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Smart Office Buildings
Richard Carl Reisman
Michael Clevenger
Piero Patri

Richard Carl Reisman

Our topic today is the intelligent office building, which could be the most tangible area for automation in the world of offices. I am very delighted to be here with Mike Clevenger and Piero Patri. My part is to tell you exactly what is happening today, where we are now and provide some background, and then set the stage for Michael to tell you what is happening tomorrow, and for Piero to tell you what is happening the day after tomorrow. They will discuss the near and not so near future in office automation, as well as environmental design and office furnishings and systems, and how the related emerging changes will impact us all.

Today we will apply a quote which I am about to read, which has become very commonplace for automation, but we would like to apply that more to 'smart' buildings of today. It is from the local Silicon Valley newspaper, and it says, "Entering its modern form barely forty years ago, the computer already has permeated almost every aspect of American life. Yet no one even remotely familiar with the computer revolution can sanely claim that the revolution is beyond its formulative stages. In other words, you ain't seen nothing yet."

Well, let us apply that to buildings today. In order to do that and explain the impact of automation on construction, I would like to set the stage and talk about some major events that have happened.

Number one, in particular, is the telephone company divestiture. Since they have split up and since they are not doing certain things that they used to do for us, we are having to do them ourselves, and we are looking to private industry to fill that gap. That has a phenomenal impact, and it is hard to get used to.

Most people, and indeed office building tenants, are born with the expectation of the God-given right to have a dial tone all of their lives. When they do not have it, they do not know what to do. Who do they go to? What are the problems? The problems and impact have a rip pling effect.

But the void has created some tremendous new business opportunities as well. Not only has the gap created a void that everyone can rush into to provide such services, but we have had a parallel event. While the phone company was busy breaking up, we have had a tremendous advancement in virtually all kinds of computer applications.

Therefore, we not only have a growth of opportunity in that the role of the phone is changing, but new technologies are creating unprecedented business opportunities as well. The combination of these events has triggered an explosive growth in automation.

The impact on the construction industry is that the building sponsor must wire up services in buildings. The imbedded base of wiring and equipment required to provide all services must now be installed as a regular part of the building design.

So much for events. There area lot of *players* running around, trying to get used to all of this. The *building developers* are the entities, if you will, that build the largest quantity of speculative office space. They are the ones who will face the responsibilities, or perhaps embrace the opportunities would be a better way to say it, of making sure that such services are provided. If they want to stay around and be competitive, they will have to do it. They can determine their own involvement. They can be totally in the office automation business, they can do it part way, or they can arrange for someone else to do it in their building.

There are *corporations* who are tenants or own their own buildings; i.e., some of them lease, some of them develop their own spaces. They are, as a rule, large enough to obtain their own equipment on a non-shared basis, for example, purchase word processors or other equipment which might otherwise be shared by smaller companies. They purchase large equipment themselves, so they are getting into the office automation 'act' as well.

The *realtors, so* far, have been very far behind. They are not up to speed on what is happening in shared tenant services. They are not

up to speed in leasing office buildings as buildings which provide services as well as providing shelter. They will need to catch up and may play an important role.

The service providers are in the lead because so much of the office-automation revolution is vendor driven. They are, however, creating a lot of hype, and we are trying to sort out what is legitimate, leading, front-edge development and activity from hype. We are doing our best to serve our clients by sorting all of that out.

Vendors are in the same situation, but they are also grabbing the new business opportunities. IBM has always made office equipment and is now jumping in. They are making furniture. There is a tremendous impact on business, wonderful opportunities, and everybody is grabbing at it.

Honeywell is a little different story. They have always made building controls. Now, they are getting into shared tenant services. So, everybody from the large companies to the small are revising profiles, in light of automation changes and opportunities.

So, given all of these players, all of this background, and the increase in automation, we have need, then, for them to come together in the 'intelligent' building, and an 'intelligent' building is one then that combines two essential ingredients to make it intelligent. By the way, we are in the process of calling them 'intelligent' now, replacing the older term 'smart.' If I lapse into 'smart,' please excuse me. The two ingredients are provisions for computerized (intelligent) building systems, and shared tenant services.

Of the shared tenant services, certainly the telephone services now are the biggest. They are the most lucrative, and of the telephone services, long-distance resale revenues are the most lucrative. Those are by far in the most demand in view of the phone company's split-up, as I mentioned. But, there are other services, as well, such as word processing, data, and a number of other things which we will go into a little later.

The other ingredient that is in the 'smart' building is the building management services or systems. These have been around a little longer. They are the dark horse that have come more to the forefront since the spotlight has now been highlighting office automation. I can walk into a building and take my 'key' (actually a magnetic card) and put it in front of a plate, and all sorts of things will happen, even if it is Sunday night. The lights will turn on the way to the elevator and the elevator will allow me to go to my floor, and the lights will go on from the elevator to my office, and my office will not only function with lights, air conditioning and shared tenant services, but a security system printout will let my landlord know exactly who was in the building, where and when. That is getting to be a pretty intelligent building system.

Everybody is getting into this now and scrambling into the act at different speeds. The Urban Land Institute, which is probably the premium organization of the real estate development businesses in the country, brought the subject into focus in Chicago in June in the conference 'Developing the High-Tech Commercial Project.' We participated in that conference, and the conclusion of the conference was that everybody is still problem solving, and we are all going to get out there in the next two years and build some more buildings and get back together to compare what we have done.

What we are doing is doctoring up our buildings in certain ways to make them 'smart' or ready to be 'smart.' In our particular firm, we are trying not to let a project out of the door that ignores at least some of the design principles which I will touch on briefly here.

We certainly are seeing a change in the mechanical and electrical components of buildings. New demands in office equipment and office environments require that more intense localized demands be met by more flexible systems. You cannot go into a building that is not ready for it and put in a specialized installation and run an extra grille into the ceiling when the system is not prepared for it.

Automated equipment is growing. Cooling is

not only required to keep us comfortable while the computers are generating heat, but more importantly, those computers cannot function if the environment is not properly controlled. So, we are seeing 25 to 50 percent more costs in mechanical systems right now. We are seeing a need for 24-hour performance and flexibility. We are seeing a lot more flexibility and, thus, as a bottom line impact, we are generating higher quality structures.

There is a greater cabling and wiring need in buildings. As I mentioned, we have to do the communications cabling ourselves since the phone company is no longer providing it. We are seeing needs for local area networks. We are seeing needs to accommodate more equipment. Indeed, in a 280,000-square-foot project we recently completed, *everyone* in the building had an automated station, a screen and a keyboard. The cabling requirements were absolutely immense. That project happened to be a retrofit.

We are looking for clean signal distribution and clean grounding. This affects certain technical things that we do in the electrical installation, but we are seeing the impact in that cabling trays or racks are common in buildings. Teflon coated wiring is eliminating the large costs of having to put all of these lines into conduit, but the bottom line is still greater costs.

It may be obvious that we are needing things like increased power provisions in buildings to handle all of the new loads, but there are architectural things as well. We are laying out space for all of the equipment to make these buildings 'smart.' We are putting in greater floor-to-floor heights to accommodate the plenums, the wire management, some of the other things that have to be done in the buildings. These things, again, have a cost impact. If you take a thirty-story building and increase the height of the typical floor by six inches, for example, and your marble skin costs so much for each six inches, you can start to see you are adding a story or two of height on the building, a big impact and a big cost item up front.

Even architectural design is affected by it. We are trying to deal with the aesthetics, as well as the technical problems, such as accommodating the equipment or satellite dishes, if you will. The issue is how they look when set atop buildings. These things, as they impact industry, perhaps may not be great, but we are dealing with those human issues, and I have a counterpoint to the lack of design mentioned earlier that I might get to later in the question and answer period.

We are working structurally, preparing the rooftop for equipment. We are preparing our rooftops to bring signals in from the top, as well as we have always done from the bottom.

Our tenant service requirements are typically generating new products, such as flat wire and carpet tiles. They are becoming more present on the scene and they are developing more and more. Michael will discuss this further.

Our building management systems are becoming more sophisticated. I mentioned an example of security systems, but every system in the building is now being run that way. Elevators, for example, which might be more critical and more important in high-rise buildings, now typically have call monitoring happening sixty times per second. Thus, the controller can reassign elevator cars to respond to calls so much more efficiently that we might reduce, say, a high-rise elevator cab requirement from twenty to eighteen and save square footage per floor. I estimate that a $15,000 computer used in this way in a thirty-story building would probably increase the building's value by $1 million through savings in usable area. That is a big impact.

We are seeing a lot of digital thermostat control that gives absolute, pinpoint environmental control. If you put 68° on your thermostat, then that is what you will get. It will not be 69° or 67°, it will be 68°.

The fire alarm system will do far more than indicate the fire on a lighted panel downstairs. It will tell you what kind of fire is underway; it is going to lock the stair doors getting into that floor and open up the doors on the other floors; and it is going to do a number of things which can help with the fire fighting and save lives.

These things have been around for a while, but they are getting more sophisticated, and as I mentioned, they are coming more into the spotlight.

Impacts and Trends

Business services costs, as well as rental costs, will now greet the tenant who walks in the door of the speculative office building. The tenant is looking for service as well as shelter. We do not feel that as of today these services have given 'smart' buildings the edge for making deals versus buildings that have not had them. Indeed, there are probably under one hundred 'smart' buildings up and running in the country right now.

We do see it in five years as being a deal breaker if the services are *not* provided. One just would not go into a first-class office building that did not offer it. But, it is our view that, while the tenant will be spending more through his/her landlord and/or service provider, he/she will have significantly improved performance and efficiency to offset additional costs.

Office buildings will cost more to build, but will make that money back by improved operating efficiencies and lower running costs. Also, we will make money back because people who build buildings have revenue opportunities to resell services. These sophisticated buildings will require more sophisticated people to take care of them. People need to be technologically trained. This is the shortage that we have right now. We do not have people who can adequately run out and really service computer-oriented systems. That is coming around. That will have to come around.

As an industry standard, a Class A office building will have these higher floor-to-floor heights, more expanded and more capable HVAC systems, roof signal communications and distribution for them through the building.

Integrated telecommunications systems provialed in the building will simply be a standard, and also better acoustic design and more energy-con-scious design. Light standards, such as glare reduction, all of these things are coming to be higher, but expected, standards.

Mike Clevenger will show you the substantial proportion of the stock of buildings that will have to be retrofitted, but by far, most of those buildings will be able to be retrofitted successfully. We will not have to junk all of our buildings, but a short history of retrofit automation and many variables make predictions and price estimating quite tricky.

For example, if there is a building that is abandoned and there is no tenant and no ceilings, it's quite easy to go in and wire that building in comparison to one that has ceilings and tenants in, in which case there would be great disruption, off-hours overtime and so on.

How much automation does a tenant use; what are the sizes of floors; how old is the building; what is the type of construction; what is the adequacy of the existing electrical service; what was the building used for before? A number of factors make quite complicated the task of predicting retrofit costs in general.

We are doing a lot of it, and as 1 mentioned, our most sophisticated automated example of anything we have built in the last five years was a retrofit condition, interestingly, in a new building.

The new buildings, which were not wired by the phone company, are perhaps the most demanding. The old buildings that had the embedded wire base have cable running around the building you could hook into and run signals around. It is the recent buildings that do not have the embedded wiring that you have to be careful of.

The big impact then is that we are going to have the more expensive projects being a sum of the traditional shelter provision and the service unit, all better constructed and more automated. So, it is not only shelter, it is also service, and that is what I want to emphasize here.

So, the basis of change is here for our buildings, and we have seen a lot of it happen. Everybody is trying to get into the act, but we now see this explosive mushroom ahead of us compared to what we have had, and as that takes over and as we really go crazy with office automation revolution, we see a lot more change coming in the future.

I would like to turn it over to Michael Clevenger and Piero Patri to tell you what those are.

Richard Carl Reisman is a Principal with Whisler-Patri, an Architecture, Planning and Interior Design firm in San Francisco.

Michael Clevenger

This paper is a short compendium outlining the key points:

1.) The Office of the Future has arrived and will result in fundamental shifts in the planning, design, construction, and operation of speculative office buildings.

Up to the mid-1970s with the advent of the micro-computer technology, office technology had been confined to developments in telecommunications, centralized data processing, reprographics, and word processing. The impact of these technologies on the work place were significant, but not revolutionary. From an office design and construction standpoint, little change to the building development process has occurred since the Second World War, with the evolution of the high-rise office building. But with the emergence of the micro-computer in the mid-1970s, and the related developments in advanced distributive processing, electronic printing, local area networks, software, microwave and satellite communications, a profound change in the very essence of the conventional office development is now well underway. (Figure 1).

Another driving force that's propelling this change is the break up of AT&T on January 1, 1984. The deregulation of the telecommunications industry has created near chaos within the local Bell company operating areas from the standpoint of building wiring, and equipment servicing. In effect, the building owner is now able to directly capture telecommunications (and related office service offerings) within his captured tenant market. This ability to resell communications services creates substantial profit opportunities and risks for the building industry.

2.) The Key Components of the Office of the Future.

The key communication and office automation technologies that are now converging on the office building include:

- Electronic work stations from the most simple personal computers, to high-performance professional workstations and word processors. (Figure 2).
- These work stations are being integrated into sophisticated digital telecommunication systems or PBX systems, allowing both local area communication within the building as well as communication into national and international networks. In parallel to telecommunication systems, these work stations are also being integrated into high performance base band and broad band local area network systems, allowing both high-speed data and video transmission throughout the building. These networks are gradually being integrated into the telecommunication systems utilizing software that allows one system to interface with the other. (Figure 3).
- Attached to the network are shared electronic services including high-speed electronic printers, file servers, and sophisticated, high-quality document scanning devices for document input. (Figure 4).
- Specialized application technologies are beginning to emerge on a shared basis, including video conferencing facilities, electronic publishing centers, public access such as the Source, and CompuServe, and satellite earth stations that permit building tenants to access directly long-distance communications systems thereby completely 'bypassing' the local telephone operating company system at attractive reduced operating costs.

3.) The Growth in Office Automation Over the Next Eight Years, Particularly the Growth of Individual Electronic Workstations or Video Display Units (VDU) Will Create Severe Physical and Operational Problems Within Existing Office Structures Which Have Not Been Explicitly Designed for These New Technologies.

These problems will create significant shifts in demand for commercial office space, both in the location of offices, as well as the configuration and design of offices. Most importantly, this change will also result in a shift in tenant demand for new services as part of the building tenant service offering. (Figure 5).

Some statistics in office automation growth:

- At the end of 1982, there were nearly six million video display units in American industry. By 1990, this number is expected to grow to over forty million units in the U.S. alone, and

Figure 1

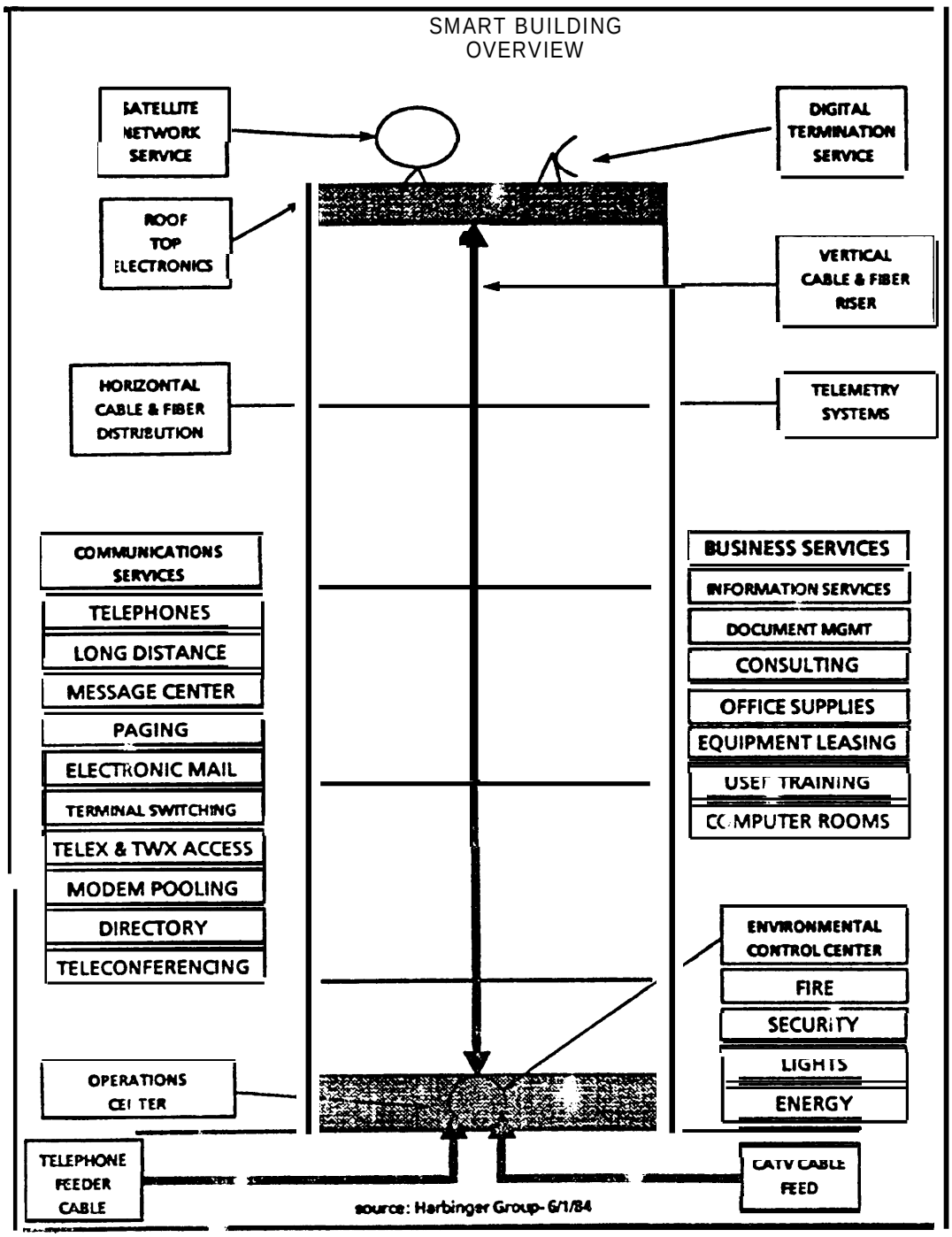

SMART BUILDING
OVERVIEW
SATELLITE NETWORK SERVICE
DIGITAL TERMINATION SERVICE
ROOF TOP ELECTRONICS
VERTICAL CABLE & FIBER RISER
HORIZONTAL CABLE & FIBER DISTRIBUTION
TELEMETRY SYSTEMS
COMMUNICATIONS SERVICES
TELEPHONES
LONG DISTANCE
MESSAGE CENTER
PAGING
ELECTRONIC MAIL
TERMINAL SWITCHING
TELEX & TWX ACCESS
MODEM POOLING
DIRECTORY
TELECONFERENCING
BUSINESS SERVICES
INFORMATION SERVICES
DOCUMENT MGMT
CONSULTING
OFFICE SUPPLIES
EQUIPMENT LEASING
USER TRAINING
COMPUTER ROOMS
ENVIRONMENTAL CONTROL CENTER
FIRE
SECURITY
LIGHTS
ENERGY
OPERATIONS CENTER
TELEPHONE FEEDER CABLE
CATV CABLE FEED
source: Harbinger Group- 6/1/84

Figure 2

VIDEO DISPLAY UNITS

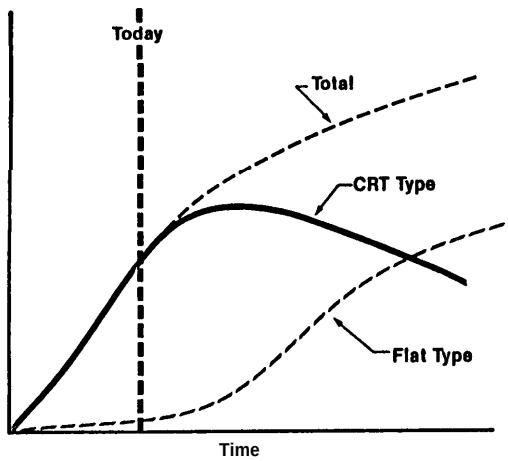
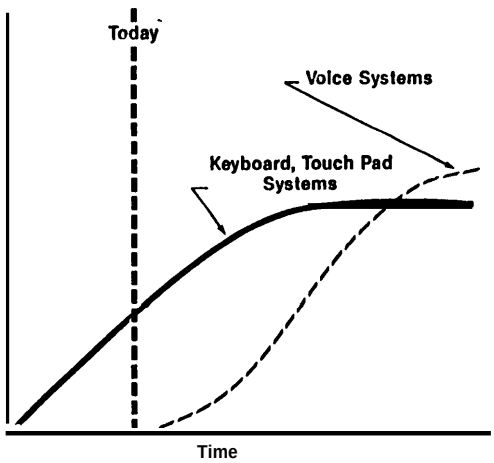


Figure 3

AUTOMATION EQUIPMENT IN WORKSTATIONS



could reach eighty million units world wide by the mid-1990s.

- At Xerox, in 1983, there was roughly one Video Display Unit for every ten employees. By 1986, this ratio will drop to one VDU for every four employees. By 1988, the ratio is expected to be one VDU for every white collar employee throughout the Corporation.
- While there is substantial growth in the number and type of computer terminals, and attendant peripherals, a very small percentage, merely 5 percent of this growth can be accommodated in newly designed and built office structures over the next eight to ten years. The bulk of this technology must be accommodated in existing office stock suggesting that substantial office redesign and reconstruction will be required in the near term. Over the longer term, the miniaturization of product, the advent of fiberoptic technology, and the increasing use of portable (and potentially) wireless electronic workstations will begin to ease the physical pressures on the building envelope. Another mitigating factor will be the growth of the remote or (home worker) employee work force. Recent studies have forecasted that nearly 25 percent of the office work force (primarily professional and clerical) will operate in some form of remote location by 1992, This shift will absorb a fair measure of the demand in the early part of the next decade.

4.) The convergence of these technologies, as well as deregulation of the telecommunications industry, will establish the building owner as a primary information vendor and systems integrator for the second half of the 1980s.

This convergence of the real estate industry with the communications industry will rival, if not exceed, the impact of the interstate highway system on the hotel, motel, shopping center, suburban residential real estate, and recreation industries. The convergence, however, will radically change the building development process and the role of the building owner.

Each of the key participants and stakeholders in the development process will be faced with a fundamentally new set of planning issues to ensure a successful development project.

The key issues relate to:

- Changing technologies
- Building obsolescence
- Changing land values
- Changing regulatory issues associated with deregulation
- Changing real estate markets as telecommunication technologies allow for development in remote areas and greater migration of back office operations from the downtown to suburban centers.
- Changing building operations associated with the management of sophisticated building communication systems and other shared tenant services.

The office tenants will increasingly demand flexible building environments that will readily adapt to changing technologies. Tenants will demand and most likely expect to share in the economies of scale associated with telecommunications resale. Many tenants will require that their office automation systems be compatible with the building systems and networks, and that they can depend on the building operator for service maintenance and equipment replacement and upgrade.

The project lender will require assessments of risk and opportunity associated with the high-tech building. They will be concerned with valuation as it relates to building obsolescence. They will want to assess the effect of these technologies on land values, and what changes in demand and value will most likely occur over time.

The appraiser will now have to update building and land valuation assumptions and methodologies to account for the effects of technology. Assessments of income, cash flow, and discount factors for risk will be required to recognize the fundamental changes in both revenue and expense in the high-tech building.

The real estate broker and builder are now confronted with a new product and new markets for their wares. An office building is now an information utility and communication service center. it is an automation emporium, electronic conference center, and technology service management center. It is a complex envelop of information workers, networks, and technologies

Figure 4

TYPES OF OFFICE BUILDINGS

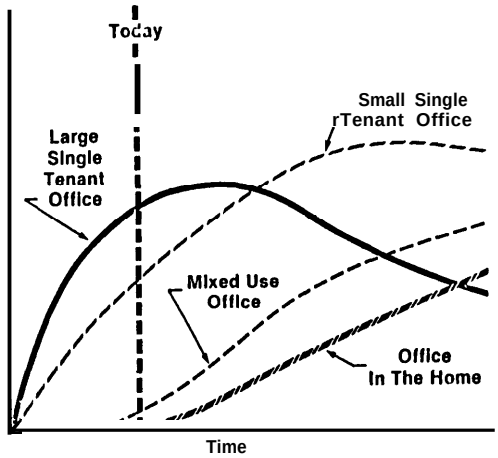
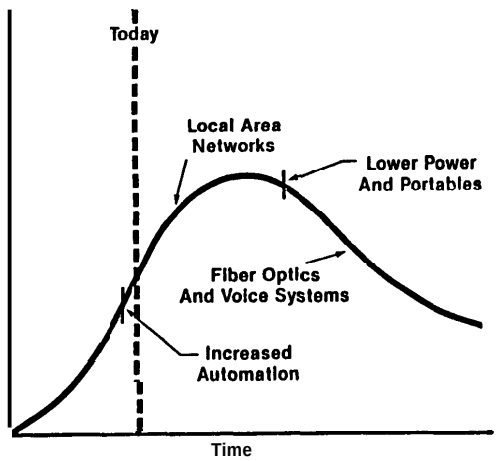


Figure 5

POWER AND WIRING IN WORKSTATIONS



interacting in a highly dynamic mode. It is these products that the broker must now understand in order to market effectively to a newly emerging tenant base.

Finally, the developer/builder who is central to this process must concern himself with all the issues and perspectives of these issues outlined above. The developer/builder must radically change the development planning process to allow for an integrated approach to planning that melds architectural design with systems design, with applications design, into a business plan that addresses tenant markets along communication, automation, and applications segments. Feasibility studies will need to incorporate these new business opportunities requiring new financial assumptions for risk and benefit. New partnerships between the developer, automation vendors, service businesses, and telecommunication companies will need to be assessed. Site selection will have to be evaluated from the standpoint of micro-wave and satellite reception/transmission performance. Regulatory constraints of local public utility commissions relating to bypass and resale strategies will be required. Tenant allowances relating to improvements for office automation will be a key element in the building pro-forma and marketing plan. Studies of competitive activity in the building's market are essential for no other reason than to assess the cost of doing nothing in the new project. Most, if not all of these considerations will apply in varying degrees for the retrofit and upgrade of existing structures. (Figure 6).

5.) Summary

- The office of the future has arrived!
- The building owner/developer/builder will become a key information vendor of the next decade,
- The building investor can expect significant new profitability and risk with this highly dynamic and turbulent new business.
- New partnerships will emerge between building owners and automation/communication vendors.
- Most of the explosive growth in office automation/communications will occur in existing structures.
- The key to success in the high-tech building industry will be a radically updated planning process which integrates the planning for real estate development, telecommunications, office automation, and office services management.
- The payoff for effectively planned projects will be extraordinary.

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Figure 6

PLANNING CHECK LIST FOR THE HIGH TECH BUILDING

Technology Issues

- Telecommunications
- Cabling
- Office Automation
- Integration
- Software
- Services
- costs

Desire Issues

- Location
- Site Configuration
- Building Configuration
- Structural Design
- Floor Configuration
- Vertical/Horizontal Distribution
- Tenant Allowances
- Flexibility
- Antenna Siting
- Building Systems

Financing Issues

- Valuation
- Assessment of Risk
- Feasibility
- Pay-back
- Tax Implications
- Life Cycle Costing
- Allocation of Costs
- Break-even Analysis
- Cost Estimating
- Pricing

Operational Issues

- Vendor Selection
- Technical Support
- Maintenance
- Tenant Support
- Services Organization
- Marketing
- Services Administration
- Contract Administration

Regulatory Issues

- Local Practices
- Public Utility Commission Regulations
- Re-sale Provisions
- Tariff Structures
- FCC Actions
- AT&T Settlement Impacts

Piero Patri

I am going to look at our crystal ball approximately through to the beginning of the 21st Century, basing my predictions on 30 years of experience — not in research — but in the practice of architecture, planning, interior design and, more recently, in facilities management. I am aware of the research that is currently underway at NBS, HUD and elsewhere and am a little awed by the research power in attendance here. I fully expect to learn a lot more today than I will teach anyone.

The subject of 'smart' buildings has been something I have been involved in for a long time. I have here articles that read, *The Electronics Man In His New Office,* and *The Brave New World With Home Electronics.* They are dated December 1972. Pete Valentine, President of Comsul Ltd., communications consultants, and I were interviewed then and talked about the future of 'smart' buildings. It has taken a little longer than we thought for these ideas to come to reality, but the concepts have obviously been around for a long time.

Today I will talk about, one, the future of 'intelligent' or 'smart' building technologies; two, their general impacts; and three, their impact on the future of building construction and related industries.

First, with regard to building technologies, I think all agree that what Richard Reisman and Michael Clevenger talked about earlier is not a 'flash in the pan' or 'pie in the sky.' It is not a question of 'if' but 'when' or 'what form' or 'how,' as Bob Gold said. The cost effectiveness and demonstrated enhancement of productivity from office automation clearly point to their increased future impact on how buildings will be designed to facilitate their application. This, along with reduced costs of building ownership by means of sophisticated building systems, indicates that 'smart' building will be the rule — not the exception — by the turn of the century.

Again, going back in my professional experience, I want to mention two related trends that are merging with 'smart' building technologies, and they are simply the utilization of factory-built components that have been developing for years as a means of reducing construction costs and time, as well as improving quality; and two, flexible building systems to accommodate increasing organizational changes — that 37 percent a year churn that Michael Clevenger talked about — and also the rapidly evolving intelligent building technology.

We do not know precisely what the full impact of office automation and smart building technology will be over the life of a building ten, twenty or fifty years from now. So, as architects, we must build in flexibility or adaptability.

I predict that the 'smart' building itself and the trend toward factory-built components and flexible building systems will merge to create a building that will be qualitatively different from the traditional building we see today.

I would like to take a moment to quote a statement by Joseph Newman of Tishman Realty and Construction Company. "In the new age of buildings, buildings will be better places in which to work, live and interact. Buildings will run more efficiently, be more responsive to the needs of their occupants, and will more effectively accommodate the new high-tech tools of business. More durable, better designed, easier to maintain, and higher-quality materials and products will be utilized, A lot of this is coming out of other areas like NASA and space. In the new age of buildings, more attention will be paid to increased construction productivity and expeditious building cycles. Not only will buildings be more intelligent, providing more effective life safety, security, energy conservation, communications compatibility and environmental control. Those who design, build, manage and own buildings will be smarter."

Well, what does that really mean? As you might expect, these 'smart' buildings will become still smarter, and they will be active, not passive. For example, the building management systems, by means of sensors placed throughout the building, will see, hear, smell, breathe, move, think, prepare and react to changing building conditions. AI, artificial intelligence, is going to be another element that will eventually contribute to buildings interacting with their user. Buildings will not just sit there, passive, as they have in the past. Actually, Arthur Clark's 2002, I think, will turn out to be a pretty accu-

rate guess. So we had better watch out for HAL.

With the advent of speech recognition technology, voice commands will activate the lights and air conditioning, or command a remote-controlled robotic element of a wall to move. And, most importantly, speech recognition will make the computer accessible to everybody and as universal as the telephone. In other words, one will not need to know how to type or anything about computer programming. This is coming very soon. There are already specialized pieces of equipment on the market that are capable of some level of both voice recognition and synthesis.

Clearly, these 'smart' buildings are going to be more complex, and their elements may not be all of the buzz words we are talking about, but only those that really make sense. They will be modular, standardized, integrated, miniaturized, light-weight, micro-environmentally controlled, and energy efficient.

The next practical step in 'smart' office building design will probably be utilization of raised access floors for wire as well as air distribution, which will provide individualized environmental controls for the user. This, along with glare-reducing reflected ambient light will create a whole new series of design opportunities for the office ceiling.

'Smart' buildings of the future will also be highly flexible. That is the key word: easily reconfigured, relocated or replaced. They will take advantage of space technology and will be precision built with the help of computer-assisted design combined with robotic manufacturing.

What we think of traditionally as the building elements — the furnishings and the electronic equipment — will all be wired together to create an integrated continuum with no clear distinction between them. This is the qualitative change we think will take place. Walls will plug into floors. Furniture and equipment will plug into each other and then into walls, floors, and ceilings. Everything will be pre-wired. In my review of the literature in preparing for this presentation, it was interesting to note that a recent study showed that electrical work is one of the areas where there seems the greatest potential for improvement in construction technology.

So the 'smart' building will be an information utility, not just an enclosure of space. The entire building will be like a piece of electronic equipment. For instance, with flat screen technology, walls can become electronic displays either of information or simply color and pattern, creating the possibility of changing the whole character of the office instantaneously.

Signal compression technology that is taking the broad band width of video and reducing it to utilize existing telephone wires will result in every telephone having a video screen so every call will be a video teleconference, if desired.

In the future, other building types will be 'smart,' not just office buildings. For instance, more working, shopping and learning will take place at home with the help of computer and video networks. Donald Sullivan of Arthur D. Little sees the automated house of the future being smaller and containing fewer objects, with robots moving walls and furnishings to accommodate different needs. In other words, the house itself is a robot.

Professor Carolyn Dry of the University of Illinois has studied how the 'intelligent' house can physically adapt to the various needs of the disabled and the elderly, compensating for limited strength and mobility. Japanese researchers are already working on robots to move hospital patients in and out of beds.

Hotels have also started to be 'smart,' tracking when you are in your room and when you have left for improved security, providing fingertip control of the room's environment, and maximizing effective management by providing up-to-the-minute billing information at checkout and alerting the front desk as soon as the room is available for the next lodger.

'Intelligent' buildings will probably be more expensive because of their complexity, even though they will be computer-designed with very efficient use of materials and to minimal tolerances. Shorter construction times and the tendency of electronic equipment to go down in cost will probably help to keep costs in line.

In any case, any greater cost will be more than compensated over the long term of ownership by the added capabilities in building maintenance and user productivity. The

demonstrated enhancement of productivity through office and building technology has already increased corporate interest in 'smart' facilities. Now a Facilities Manager can prove to the CEO that spending money to make a building 'smart' clearly has added value to the company's bottom line.

In terms of the general impacts, almost all new buildings in the future will be 'smart' to some degree, and many existing buildings will be retrofitted to be 'smart.' Telecommunications will continue its decentralizing effect. Particularly because it is not only moving back offices out to the suburbs, it is also moving office work into the home. So, I think not only will we have more suburban sprawl, we will probably also witness rural sprawl.

Video teleconferencing will eventually come into its own. Its promise up to now has not been fulfilled, but it clearly is coming and will no doubt reduce business air travel and affect the hotel industry as well.

In general, therefore, regional land use, employment, density and transportation, as well as land values, will be affected. It should be noted that complex telecommunication technology has some centralizing aspects whose impact on land-use distribution has yet to be fully felt. I think in the last decades of the 20th Century, access to telecommunications channels, such as teleports and fiber-optic highways, will be as important to development as access to rivers and bodies of water were in earlier centuries, and access to freeways and airports are now. Availability of sophisticated telecommunications will change the way we use and value land, giving new meaning to the real-estate adage 'location, location, location.'

There is no question in our minds that there will be other significant economic impacts. In describing the buildings of the future, I suggested that there will be an integrated continuum of building elements — walls, ceilings, floors, furnishings and electronic equipment all wired together into an information utility. I have suggested that most of it will be manufactured, pre-wired, and 'assembled' at the site.

This could imply the merging of the construction and furnishing industries with the telecommunication and computer industry. The construction industry, even though fragmented, is the largest industry in the United States, contributing over 200 billion dollars a year to the GNP and employing 10 percent of the U.S. workforce. To quote Marvin Citron of Forecasting International, "Telecommunications has been the fastest-growing industry in the world every year for the last 10 years and will be the largest industry in the world and will have touched and changed the lives of most of the people living when the century ends."

What we may witness is the merging of the largest existing industry in the U.S. with our largest emerging industry. Inevitably, this will have enormous impacts on the way buildings get built, and organization and ownership of the construction industry, and the number and type of jobs in it.

Richard Reisman mentioned earlier that IBM has expanded into the furniture business and Honeywell has diversified its services. Another important example of this merging is represented by Steelcase Furniture Company's acquisition of Dorm Architectural Products, manufacturers of totally-integrated wall, floor and ceiling systems. This is a logical expansion for a furniture manufacturer because, in the future, everything will be linked together. Following the pattern of other manufacturing industries, such as automobiles and now computers, I foresee there will be fewer and larger corporations in the construction business, and these companies will be highly automated, more capital intensive, and less labor intensive.

How will this impact construction jobs? There will be fewer traditional construction jobs, as I have already mentioned, with less field work, although there is a bright spot in terms of retrofitting existing buildings to accommodate this new office technology. Even though there's less field work, more work will be done in the factory, but most of that work will be done by robots. So there will be a cap on factory jobs.

Clearly the need for skilled technicians will increase; that is, white- and gray-collar jobs will increase, while blue-collar jobs will diminish. This also applies to the operation and maintenance industries as well. The maintenance worker in overalls with a hammer sticking out

of his pocket, walking around in the bowels of a building, will become a technician in a white coat, sitting at a console, checking readouts.

The practice of architecture will change and tend to merge with industrial design and engineering as a result of buildings becoming products of industrial design and a manufacturing process. CAD will increase in sophistication with professional expertise programmed into the computer system as described by Harry Mileaf earlier.

The good news is that some new jobs will also be created. There is clearly a need for more design engineers, architects and industrial engineers, more CAD specialists, 'smart' building retrofitters, laser, electronic, and fiber-optic specialists. We in interior design also see a greater demand for the handiwork of artists and artisans in response to the 'high-tech/high-touch' needs of the electronic office worker.

The bad news is fewer jobs for field construction workers and no increased need for factory workers. Problems will exist for traditional architects and drafters and for blue-collar building operations and maintenance people. Michael Clevenger mentioned the reductions in the users of these 'smart' office buildings from the ranks of the clerical and the middle-management people whose jobs will be automated.

I cannot predict whether the net result of new jobs will balance the old jobs and what effect expanding industries like leisure and health care will have. If we are to believe some predictions that by the year 2000 four million jobs will be taken over by computers, there will clearly be significant changes in employment patterns that will certainly affect the building industry.

Therefore, it seems reasonable to assume that significant retraining and even re-educating will be required for workers within the construction industry, as well as those forced out of other traditional professions I mentioned.

The U.S. construction industry currently seems fragmented and ill-prepared to deal with this upcoming problem. Crucial to success will be a suitably educated and trained workforce and a coordinated research and development effort by the U.S. construction industry to develop and disseminate appropriate technology.

I have already mentioned the problem of the lack of compatibility between equipment and the lack of coordination between regulatory agencies. To be successful in this transition, we must also deal with the problem of the de-skilling and dehumanizing of some of these jobs and the resultant growth in job dissatisfaction among the electronic-office workforce, a workforce that will be better educated, with more job mobility and higher expectations, and a greater willingness to voice dissatisfactions with employers and work conditions, including litigation.

Just to touch a moment on foreign competition, it is clear that the other industrialized nations have a better-educated workforce in the areas of engineering and manufacturing. As an example, the Japanese graduate several times the number of engineers per year that we do. They are world leaders in robotics and appear to be ahead of us in computer-controlled, factory-built housing. Therefore, as more building construction takes place in the factory, they will be extremely competitive.

To summarize, by the 21st Century we are clearly going to be in the Information Technology Age and the Industrial Age will be over. There may be a lot of potential scenarios, but it is clear that this change is going to have profound impacts on the building industry. Specifically, buildings are going to be incredibly 'smart,' complex, active environments and costly.

Secondly, 'smart' buildings are going to be everywhere, and not just 'smart' offices, but 'smart' homes, hotels, hospitals, etc. They will impact land use, density and transportation. In other words, they will impact our whole society and the way in which we function.

Thirdly, we believe we will see the merging to some significant extent of two mammoth industries, construction and telecommunications, with a net loss of jobs and an increased demand for highly-skilled technicians and, with this, the need for re-education and retraining.

Lastly, it is really exciting to be here to address this pressing need in the construction industry. I hope this forum will continue because over the next several years. We must carefully coordinate government policy and private indus-

try goals to fully realize the enormous potential these forces promise.

Some After-Thoughts

There is a pressing need for a better-coordinated research effort in the U.S. Construction Industry. This effort should involve the full range of people in construction: design professionals, building material and furniture manufacturers, contractors, building owners, academics, telecommunications and office automation manufacturers and service providers, as well as government officials. There is also a fundamental need for more indepth studies on productivity gains attributable to the implementation of office automation and telecommunications systems, especially at the middle management level of organizations.

This research and exchange should serve as the basis for the development of a national policy regarding the future of the Construction Industry, particularly as it relates to the computer and telecommunications industry. It would be my hope that this Committee would serve as an impetus toward accomplishing that goal.

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