The generic contents of a database which could assist in determining building success or failure is something which must be addressed

(13) Dana Vanier, IRC/AT Group (Ottawa)

Though it may be 5 or 10 years away, integrated CAD is an issue which needs to be addressed because it can lead to better buildings and higher quality services for tenants, as well as bring about greater efficiency and cost-effectiveness in the building industry.

The issue of **design representation of buildings** is also quite important because it is paramount in the description of the integrated database: it is vital that we understand what the owner needs and the form he wants that data in, as well as how the designer can provide it. A final area for investigation might be **user input** - how people use the tools to do design - for example, how they manipulate data, alter shapes, move objects, change, iterate, etc.

(14) Al McKinley, IRC/AT Group (Ottawa)

Considering the problems raised in the facilities management field, it would seem that there is much useful work to be done here. One issue that seemed to have been downplayed somewhat in the discussion was the area of human factors research.

(15) Mark Rea, IRC/Lighting Group (Ottawa)

One of the things that IRC can offer is insight into what kind of data needs to be collected and how to present it. What makes NRC unique is its ability to disseminate research information while at the same time developing new data. This concern cuts across many of the topics discussed today.

(16) Kal Ruberg, IRC/AT Group (Ottawa)

Mr. Ruberg thanked everyone for their contribution in making the day productive. Many of the issues discussed were the same ones that the AT Group has been grappling with during the past year, but without the benefit of substantive industry input. The four options under consideration by the AT Group were encompassed by the recommendations made by participants. The usefulness of integrated design databases came out clearly in the discussion, particularly as it relates to the facilities management field.

6.3 Chairman's Closing Remarks

Dr. Baniassad suggested that the roundtable proceedings be circulated to everyone for their review and comments. This, he said, is important because there is a symmetry about meetings of this sort, only half of which is what we see; the other half is yet to come after we go away and reflect on what was said.

Some attention must be give to the difficulty of dealing with the reason for technology altogether (i.e. the human side of things). There is need for research of a basic kind, searching for ways to do research on the human factors side of buildings. We do not know very much more than we did during the Renaissance about what people want out of buildings. It is difficult to argue the case that this sort of research fits within the mandate of NRC. Yet, it is important that NRC begin this questioning because, in the end, this will give research into technology its reason and sense of direction. It is a very good sign, therefore, that NRC has been open enough to invite a group of people to come and advance ideas in this area.

From an architectural standpoint, there is a certain totality that needs to be borne in mind in doing every bit of research. We have perhaps not done enough research about the nature of the **total process** of building, a process that goes from conception to completion and management. We know a lot about its different parts and we have been assuming for too long that these parts do add up to a whole. There are major gaps; this is evident from the failures in buildings. There is room, therefore, for specific research about reasons for **architectural** failures (occupant dissatisfaction with the building), not only technological failures. Just as in science we have gone from physics to biology and, finally, to human sciences, in this field of research the same development must be tracked. Currently, this type of research is not being done, but it would be doing a great service to the industry if NRC would at least begin.

6.4 Expression of Thanks by Dr. Ron Biggs

Dr. Biggs thanked participants for their active involvement and, in particular, for the candor they exhibited in expressing the nature of their research needs. There is a tendency for an agency such as NRC to become isolated from the industry it was set up to serve. One of the reasons IRC has had such great difficulty in getting a firm handle on where it should be going with AT research is that, by its very nature, this research occurs at a point of convergence between two industries - the advanced technology industry and the construction industry. This roundtable discussion, then, has been particularly helpful in bringing these two interests into dialogue, providing some direction in what had been heretofore a very trackless subject area.

PROFILE OF ADVANCED TECHNOLOGY GROUP
and
OUTLINE OF POTENTIAL RESEARCH DIRECTIONS

Building Services Section
Institute for Research in Construction

INTRODUCTION

New technologies--particularly new electronics based information technologies--have become part of the construction industry. In response to a growing demand by the construction and electronics industry to clarify the role of electronic information systems in the building design, delivery and operation of buildings, IRC has formed an Advanced Technology Group.

The group comprises four engineers and an architect who have direct access to many of the leading researchers in the building technology field. IRC's expertise covers the building envelope domain (windows, walls, and roofs), building codes, fire codes, structural codes, geotechnique, structures and lighting. The Advanced Technology Group (AT Group) is helping to "package" some of this information electronically for access by the industry. In addition, the group develops standards for measuring the performance of CAD programs, monitors progress in the use of communications technology in buildings, and performs research on the use of Energy Management Control Systems (EMCS).

Our work is computer-based. Because of this orientation we have invested in tools to support artificial intelligence work, and the transfer of developments to the micro world. Our tools include:

- 2 Symbolics 3620 Lisp workstations and ART knowledge base software.
- 4 IBM-AT micro computers supporting LISP.
- 1 Apple Lisa

In addition, we have access to Vax 11/780 and a DEC graphics engine at the division of electrical engineering.

RESEARCH

To date, our research comprises a broad band of topics:

- CADD (Computer Aided Design Drafting) has been the area of research for Mr. D.J. Vanier. His work in this area has led to the development of standard evaluation methods and graphic standards for CADD programs. Three dimensional visualization has been a recent area of related research.
- KBES (Knowledge Based Expert Systems) is an active field of research for Mr. K. Ruberg, Mr. S.C. Cornick and Mr. D.M. Sander. This development work includes a prototype "expert" system for diagnosing problems with windows A second, general application field is exploration of "computerizing" the building code.
- IB (Intelligent Buildings) is an emerging field with emphasis on a new building service--communication. Mr. A. McKinley is monitoring the progress in this field and is participating in discussions about new standards and communication protocols.
- EMCS (Energy Management Control Systems) and their application in large commercial buildings is being explored by Mr. D. Sander.

This approach has provided an overview of the impact electronic technologies are having on the construction industry. But the breadth of topics now being looked at prevents significant advances in any one area. The roundtable convened by the AT group in November of 1986 should help determine specific future directions and help identify critical projects.

FUTURE DIRECTIONS

Four potential research directions include:

- Support of the the facilities management field by **developing software**--namely a suite of computer tools and energy management systems.
- Support of the electronic EMCS control industry by **developing standards** for application of controls to buildings.
- **Basic research** on the types of building design tools and building operation tools required by the construction industry.
- **Basic research** of human factors in office environments, with experimental trials of communication systems. This work would support developments in the intelligent buildings field.

These options require the participation of the whole AT group for impact on the industry.

Facilities Management

Eighty percent of the building stock in place today will still be standing by the turn of the century. The load on facilities managers to diagnose and remedy problems is increasing. There is a need for computer-based tools to help diagnose building related problems, to manage HVAC systems, and to access updated descriptions of buildings.

Research in this domain involves:

- identifying KBES representations to support diagnosis and advise facilities managers
- developing and testing data-base structures that would support facilities managers in their tasks
- developing control strategies for energy management and control systems

Development would include:

- software for KBES and database interfaces
- interface design for facilities managers (including control screen design)
- choosing the delivery platform for software
- choosing the vendor for dissemination and marketing

Standards and Codes

Standards development has been a traditional role played by NRC. Standards are required for testing the applicability of CAD programs as well as for defining the communication protocols in "Intelligent Buildings". In this domain, the "Computerization" of the National Building Code (NBC) would provide a large scope of work for the AT group. With respect to the NBC, two questions must be addressed: "Is it worth the effort?" and "Is it possible with current techniques?" Dr. J. Boose of Boeing has pointed to seemingly insurmountable KBES representational problems with the building code. Its poorly defined structure would require rewriting many of the regulations. Formal agreement of the code authoring bodies would be necessary.

Research in the domain of codes and standards includes:

- •developing plausible models of CADD use and developing tests representing that use
- •defining standard data transfer formats for CADD users
- •defining standard human-computer interfaces for EMCS systems
- •defining standard computer-computer interfaces for EMCS systems

For building codes:

- •developing a building taxonomy agreed upon by all code related bodies
- •developing a KBES representation amenable to building code structure
- •rewriting the code to fit the new representation

Development includes:

- •arriving at agreement with industry on the CADD standards
- •developing standard communication protocols

For building codes:

- •writing software to represent the NBC

Research and development of building code related software would require a large commitment on NRC's part.

Design Tools

The activity of building design received much attention during the 1960s with the work of Eastman and Negroponte. Yet many questions remained unanswered. What type of computer interfaces support this activity and what are the information needs during this enquiry?

Basic research would include:

- •field research in design offices to define design methods and the descriptions of tools to support these methods. In turn, the research would provide software houses with guidelines for interfacing techniques.

Development comprises:

- •writing software to support design decisions and information retrieval

Guidelines for Intelligent Building Design and Specification

Information from commercial building equipment vendors is often incomplete. The consumer or user of the equipment has few criteria to judge the appropriateness or level of "intelligence" needed in the building. Fundamental research on user requirements for view, acoustical privacy and the cost/benefit of these attributes is necessary to develop office design performance criteria.

RESEARCH DIRECTIONS

The above four research directions are not all inclusive. Our research is driven by the needs of the construction industry and the available technology to build tools for this industry. As industry begins to make its needs better known, our research directions become more focused.

This Advanced Technology Roundtable has been convened to focus the industry's needs and discuss the computer tools necessary to meet those needs.

Slides presented at the Advanced Technology Roundtable
November 1986

1.

ADVANCED TECHNOLOGY for BUILDINGS

"Where's the Research?"

2.

CAPSULE

- **Includes electronic and computer technologies**
- **Includes AI, CAD, Control Theory, Ergonomics, psychology, Architecture, Systems Analysis...**
- **ESTABLISH SOME PRIORITIES FROM INDUSTRY VIEW**

3.

BENEFITS

- **Building industry and computer industry input for applied research**
- **Private sector has opportunity to target research**

4.

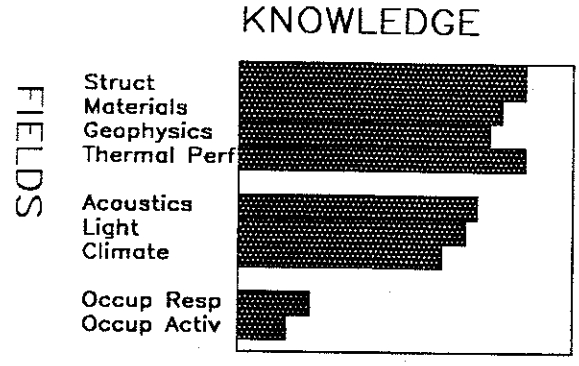
ROUNDTABLE STRUCTURE

●ROLES
●NRC ROLES
●AT Group Work
●Research and Development
●What Now?

●Facilities Management
●Testing, Standards and Benchmarks
●Computer Software Development
●Architectural Research: office ergonomics, communications

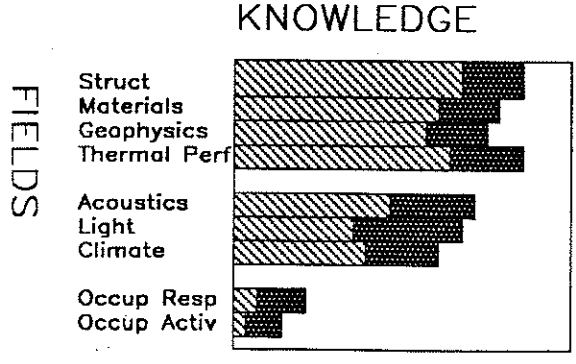
5.

ROLES ●Basic Research



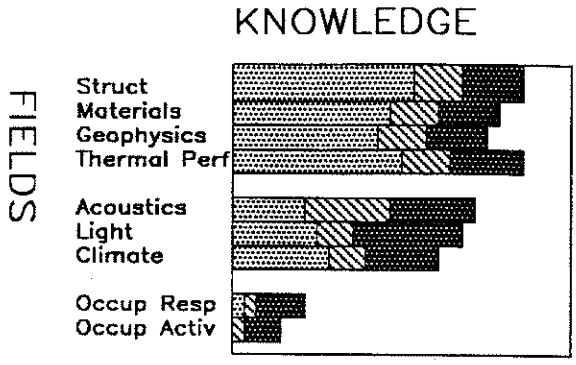
6.

ROLES ●Development



7.

ROLES •Implementation



8.

NRC ROLES

•Basic Research (Materials, Heat Transfer)
•Development (Digital Thermostat, HOTCAN)
•Implementation (Information transfer to user, CBD, Building Practice Notes)

9.

AT GROUP WORK

•Knowledge based diagnostics
•CAD Benchmarks, Symbols, Standards, Integrated Databases for CAD
•Simulation of building thermal performance, control systems

10.

RESEARCH IN AT FOR INDUSTRY

- **Facilities management**
- **Standards, Benchmarks and Interfaces**
- **Development of Software Tools for the Industry**
- **Basic Research of occupant activity.**
  Use and usefulness of computation equipment in office environments.

11.

FACILITIES MANAGEMENT

- **Collection of research, development and implementation (information transfer) issues.**

- maintenance procedures--CFTOs
- building taxonomy and representation
- development of controls (EMCS)
- development of KBES for diagnostics

12.

STANDARDS, BENCHMARKS AND INTERFACES

- **Standards for EMCS interfaces, prototype testing, form criteria specification of standard**
- **Standards for CAD symbols, taxonomy, data structure IGES BC Committee**
- **Standards for KBES/CAD structures, taxonomy, ICAD (SYMBOLICS) verification**

13.

SOFTWARE DEVELOPMENT

- **Develop software for building industry**
- **Examples**
  - oKBES Window diagnostician
  - oHOTCAN
- **Develop deterministic (models) and KBES systems based on IRC research**
- **Which fields? KBES? CAD? Integrated DB?**

14.

"COMPUTERIZED CODE"

- **KBES representation of building requires large investment ($millions)**
- **Building taxonomy, logical code**
- **Benefits? Clients?**

15.

DEVELOPING MACHINE INERFACES

- **Effective software interfaces for desing. Basic research of design information needs and prototyping.**
- **Human Factors Research**
- **Systems research of design**

16.

ELECTRONIC OFFICES

- Occupant activity, ergonomics
- Electronic tools–their effectiveness (communications "fit" into environment)
- Specification needs of industry

17.

FUTURES

- Immediate needs do not promote long-term innovaton
- Computer generated holograms
  Automated checking of drawings
  Integrated information systems
- Curiousity driven

Appendix 2

IFMA RESEARCH FRAMEWORK

July 1986

The concept of a framework was chosen specifically so that each year IFMA can change the priorities and allocation of resources within the following research topics. Committee members this year assumed responsibility for developing one of the six programs. Ranked from top priority down for this year, the programs are as follows:

1. External Comparison. How do my organization's facilities and operations compare with others?

   Similar to a competitive benchmarking study, the program will compare members' facilities by industry, size of company, and geographic location. It will comprehensively investigate all aspects of facility operating costs and organizational staffing. A pilot study will be conducted this year by the International Center for Facilities (ICF) to develop the survey instrument that will be used to collect data annually or biennially. This is envisioned as a major, long-term research effort, and may expand to include non IFMA facilities managers in the future. (Allen Baldridge)

2. Performance Improvement. How can my organization improve performance of facilities and their management?

   This program will study the areas such as cost reduction, energy retrofit, product and service assessments, quality and performance evaluation of those products and services, and the impact of new technology. This will be a short-term ongoing survey and report effort. Periodic surveys or case studies, probably three per year, will result in immediate reports to IFMA members. Reader response cards may be used to evaluate the usefulness of the reports and to receive members' suggestions for future studies. (Don Magill, Wayne Mills)

3. Expertise Referral. Who has expertise or experience that I may contact?

   A profile of IFMA members will be developed through an annual census of the membership, indicating their experience and areas of expertise, and will be accessible by phone call inquiry. The committee is investigating how a computer network would be used for this service. This program will be undertaken initially as a research effort but may eventually become part of basic IFMA membership activities. (Mel Schlitt)

4. Standard Language and Measures. What useful standard definitions and measures would help me communicate with others?

   In an effort to achieve standardization of terminology, this program will look at the definition of facility areas and in calculation procedures, financial and accounting practices for capital expenditures and operating costs, and the definition and measurement of workload indicators, i.e., churn. This is seen as a long-term program involving the assignment of a task force which would possibly collaborate with other industry associations, such as AIA, IBD, Tradeline, CSI, BOMA, and IDRC, among others. (Paul Tranquada, Steve Marjulis)

5. Internal Practices. How do I set up a facility management organization? What are the options and future trends?

   This category encompasses many of the subjects addressed in Research Reports #1 and #2, then expands the list of internal practices to look at: facility management functions; organization responsibility; job classifications and salaries; computer tools and techniques; management style, process and methods; and workload and staffing. This will be a long-term program, perhaps moving from survey research to case studies. We also envision conference papers that address more areas of facility management methodologies, and ultimately plan to disseminate these through the IFMA newlsetter or journal. (Steve Philips)

6. Roles, Relationships, Alliances. What ideas and practices would advance the interrelationship among IFMA member groups and with other associations?

This program will look at buyer and provider relationships in terms of contracts and procedures; product and service feedback on selection criteria and selection processes; new trends/buyer needs and benefits; new types of facility technologies; and product education. This would be an ongoing program using focus group sessions. We have already begun such discussions with NOPA and BIFMA. IFMA's annual conference will also provide an ideal time to hold these types of exchanges between memberships. (David Numark, William Back)

Appendix 3

Reprinted from

AN AMERICAN MANAGEMENT ASSOCIATION PUBLICATION FOR MEMBERS

MANAGEMENT REVIEW

THE FUTURE OF THE OFFICE (OF THE FUTURE)

BY DUNCAN B. SUTHERLAND JR.

AMA

THE FUTURE OF THE

BY DUNCAN B. SUTHERLAND JR.

Top management is getting more nervous when it comes to the question of office technology. The denizens of the nation's executive suites are caught on the horns of a dilemma. On the one hand, failure to embrace change—particularly, change wrought by sophisticated and expensive information technology—may seriously weaken their ability to compete in an increasingly competitive and uncertain world. On the other hand, there is no conclusive evidence that the hundreds of millions of dollars already invested in office technology over the past 20 or so years ever will result in dramatically improved productivity or profitability.

Too many American companies, already awash in advanced modular furniture systems, computer systems, and communication systems, continue to stumble down the path of ever-greater technology investment without any real confidence that they are doing the right thing. They are suffering from what might be characterized as a case of "technomania"—an insatiable desire to acquire more new technology without ever achieving any real, long-lasting satisfaction from the effort.

TYRANNY OF TECHNOLOGY

Put yourself in the place of a typical CEO in, say, the year 2001:

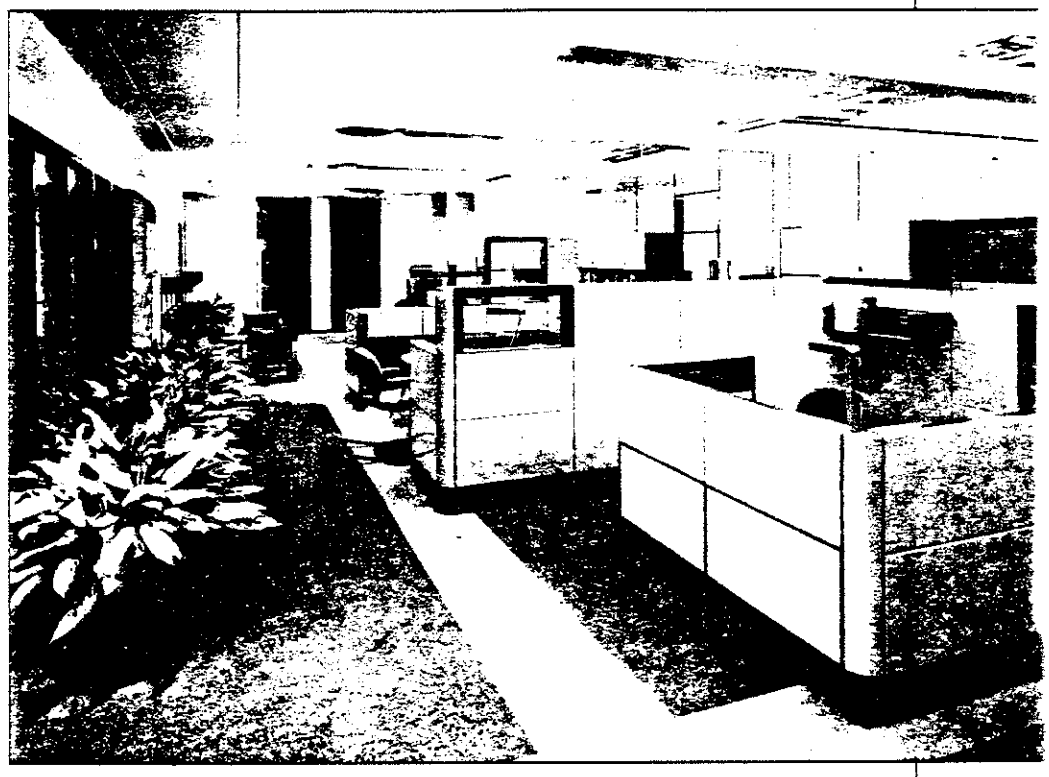
It's 5:30 a.m. and you have just been nudged awake by your computer-cum-alarm clock which has been programmed to wake you in the voice of your choice. Because it also has monitored your REM (rapid eye movement) sleep pattern, the computer "knows" whether you had a restful night and adjusts its tone—and persistence—accordingly.

As you shower, you call up a display of yesterday's closing stock quotes, plus your calendar and to-do list on a waterproof, color LCD (liquid crystal display) panel.

Leaving the house, you use your car phone to review messages which have been left overnight in the "mailbox" of your electronic voice messaging system. You respond to several, dictate a reminder note to yourself (it's automatically added to your to-do list), then begin making the first calls of the day as you head onto the expressway.

Following a brief conversation with the general manager of your U.K. operation, you command the phone to take memos to two colleagues. Your words are transcribed automatically into grammatically and syntactically correct memos to await your arrival at headquarters. You order the car's computer to read

OFFICE (OF THE FUTURE)



your corrected memos back to you in synthesized speech.

Arriving at headquarters, you clear security by stating the day's password to the voice pattern recognition system. This is only one of several new security systems your company has introduced recently to thwart the latest international terrorist stratagem. Saboteurs, who had managed to infiltrate the customer engineering organization of a major computer vendor, installed memory chips—modified to contain "worms" (small programs which systematically destroy other programs)—into the major financial systems of more than half of the *Fortune* 100 companies. The scheme was discovered quickly, but productivity losses ran into the billions of dollars.

As you enter your office, your lights are turned on by a sensor and your electronic desk winks to life with a display of your calendar and to-do list, updated with the memos you dictated in the car. You review the memos one last time, dictate a couple of minor changes, and send them along to the electronic mail system—noting that electronic copies are also to be sent to the Hong Kong office.

As you scan today's meeting schedule, an urgent call comes in from New York. The transaction involves Chicago as well, so you punch up a three-way video conference and quickly resolve the problem. You turn back to your electronic calendar, but another call is already waiting. It's going to be one of those days!

There are two important observations to be made here:

First, virtually all of the technology used by our hypothetical executive exists today, either in the marketplace or in the laboratories of the world's computer and communication vendors. Even so, with all of this whiz-bang technology at hand, is our 21st-century CEO really more productive than her counterparts of today? Or, is she simply doing what executives have always done—only with different tools? More to the point, does placing all of this advanced technology in the hands of *individuals* have any measurable (positive) impact on the effectiveness of the *organization* as a whole?

This brings us to the second observation, which, although more subtle, hits at the very heart of the issue. You will recall that our hypothetical CEO's day "at the office" began long before she arrived at headquarters. Similarly, it will continue far past departure. In fact, we never actually stop "working"—even when we are asleep our subconscious continues to process our daily experience.

The key point is this: How we view the role of "office technology" is shaped by how we view the "office." If we view the office as a physical environment in which "office

work" takes place between certain hours of the day, our expectations for new technology will be to improve the performance of the physical environment, the performance of work within the time constraints of the "work day," or perhaps both. In fact, it is exactly such a view of the office that has led to management's recent fascination with word processing, electronic spreadsheets, executive workstations, systems furniture, and so forth.

If, on the other hand, we view the office as it really is—an intellectual phenomenon independent of time and space—how might this change the way we think about office technology? More important, how might this affect our current notions about the "relationship" between office technology and office productivity?

A bit of social history may be instructive here.

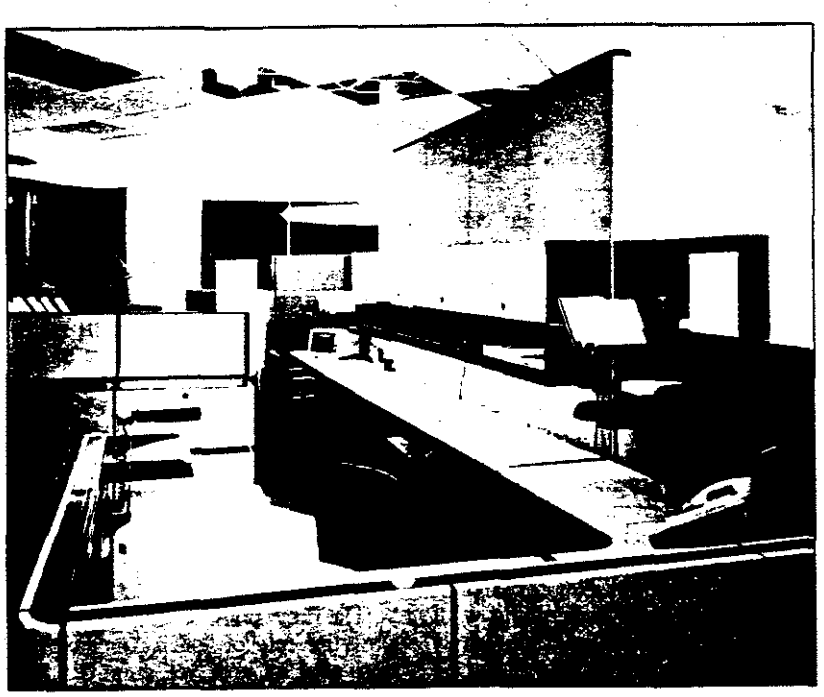
THE PAST AS PROLOGUE

How a society organizes knowledge in space and time to accomplish useful intellectual work—i.e., how a society "offices"—is more often than not a reflection of how it produces its more tangible goods. Thus, it should come as no surprise that the office of today is rooted in the industrialization of Western society.

Prior to the emergence of the British mill (the forerunner of the modern factory), work and family life were virtually indistinguishable. Even with the rise of commerce and mercantilism, buying and selling goods typically was done either in the home or in the coffeehouses of the world's emerging business centers. Socializing was intermixed with physical labor in a pattern that persisted well into the early 19th century. But with the advent of the mill, all of this changed.

With the mill came the necessity to synchronize mill workers. The result was the invention of an artifice: the workday as we still know it. Workers were (and are) told when to arrive at the factory (office), when to eat lunch, when to rest (if at all), and when to return home. As the need grew for clerical and administrative workers to support the world's growing industrial base, the organizational concepts and the discipline from the factory were carried over into the "office"—often nothing more than a room crammed full of tables with an overseer (manager) on a raised platform at the back to spot shirkers and resolve problems.

Today, despite changes in physical appearance and the introduction of new computer-based tools, the office, as an organizational entity, remains strikingly unchanged.



The office hasn't changed as quickly as the nature of work.

OF MODELS AND METAPHORS

We are all products of socialization. At a very young age, we all learn to perceive the world the way we believe parents, friends, and society in general expect us to perceive it. Consider how we are socialized as children to think about "the office" and about "office work." The *office* is where Daddy and Mommy go every day. Likewise, *office work* is something that takes place 9:00 a.m. to 5:00 p.m. (or, if we're lucky enough to be on flex-time, anytime we like—so long as it's between 7:30 a.m. and 5:30 p.m.). How many times have you heard someone say, "When I go home, I leave my work at the office!"

As we mature, these frames of reference, embedded deep in our unconscious mind, make it extremely difficult to envision radically different ways in which "officing" might be carried out. Sure, we can imagine (someone else, usually) working at home on a computer terminal—"telecommuting," to use a current buzzword. Even so, what we typically visualize is simply a minor shift in the *locus* of work, with everything else—including the workday—remaining pretty much constant. Beyond this, the water gets pretty murky. As a case in point, following a speech a few years ago in which I had questioned whether we even need office buildings at all, an individual came up to me and asked (in all seriousness): "But Mr. Sutherland, if we don't have office buildings, where are we going to put all the office workers?"

The result is a vicious cycle in which the future, because it is so strongly shaped by the past, can look only slightly different from the present. Ultimately, new "solutions" evolve, but the process is long and laborious—and unnecessarily expensive. Today's business conditions won't make allowance for a languorous, evolutionary response: today's economy won't make allowance for the costly fits and starts, trials and errors which are part and parcel of an evolutionary model. Bolder and more profound changes are required.

A MESSAGE FROM DETROIT

Detroit's manufacturing gurus

have been forced to step back and question some of the most basic assumptions about the process of designing and building vehicles. Along the way, they have discovered that one of the major stumbling blocks to improved manufacturing productivity is the very innovation that created the automobile industry as we know it today: Henry Ford's progressive assembly line.

The key here is that Detroit is undergoing a fundamental change in its thinking about vehicle manufacture: it has begun to see its productivity problem in new ways. Likewise, when it comes to officing, management must manage a similar quantum leap into the void.

We must begin today to rethink the office itself: to reassess what offices really are, what purposes they serve, and how they work. We need to create new metaphors for the office that will help us break out of our traditional ways of thinking about how business marshalls people and the technology that supports them. And we must expand our view of technology to encompass much more than simply a means of doing what we do today, only more efficiently or more effectively. We must look to technology as a force that will enable new types of organizations to accomplish knowledge work. We must seek major shifts in the balance of people and technology (including facilities) in the business productivity equation.

In uncertain times like these, companies are correct to seek maximum flexibility in their workforces and maximum liquidity in their balance sheets. In terms of officing, the former suggests the introduction of new schemes for organization; the latter suggests prudent, mission-directed investment in technology and the unloading, where possible, of unproductive assets. Among the most unproductive of these assets may well be our gleaming, high-rise office towers with their set-in-place office facilities and 9-to-5 workforces.

Solutions to the white-collar productivity puzzle—and all the right pieces, as well—remain to be discovered. But two things seem certain:

□ Organizations must quickly find the leadership—and the vision—to see the possibilities for radical change, and to avoid the pitfalls of halfway measures that consume scarce capital but fail to further the organizational mission.

□ Only through the development of fresh approaches to technology planning—which lead to integrated strategic thinking about facilities, computers, and human resources—will top management ever achieve the substantive improvements in white-collar productivity it has so long sought.

American business stands astride a watershed. To one side lies the conventional workplace, albeit updated with new technologies of myriad sorts. To the other lies the challenging, barely glimpsed territory of the organization—and the office—of the future, which may or may not look like anything we know today. Responsibility for choosing a path lies squarely on the shoulders of top management—not something that they feel comfortable doing, nor even something that they really want to do. However, it is something that they must do if their organizations are to survive in an increasingly competitive world.

If today's office looks like yesterday's, and if the "office of the future" looks suspiciously like the office of today gussied up with a lot of technological gimcracks, we have no one to blame but ourselves. The contemporary office is an artifact—a product of a particular form of organization anchored in the conditions and circumstances of the Industrial Revolution. Management's challenge is to quit brooding about what the office of the future might look like and refocus on the bigger issue—what the organization of the future *must* look like. The office will take care of itself. □

Duncan B. Sutherland Jr. is vice-president and director of officing for the Houston-based architecture/engineering/construction firm CRS Sirrine, Inc. Sutherland leads the company's research and consulting program in technology planning. The goal of the firm's officing program is to help clients develop new approaches to organizing knowledge and the technologies which support its application. Prior to joining CRSS, Sutherland spent six years at Wang Laboratories, where he held various management positions, including director of office automation programs. He was the founder and first director of Wang's Advanced Systems Laboratory.

(To order reprints, please see page 4.)

The authors see the contemporary office as an "artifact."

Appendix 4

MAY, 1980

SMART
HOUSE

Tom Bowling, BNR

BNR

MAY, 1986

SMART HOUSE

- Is a multi-company project, directed by the National Association of Homebuilders
- To introduce a new range of integrated power and communications wiring, wiring products and appliances to:
  - improve home safety
  - encourage new product innovation and sales
  - to keep out Japanese competition

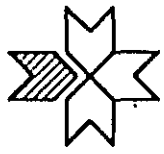
SMART HOUSE

BNR

MAY, 1986

THE NATIONAL ASSOCIATION OF HOME BUILDERS

- 130,000 Member Companies
- Who build approximately 90% of all domestic, light commercial and industrial properties
- Education and training
- Standards setting and testing
- Product innovation
- Code and Standards changing
- Industry spokesman

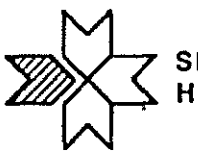


BNR

MAY, 1980

THE PROBLEM

- No basic improvement in domestic wiring in fifty years
- Marginally safe
- At least seven different electrical contractors needed to wire a house
- Spaghetti wiring, zipcords, multiway adaptors, and powerbars
- Capabilities of equipment unrealizable
- Innovation restricted



BNR

MAY, 1986

THE NATIONAL JOINT VENTURES ACT, NOVEMBER 1984

- Encourages firms to engage in joint R&D with considerable exclusivity of use of resulting designs thereafter
- Venture Capital funding encouraged
- Is being applied in the following areas:
  - semiconductor industry
  - civil aircraft
  - petro-chemical
  - home construction

BNR

MAY, 1986

SMART HOUSE GENESIS

- On November 24 1984, after a mail shot to some 2000 companies, representatives of some 100 firms and organizations attended at NAHB, Washington, D.C.
- Included were many industrial companies, and also
  - electrical power
  - cable
  - accessories
  - HVAC

BNR

MAY, 1986

SMART HOUSE GENESIS (cont'd)

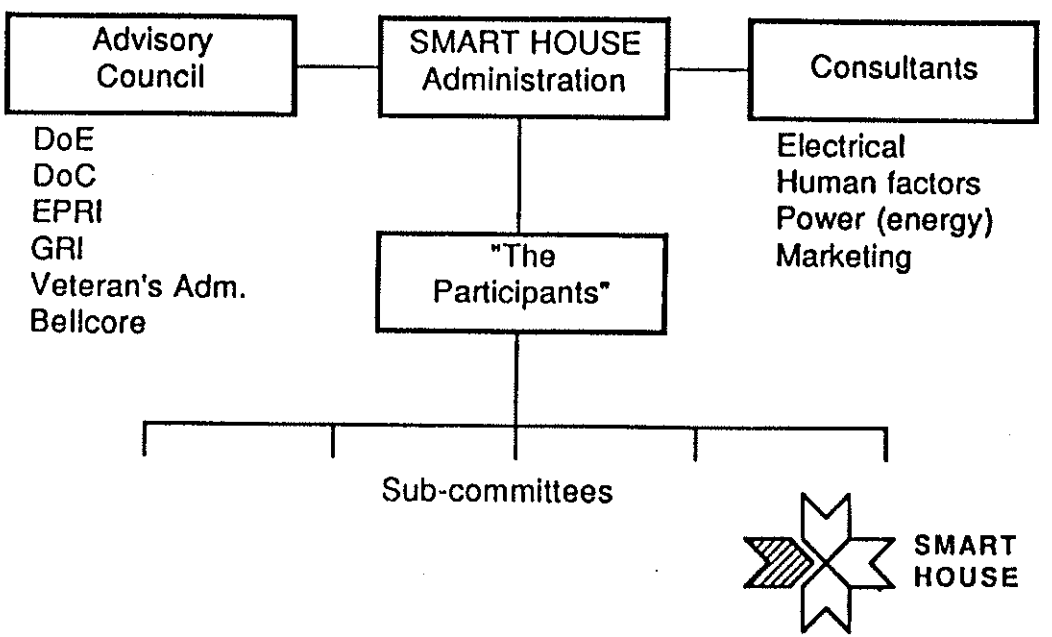
- large appliances
- small appliances
- telephone
- entertainment products
- computer
- security
- Government
  (D.o.E., D.o.C., Vet. Adm., NASA, Oak Ridge)
- consultants
- technical press

"But when's the go, no-go?"

BNR

MAY, 1986

THE VENTURE



BNR

MAY, 1986

THE PARTICIPANTS

- AMP
- Apple
- AT&T
- Bell-Northern
- Brand-Rex
- Broan
- Burndy
- Carrier
- Dukane
- Dupont
- Emerson Electric
- Federal Pacific
- General Electric (RCA)
- Honeywell
- IBM
- I-T-E (Siemens)
- Landis and Gyr (Swiss)
- Lennox
- National Semiconductor
- N.A. Phillips
- Northern Telecom
- Nutone

BNR

MAY, 1980

THE PARTICIPANTS (cont'd)

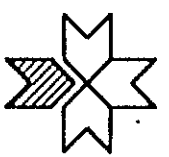
- Pass and Seymour (Legrange, France)
- Robertshaw
- Schlage Lock
- Scott Instruments
- Shell Development
- Signetics (N.A. Phillips)
- Slater Electric
- Sola Electric
- Square D
- Systems Control (U.K.)
- Whirlpool
- Wiremold

BNR

MAY, 1980

MARKET SIZE

- 1.5 million homes are built in the USA each year
- Components and wiring (incl. labour) - $2B/yr
- Appliances - $8B/yr

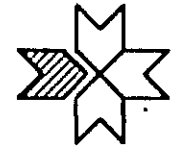


SMART HOUSE

MAY, 1986

The retail sales values of the new-home markets for products are:

	Sales to New Homes (millions)
Water heaters	$ 660
Furnaces and heat pumps	1,500
Air conditioning, excluding heat pumps	805
Televisions and VCRs	980
Stereo systems	70
Telephones	150
Security and Fire Detection Systems	75
Home computers	75
Kitchen appliances	2,625
Clothes washers	480
Clothes dryers	420
Lighting fixtures	225
TOTAL	$8,065



SMART HOUSE

BNR

MAY, 1986

COST COMPARISONS

- To wire a basic 'Smart House' (fixed wiring, control etc.) has been costed as approximately $500 more than an equivalent conventional home (4 br, 2 floors, no basement, $137,000 U.S. including land).

BNR

MAY, 1986

EXPECTED SMART HOUSE PENETRATION

- (No of homes)

1987	1988	1989	1990
5000	30,000	100,000	300,000

BNR

MAY, 1986

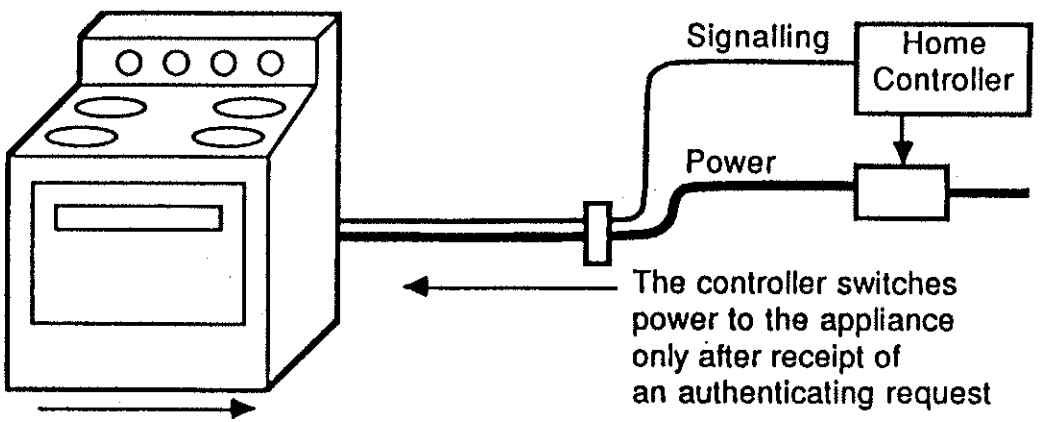
TECHNICAL CONSIDERATIONS

- Smart House main features
  - improved home safety
  - integration of electrical distribution and control
  - appliance and services innovation

BNR

MAY, 1986

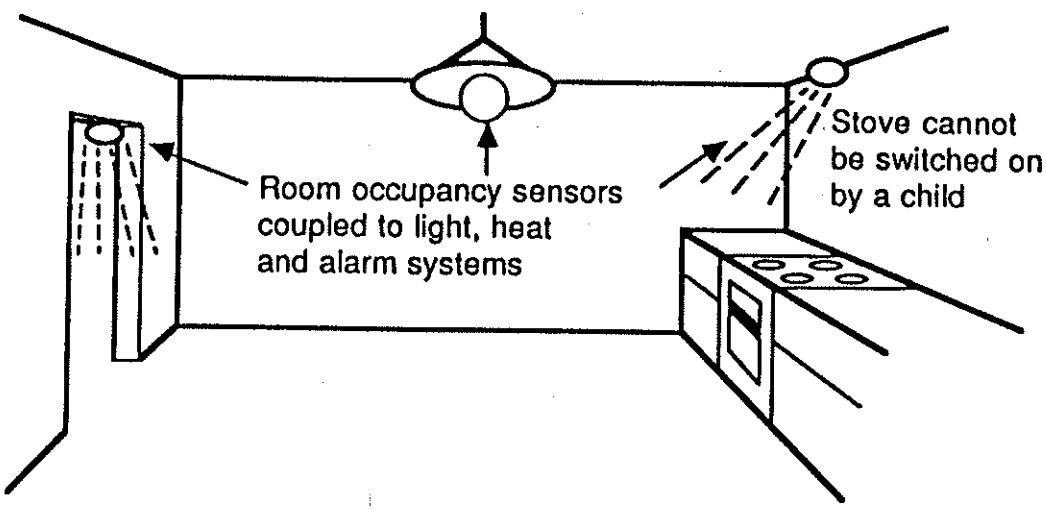
THE CLOSED LOOP 'SAFE' SMARTHOUSE POWER SYSTEM



SMART HOUSE

MAY, 1986

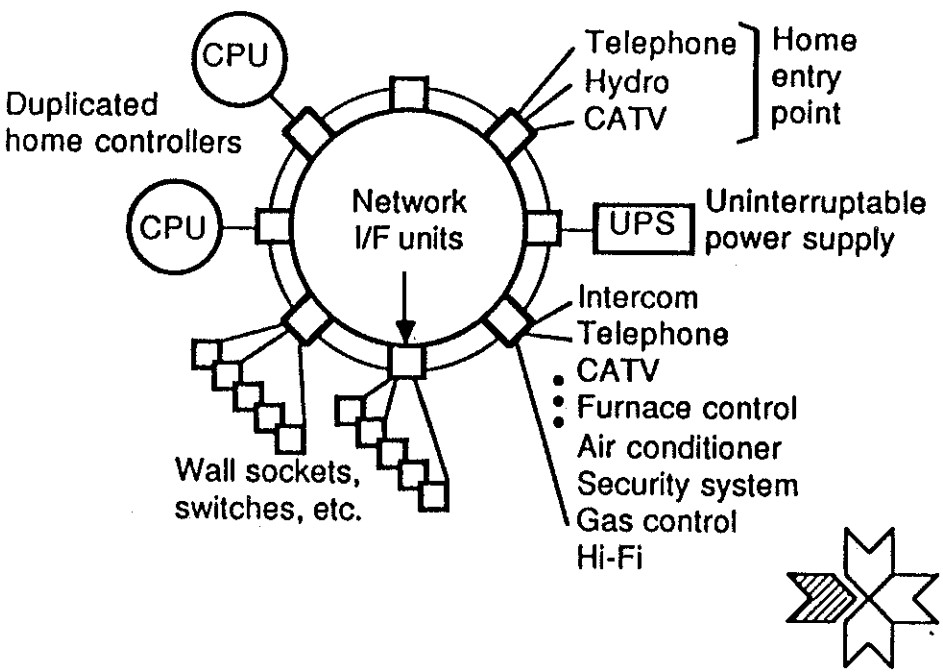
SOME SMART HOUSE NEW SERVICES



SMART HOUSE

MAY, 1986

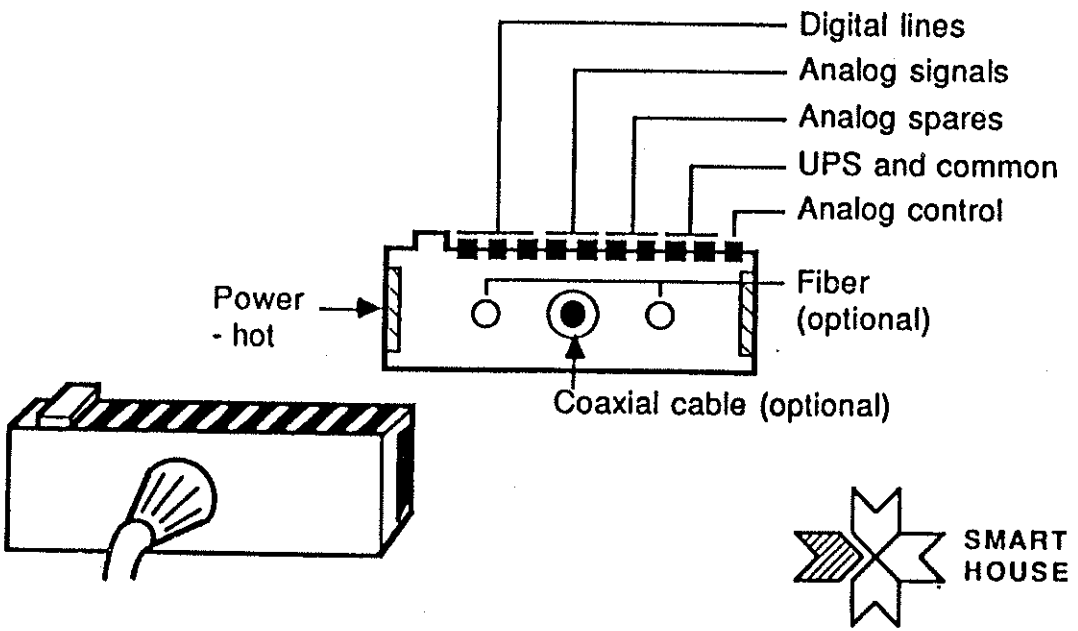
THE SMART HOUSE
GENERAL ARRANGEMENT



SMART HOUSE

MAY, 1986

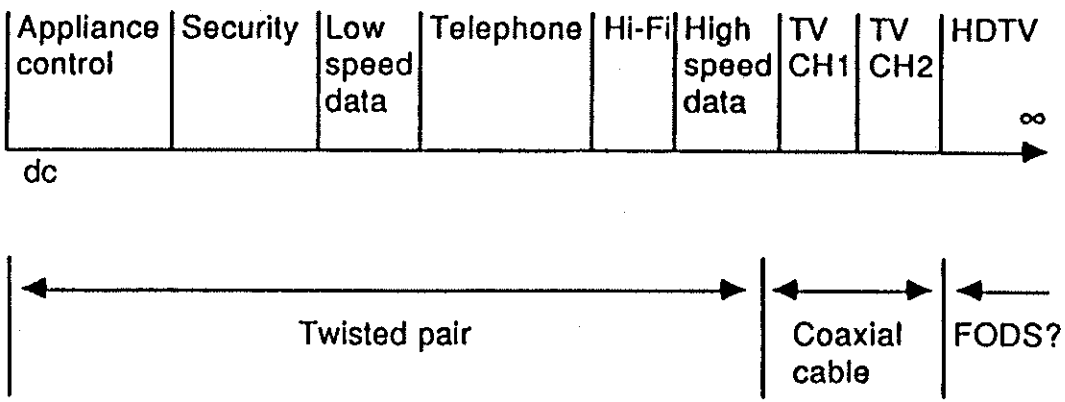
SERVICE INTEGRATION
- THE SMARTHOUSE PLUG AND SOCKET



SMART HOUSE

MAY, 1986

THE COMMUNICATIONS SPECTRUM



("Marketing is to be driven by entertainment")

SMART HOUSE

BNR

MAY, 1986

STATUS TO DATE

- Product interface specifications are complete
- Tender documents for R&D will be issued by 1 May '86
- R&D contracts - funded by participants (except software and ICs) by 1st July '86
- Demonstration Electric & Gas Smart House on tour
- Prototype Smart House is being built now

BNR

MAY, 1986

STOP PRESS

- BNR (NT) are not the only telecommunications company in the Venture. Now, AT&T have joined (Feb. '86).
- The National Electrical Council (NEC) have agreed to all 12 proposed code changes to permit Smart House
- UL are very supportive
- IBM and Mitsubishi have recently requested to join as participants, the latter disallowed under Anti-Trust

BNR

MAY, 1986

STOP PRESS (cont'd)

- Fibre expertise is held by other participants - AMP, Dupont, ITE (Siemens) and AT&T
- E.F. Hutton and Partners will handle the Venture capital launch (for core technologies only and marketing)
- Yankee Group, and Yankelovich, Skelly and White have completed very optimistic reports for Smart House market expectations. The former consider the retrofit market could be four times Smart House forecasts.

BNR

MAY, 1986

"The Smart House Venture possesses
the necessary elements to bring home automation
to the mass market through its innovative
technology, comprehensive promotional activities,
and most importantly, aggressive marketing
strategies."

Yankelovich, Skelly and White, January '86

SMART
HOUSE

BNR

MAY, 1986

". . . compared to the Yankee Group's estimates (of the future home automation market through 1995) the Smart House projections (of market penetration) are rather conservative."

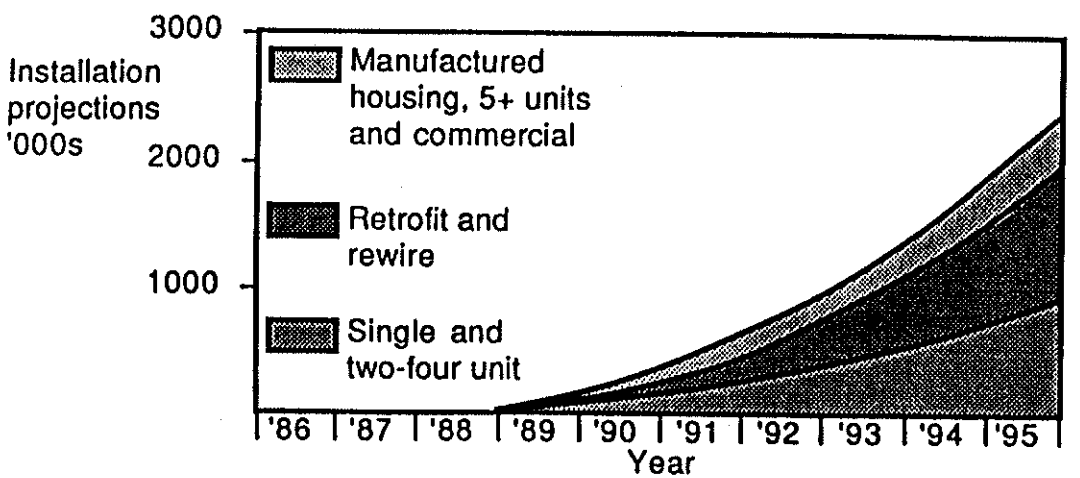
". . . on a long-term basis the Smart House is likely to become established as the standard and norm for home wiring."

The Yankee Group, January 1986

RNR

MAY, 1986

PROJECTED SMART HOUSE INSTALLATIONS IN U.S.A.

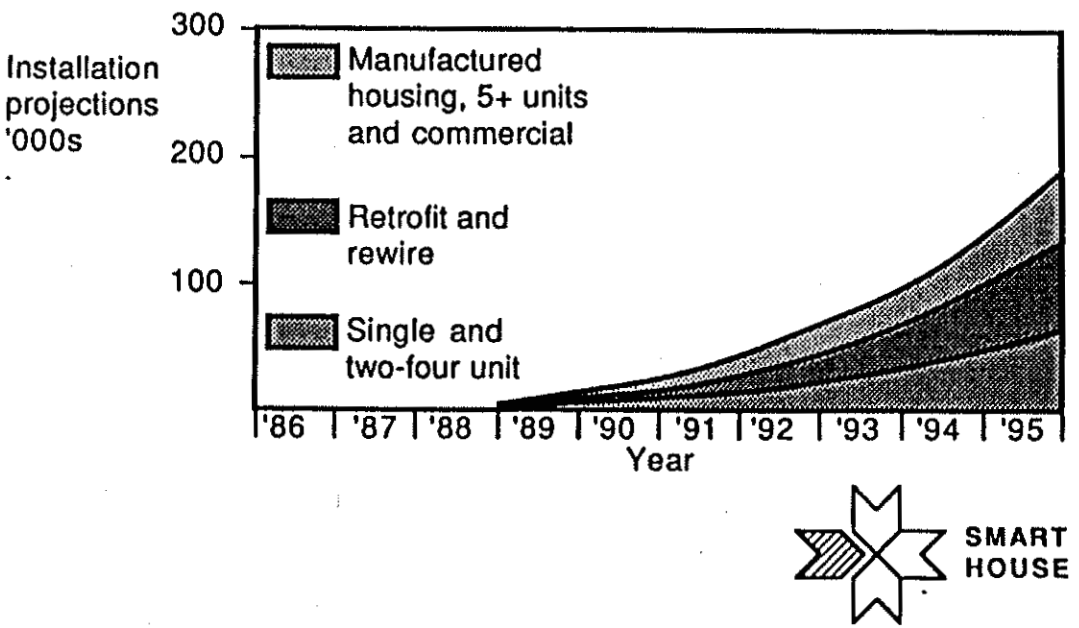


SMART HOUSE

BNR

MAY, 1986

PROJECTED SMART HOUSE INSTALLATIONS IN CANADA



SMART HOUSE

bnr 565b/8011

Appendix 5

National Research Council
Building Research Board

1986
WORKSHOP ON INTEGRATED
DATA BASE DEVELOPMENT

National Academy of Sciences
Woods Hole Study Center
June 15-20, 1986

INITIAL INTEGRATED DATA BASE DEMONSTRATION

On Monday evening, June 16, the project team plans to conduct a demonstration of the initial integrated data base prototype. We request that participants in the workshop review this memorandum before that date so that the background and objectives of the demonstration will be more clearly understood. On the morning of June 16, members of the team who have helped to implement the demonstration configuration will explain the following material in greater detail as part of the project team's presentation.

BACKGROUND

Although the idea of the integrated data base for use throughout the building process originated at the Woods Hole workshop in 1983, it was not until the 1984 workshop that the concept of a prototype surfaced. At the workshop in 1985, two working groups investigated ways for implementing the demonstration prototype. As a direct result, the project team was subsequently organized and held the first meeting on October 29, 1985.

Project objectives were established by the team as follows:

> Design, implement and utilize a demonstration prototype of the Integrated Data Base (IDB) that will serve as a research tool for 3 to 5 years and will be used by project participants and clients of the Building Research Board or their representatives to:
>
> 1. Gain a better understanding of how the IDB will be used in the future building process and the resulting requirements that the IDB will have to satisfy.
>
> 2. Investigate alternative technical solutions to IDB implementation problems of linking data files and data bases of multiple computer systems via a common (integrated) data base for use throughout the building life cycle.

In accordance with a recommendation from the 1985 workshop, the team targeted June 1987 for the prototype to be operational and available for demonstration at Woods Hole. However, at the meeting of the project team last December, it was decided that it would be very helpful to the participants at the 1986 workshop if an initial prototype could be available this June.

The initial prototype has been planned as a tool for both the participants at the workshop and for the prototype development team. The concept is to use the initial prototype to walk through a typical scenario in the building process so that workshop participants can use that concrete example to address specific questions relative to the IDB as well as the future enhancements of the prototype. The prototype development team will be looking for feedback from the workshop on such questions as, "Is this the kind of prototype required to resolve the issues that now delay the introduction of the IDB technology in the building process?", "What kinds of changes are desired in the prototype over the coming year?", "What resources are needed to provide the prototype desired by June 1987, and how will those resources be obtained?"

CONFIGURATION

The prototype configuration to be demonstrated next month is the first phase of a multiphased approach to the implementation of the prototype. The central processor is a DEC MicroVAX II, with 5 megabyte MOS memory plus three 71 megabyte fixed Winchester disk drives with controller, a VT240 terminal and an LA100 printer/terminal. The operating system is MicroVMS, configured for eight concurrent users. The permanent prototype configuration will include the Tektronix high resolution color graphics terminal, Model 4125, although the terminal to be used at Woods Hole will be a borrowed Tektronix 4111. An IBM PC/AT equipped with EGA is planned for use during the demo also.

The DBMS to be used in the demo is ORACLE. Applications to be used include AUTOCAD, GDS, STRUDL and STAAD III.

Vendors have generously donated the equipment and software required for the prototype, or loaned it to the Building Research Board for an extended period. (We estimate the dollar value of the hardware and software to be close to $300,000.) The configuration is being assembled and integrated by team member Paul Scarponcini at his offices in McDonnell Douglas AEC Company, St. Louis. Building design data have been prepared by Gary Seibert of the U.S. Army Corps of Engineers, Savannah District; he also has played a key role in preparing the initial data model. Other data have been prepared by members David Kalish and Malcolm McCullough of Autodesk and Jack Enrico of Bechtel Power Company. Jim Anderson, Consultant, CDC Information Analysis Services, is providing expert advice on design of the conceptual data model.

SCENARIO

During the demonstration, the prototype described above will be used by team members to walk through a typical sequence of tasks that occur between the design and construction phases of the building cycle. To keep the implementation of this initial prototype to a manageable size, the team decided to restrict the effort to the various tasks and activities involved in the

design and construction of a building wood truss. The building design selected as a case study is a mobilization administration and supply building for which the Corps of Engineers has an existing design. Although this snapshot of the building process is just a small portion of the entire cycle and addresses only the structural subsystem, the team has found that the lessons learned from this effort can be extended to other subsystems and phases and can go a long way towards addressing issues related to global data modeling and desired characteristics of the IDB. Future research efforts would broaden the scope of investigation.

During the demonstration, Fred Kitchens of the U.S. Army Corps of Engineers will describe the steps that the client would follow in establishing requirements for the building, including preparation of Form 1391. Although the client will utilize the IDB in a real situation, during the demo Fred will just describe the steps involved and will show the results on one of the terminals of the prototype. Data pertinent to subsequent tasks in the scenario are stored in the demo IDB on the MicroVAX using ORACLE.

Our architect for the demo, Malcolm McCullough of Autodesk, will explain how he uses the client's requirements data in the IDB to drive his activities, which involve the use of AUTOCAD to generate the architect's view of the building floor plan and a cross section of the roof. These data will be stored in the demo IDB for use by the structural engineer.

Gary Seibert, our structural engineer from the Corps of Engineers, will walk through the steps of the design task in detail. He will retrieve the architect's view from the demo IDB, generate a design, analyze it using STAAD III, and access a simulated on-line external data base for physical properties of wood materials; he will prepare a drawing of the truss design that will be loaded into the IDB.

Jack Enrico will play the general contractor role. He will use requirements and design data on the truss to prepare the work breakdown and related contractual requirements for his fabricator/subcontractor. As with the task of the client, this task will not be performed in detail, but it will be explained and resulting data for inclusion in the IDB will be displayed.

The fabricator role will be played by a colleague of Paul Scarponcini from McDonnell Douglas. He will step through the task in detail, retrieving data from the demo IDB, prepare a detailed fabricator's view using GDS and perform structural analyses using STRUDL. His results will be stored in the demo IDB.

Additional tasks will be described by the same participants in the scenario to explain the IDB involvement in tasks up to the start of construction. In addition, the use of the IDB will be described in a situation where it becomes necessary for the client to change requirements, leading to a design change order.

CONCEPTUAL DATA MODEL

The structural engineer's task and the fabricator's task will be presented in detail during the demonstration, as summarized in the above description and scenario. To ensure that the demo IDB contains the necessary data entities and attributes and that the data base is populated with the data required for these two tasks, Gary Seibert and Paul Scarponcini, aided by Jim Anderson, performed detailed task analyses and initiated the design of the IDB conceptual data model.

Two goals of this demonstration will be to explain how the tasks were analyzed and the data modeling methodology used. During the presentation in the morning of June 16, those efforts will be described. Using that work as a starting point, the Task Analysis working group will be asked to define and analyze other life-cycle tasks and to establish associated user requirements for the IDB. Similarly, the Data Modeling group will be asked to review the data modeling efforts for the demonstration protytpe and to recommend improvements in the model and modeling process to support future research efforts involving the prototype IDB.

INTEGRATOR

At the 1985 Woods Hole workshop, the concept of the "Integrator" was introduced by the working group that planned for the prototype implementation. The Integrator represents a composite of the functions of the IDB necessary to support an integrated data base in a distributed, heterogeneous environment.

There have been a significant number of research projects in the computer industry that have addressed at least some of the technical issues that derive from the distributed, heterogeneous environment. These issues include data integrity, currency, query processing, catalogue management, concurrency, fragmentation, transparency, recovery, and others. In treating these issues, a lexicon of terms have been developed by researchers to describe requisite data base functions; for example, they include "global data management," "distributed transaction management," "global-local subqueries," etc.

The Integrator concept was defined at the workshop without regard to specific implementation of functions, the data base management system to be used, or even the potential segmentation of issues as other researchers may have done. Instead, a conceptual structure was established for the Integrator, consisting of five components:

- The Director. Includes the data dictionary, information on where data are stored, file formats, access authorization, currency status, specific physical implementation information.
- The Accessor. Determines access strategies, creates files, removes files, adds data, deletes and retrieves data.

- The Communicator. Provides data transfer between hardware and systems.
- The Administrator. Ensures security of data (controls read, update, delete), integrity, consistency, currency; provides for concurrency, recovery, backup; enforces inclusion and exclusion rules.

During the detailed demonstration of the structural engineer and fabricator tasks, an explanation will be given of the steps of the components of the Integrator necessary to support the two tasks. In essence, the structural engineer task will illustrate a store data operation while the fabricator task will illustrate an operation of retrieving data from the IDB for analysis.

Although this initial prototype will not be capable of executing Integrator functions, the demonstration will be designed to show the sequential steps of the Integrator for the two tasks that will be demonstrated in detail.

In addition to the material to be included in the demonstration, a paper will be distributed at the workshop that defines the functionality of the Integrator more fully and relates that functionality to technical issues that are the subject of study in various ongoing distributed data base research projects in the computer industry. There will be a summary presentation on the subject on the morning of June 16.

With the presentations and materials described above as a base, the Integrator Specifications working group will be asked to prepare an initial version of functional specifications for the Integrator that can form the basis for the implementation of the functionality of the Integrator over the next year.

FUTURE DIRECTIONS

The goal of the project team continues to be an operational prototype IDB for the Woods Hole workshop in 1987. To achieve that goal, we must implement a substantial part of the Integrator by that date.

The initial IDB in the demonstration prototype for the 1986 workshop has been implemented on a central processor using the ORACLE DBMS. A second objective for the project over the next year is to extend the IDB to a distributed, heterogeneous environment, which is expected to be more representative of the environment that will be encountered in a real building project. Since the National Bureau of Standards has been very supportive of the current IDB effort, through both the Center for Building Technology and the Institute for Computer Sciences and Technology, the team is considering for the next phase of prototype research an Integrator design that enables the study of a heterogeneous DBMS environment that could include RIM or IM/DM operating on the Department of Commerce's CYBER System at NBS headquarters in Gaithersburg, Maryland.

At the workshop, both the Prototype Demonstration Team and the Future Directions for the IDB working group will be asked to deal with this question and to present a comprehensive plan for consideration by the full workshop. The latter group also will address new issues raised by the demonstration or during workshop discussions. The working groups ought to include in their list of options for future directions the possibility of implementing an IDB at a very early date in connection with a major building project. Even though an early application of the IDB concept may have to be less comprehensive than subsequent implementations, there are some who feel that much benefit and valuable experience can be gained by even an imperfect IDB configuration.

Finally, the Data Base Implications working group will seek to anticipate the potential impact on the building process and on the industry infrastructure as the IDB concept is widely applied.

GLOSSARY

A few terms that have been used above and will be used frequently during the demonstration warrant explicit definition to reduce the chance of confusion during the demonstration:

"Scenario" is the simulated sequence of tasks that will be demonstrated, involving "players" like the client, architect, architect-technician, structural engineer, general contractor, fabricator/subcontractor.

"Task" refers to each complete functional activity by a player in the scenario.

"Step" is one of the sequential actions taken by a player during a task in the scenario. When describing Integrator functions, "step" refers to one of the sequential actions taken by a component of the Integrator during an IDB-related operation.

"Operation" is used to refer to a process in the data base management system, including "store," "retrieve," "delete," and "update."

The "Integrated Data Base (IDB)" is, at any point in time, the stored data required by two or more users at that time to perform their tasks; the IDB includes the data, the repositories and the Integrator (as described previously).
The "transitional data base" is included in the IDB and consists of data from tasks of users who have left the project, but which data must be retained for use by users who are currently active on the project or will be active in the future. Over time, the transitional data baseevolves into the final data content of the IDB and belongs to the client/owner of the building.