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Project Management and Computers in the Year 2010

by

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PROJECT MANAGEMENT AND COMPUTERS IN THE YEAR 2010

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ABSTRACT

The goal of this paper is to answer the question: What will project management be like in 20 years? Twenty-five academic and industry experts completed a questionnaire concerning future trends in computers for project management. The results are discussed in seven sections: the project management environment, computer hardware capabilities, integration and connectivity, programming languages and software development, user interfaces, and computer applications for project management of construction. Overall, respondents foresee three major roles for future computers: supplier of more and better information, tool for multimedia communication, and advanced decision support and information processing device. Since the computer technology to support these roles will undoubtedly exist, the challenge facing the industry is to develop the information technology foundations—such as representation standards and project models—that will allow us to utilize and leverage these computational capabilities. The paper is organized into two parallel formats—a discussion of the questionnaire results and "a day in the life of a project manager in the year 2010."

INTRODUCTION

Much of the current construction-related research (including the authors') focuses on developing new computer tools. But to what end? What products will emerge from such efforts and what long-term impact will they have on the construction industry? Of course, no one can know the answers to these questions with certainty, but we believe that some understanding of the likely directions is necessary in order to heighten the efficiency and utility of research and development efforts. The goal of this paper is to share some speculations about the role of computers in project management and construction in the year 2010.

Predicting the future is difficult, particularly when considering the intersection of one of history's most rapidly advancing domains (computing) with an industry (construction) that in some ways has changed little for decades or more. Unavoidably, some predictions will prove to be ridiculous in light of future events, while many of the future's most significant developments have yet to be imagined. In order to best overcome these obstacles, we have not relied solely on our own ideas, but rather have poled a cross-section of industry and academic experts from across Canada, the United States, and Japan. Twenty-five participants (listed at the end of this paper) completed questionnaires and shared their thoughts on the future of computer hardware, user interfaces, software development and programming languages, applications for project management and construction, connectivity and integration, and the commercial environment of construction.

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This paper reports the results in two parallel formats. First, it summarizes and briefly comments on the responses generated by the questionnaire. Second, it describes a hypothetical scenario of project management in the year 2010. Both the analysis and the scenario are based on (in order of weighting) the averages or trends observed among the questionnaire responses, the comments of individual respondents, and our own interpretations and ideas. Note that although numerical summaries of the questionnaire results are occasionally provided, no attempt has been made to draw statistical significance from these responses.

The paper first looks at the overall environment of project management in 2010 and then considers the computer hardware that will be used to support project management at that time. The integration and connectivity of future computers is then discussed, followed by programming languages and development environments. The user interfaces that might be important are then described and, finally, the computer applications for project management are reviewed.

"Good morning George," calls Jana Lee as she enters her office on the morning of April 1, 2010.

"Morning," replies George, her computer.

Jana is the senior project manager for Fantasy Gardens Stage XIII—a 25 storey low-rise commercial and office building. "Has anything urgent come up over the weekend?" she asks.

"SD&B, the structural design-build subcontractor has submitted a video proposal to use composite-plastic structural framing members instead of the planned precast concrete," responds George.

Jana knows that she will have to check quite a few items before the revision can be accepted: approval of the architect and owner, macro and micro effects on the schedule, overall difference in project cost, impact on construction work force and equipment (maybe they could use smaller erector robo-cranes), etc. But the change could provide considerable cost and time savings for the project. George can quickly run through the new simulations and get her in touch with all the other people involved. Once she issues a change order (or maybe a new contract) it'll be out of the way.

"Okay," she instructs George, "Let's take a look at it."

THE PROJECT MANAGEMENT ENVIRONMENT

The questionnaire first asked about the corporate environment in which project managers will work. Sixty-seven percent of the respondents replied "no" to the following question: "In 2010, will the number, size, and type of companies involved in construction projects, as well as the relationships between them, be essentially the same as now?" Many of the comments received suggest that there will be a smaller number of companies and that they will typically be larger and more diverse, offering design-build or design-build-manage services:

There may be less, larger companies, but most likely these will operate in an integrated fashion (design-build-manage) and will exchange data in electronic format.

Fewer, but better run companies.

Other respondents, however, expect companies to become smaller, more numerous, and more highly specialized. These conflicting comments on the number and size of future firms seem to be reconciled by statements that the management, design, and construction of facilities will be performed by a smaller number of larger organizations, but that these organizations will be partnerships of smaller specialty companies:

More "quasifirms"—close knit networks of autonomous firms with long-term cooperation (like Japanese keiretsu, but more independent).

Based on these results, we suggest that the future may see the rise of prime project managers (PPM's) that spearhead both design and construction, and the proliferation of associated specialty firms (ASC's) who develop close working relationships with a few PPM's and take responsibility for the design and construction of specific facility functions. The ASC's will become very specialized, will have in-depth knowledge of their discipline, will remain up-to-date on how their work fits into the whole, and will provide copious coordinating information to the PPM's. Projects will emphasize prefabrication and modularization along the ASC's inter-disciplinarily boundaries to a far greater extent than seen today.

The ASC's will increase in number and decrease in size while the PPM's will decrease in number and increase in size. This will result in less

competition for PPM's and the evolution of stronger inter-firm relationships. For all industry participants, competition will be based more on reputation and expertise: demonstrated knowledge of innovative techniques and technologies will be a competitive marketing advantage.

It is evident from other sources that our current contractual methods are due for major revision: "Have we thought about using two subcontractors on our large jobs for the same work, with contracts to allow flexible assignment of work?" (Logcher, 1991). For such revisions to take place it will be necessary for relationships between PPM's and ASC's to change from our current focus on legally binding contracts to reputation and past experience. One respondent states that the future will bring, "the establishment of projects' remote control systems to monitor productivity and quality." With this documentation will come more certainty about what actually happened on site, why it happened, and who was responsible. Without today's confusion and uncertainty, our propensity for legal disputes may well diminish.

Some respondents suggest that there will be a "better educated work force" as well as a "reduction in overall construction work force." Many questionnaire comments emphasize that individuals will be even more important to the firm; they will be needed to maintain the relationships between firms and to provide the necessary expertise in a more highly technical environment.

Success depends on individuals.

People [are] always number one.

We also received an undercurrent of comments that highlight the negative effects of computerization on people:

New technology creates an intense workplace.

Many people will feel that they are controlled by computers.

Eighty-five percent of the respondents believe that in 2010, the success of companies offering project management services will depend on their computer and information technology capabilities. Ninety-two percent of respondents believe that everyone in the project management team will be using a computer in 2010. These results point toward an environment which is very different from today; an environment where computers are more common than desks and project managers use them as often as we use pencils and paper.

Jana works for Delta Prime Inc. Delta Prime is located in Vancouver and provides "total project management" for a wide range of facility types throughout the Puget Sound Free Trade Region. The company was founded a decade ago and became one of the first firms to market themselves as a prime project manager. Their aggressive marketing has always followed the same theme: "We have the technology that will put you in a higher quality facility, more quickly, and less expensively than anyone else."

Delta Prime typically negotiates projects with an owner and then takes responsibility for financing, design, approvals, and construction. Delta Prime monitors, coordinates, and plans site operations by relying on extensive data which is collected on site; much of this data is collected by specialty firms which work closely with Delta Prime. Delta Prime's largest current project is the Fantasy Gardens Stage XIII. Its owner, IAA Group of Tokyo, is expecting to occupy on December 1 of this year. Jana has managed to pull together five of the best project personnel from Delta Prime and has received good proposals from the major design-build specialty firms. The project will cost approximately $150 million U.S.

Jana will soon be breaking ground for Stage XIII. The long (six month) owner negotiation phase is complete, financing is in place, contracts with most specialty firms have been finalized, and environmental approvals have been obtained. After finalizing a few more details like this structural alternative, the subcontractors will be given the go-ahead for their final design and fabrication. Once the modular components begin to arrive on site, the total construction (or "assembly" as it is now often called) will take seven months.

COMPUTER HARDWARE

While the primary focus of this investigation is on how computers will be used to support project management in 2010, we thought it important to first consider the basic characteristics of future computers themselves. The questionnaire asked about the typical computer platform for project management applications and about the expected rate of computer evolution. On average, the

respondents expect mainframe computers to account for less than 4% of project management uses; mini computers/workstations and personal computers to account for 22% and 37% respectively (although several people suggested that these distinctions will not exist in 2010); and laptop or notebook computers to make up 29% of computer use. The remaining 8% is attributed to other types of computers, which some respondents described as "mini super-computers" or "mobile personal office-satellite systems."

When asked at what rate the speed, memory capacity, and relative economy of computers will increase compared to the last 20 years, respondents were divided. Twenty-nine percent think computers will evolve at a slower rate, 38% at the same rate, and 33% at a faster rate. Specific comments include: "While I'm sure many improvements will occur, it is hard to believe that the next 20 will match the last," and "Much cheaper, faster, and (almost) infinite capacity (by 1999)." In any case, it is clear that computers in 2010 will be several orders of magnitude faster per relative cost than their counterparts of today. We suggest that the main processes that will use this power are: managing extensive communications and information exchange, overcoming the computational overhead and basic inefficiencies of very high-level programming languages, supporting graphics (e.g., real-time, full-color, high-resolution, 3D graphic simulation takes a fair bit of processing), and supporting advanced search and simulation-based artificial intelligence reasoning (including natural language and vision). Each of these processes relate to potential project management uses as will be discussed in the following sections.

Jana begins to review SD&B's alternative proposal. Working at her large computer screen which resembles an old fashion drafting table, she gradually works her way through a series of video presentations, drawings, and documents that appear in different windows on the desk-screen. The computer itself—a small cube approximately 30 cm tall—sits in the corner. Its parallel processors can handle 700 MIPS (approximately 300 times a 80386 PC) and it can store a Terabyte of information. Whenever she leaves her office, Jana carries a smaller pocket computer that can be connected to a notebook-size screen or can simply be controlled by voice.

INTEGRATION AND CONNECTIVITY

The questionnaire results clearly show that two of the primary roles of future computers will be to provide access to information *from all sources* and to integrate the parties and processes involved throughout the project life cycle.

More information will be available and it will be available sooner.

[Computers will] support group work, networking, and sharing knowledge across disciplines, [and throughout the] life cycle.

The most significant development that will occur over the next 20 years will be the integration of design, construction, and management of the constructed facilities.

[The most important impact of computers will be] the ability to access information which is accurate and correct.

Communication between different parties will be more efficient through computers.

[One of the most important developments will be] fully implemented vertical/lateral transparent connectivity between major systems and database depositories.

We expect the management of extensive information exchange to be one of the main uses of the significant power of future computers. The questionnaire inquired about the degree of networking, the integration and connectivity of applications, and the communication standards that would exist for exchanging information. In virtually all cases, computers will be networked throughout companies' head offices, throughout site offices, and between home and site offices. This degree of interconnectedness would be much the same as telephones are now. To a slightly lesser extent, respondents agree that computers will be networked throughout the various companies working on a project, but they are split evenly over whether or not computers would typically be connected to industry-wide communications and information services.

All respondents agree that the integration and connectivity of computer applications will not be as they are today (typically stand-alone applications that "own" their data and have some limited ability to exchange information with other programs through specific file formats). Furthermore, 76% of respondents expect that by the year 2010, programs will have moved beyond the stage of relying solely on more standardized and widely

accepted data standards for their information exchange capabilities. Fifty-seven percent believe that programs will be able to exchange all forms of data with other applications on demand. This could occur through intelligent data exchange software that can accept generic requests for information, identify the likely locations of that information, and return it to the inquirer (see Howard and Rehak, 1989 and Chua et al., 1990). Almost two thirds of respondents (63%) also think that applications will operate on bodies of information that they don't "own" (such as project databases), while over half (54%) think that typical programs will be modules that perform a specific function within an overall integrated system, rather than stand-alone applications.

Regarding data standards, both defacto industry standards for exchanging data (such as .DXF or .WKS files, for example) and company-wide work breakdown standards allowing all of an organization's applications to share data are expected to be very common. Less pervasive but still common will be project-wide work breakdown structures allowing all project participants to share data, and industry-wide standards for construction information that allow data sharing between any system used by any project participant. Based on these responses, we suggest that data standards for construction information will be central to future computer use (Froese and Paulson, 1991), but that the difficulties of establishing industry-wide standards that accommodate every possible view of the project will not be fully overcome.

Jana has a number of questions about SD&B's proposed alternative. She asks her computer, George, to connect her to the structural engineer and soon his image appears in a window that opens up on her desk-screen. As they discuss the design, the engineer makes some sketches which are displayed simultaneously in front of Jana. She also brings SD&B's superintendent into the conversation. The superintendent is currently in the field on another project, but communicates though her pocket computer with its cellular data/voice/video link.

Later, Jana asks George to retrieve a few case histories of similar designs used on other projects from the National Engineering Design Database. Although the composite-plastic structural members represent fairly new technology, she is pleased to find that they have been fully classified in the Uniform Construction Information Standard and George has no trouble finding and accessing the appropriate entries.

Jana assembles several of the sketches and supporting documents into a hypermedia stack for the architect's review. She adds a brief video introduction and sends it off to his home/studio on the northern tip of Vancouver Island. Within minutes the Architect responds that he foresees no aesthetic impact and has added his formal "approval for concept only" to the stack's audit trail.

PROGRAMMING LANGUAGES AND SOFTWARE DEVELOPMENT

The questionnaire asked respondents to give their ideas about the most important developments in programming languages, the amount of effort required for software development, and who will be doing the software development in 2010. Several respondents mentioned advanced object-oriented programming (OOP) environments as being significant: "More widespread use of high-level OOP environments to allow users to build and modify applications." Some predict that programming languages won't be used to construct applications: "[The most significant development will be] the fact that they won't look like programming languages—i.e., application generators rather than programming languages," and several respondents expect natural language to be used to program computers. Finally, many respondents suggest that advances in human-computer interfaces will have the largest impact on program development: "Further user friendliness enhancement, natural voice I/O, putting the keyboard in the museum."

While a majority of respondents (65%) believe that software development will require less effort in 2010, a notable number (25%) think that it will take more effort. These beliefs may be reconciled by the suggestions that "[development will require significantly less effort] for the same task, but tasks will be 100x in scope."

The overall direction suggested by these responses is that it will be much easier for users to program their own applications. Yet on average, respondents still expect 73% of the software that project managers use to come from commercial developers (33% by general developers, 40% by project management specialists). Twenty-two percent of software is expected to come from in-house developers and 5% from project managers themselves.

Jana asks George to run a full set of construction simulations using the new designs. These calculations will generate the most likely outcomes for a wide range of factors such as cost, schedule, cash flow, site congestion, and so on. Jana has created a few of these simulation programs herself: she occasionally builds new applications or modifies existing ones to perform specific tasks. However, the vast majority of her work uses programs purchased from commercial developers. By and large, these developers are project management software specialists who contract with design-build firms to assemble custom systems from the wide range of software components that are readily available. These lower-level components come from many sources ranging from individual computer hackers to huge software component suppliers. A complex set of software protocols ensures that these components can reliably be assembled into applications. The overall result is that most users can easily assemble their own simple applications, but creating large or complex programs requires highly trained professionals.

USER INTERFACES

Respondents were asked about the frequency with which a variety of user interfaces would be used for project management tasks. The average responses suggest that for general input and output (I/O), graphical user interfaces (e.g., windows, icons, etc.) will almost always be used, while paper printouts, voice I/O, handwritten input, and video I/O will be used quite often. Virtual reality (i.e., full video simulation with sensory feedback) is expected to be used occasionally.

For the following field-based data acquisition techniques, the average expected frequency of use ranges between "often" and "usually": direct tracking of resources (e.g. with bar-code scanning); portable data entry devices (e.g. "electronic clipboards"); data collection through sensors on "smart tools"; and input from computers used by equipment operators or other craftsmen in the field. It is thought that computer vision will often be used. Additional comments state that in 2010, systems will often acquire data through "more electronic data interchange (e.g., material delivery to site will be ratified/paid electronically; man-hours from payroll will be available for monitoring productivity)" and "2D tracking systems from radio signals, lasers, or satellites." Since very few responses stated that these interface techniques would rarely be used, it is suggested that the limits to their acceptance will be based more on appropriateness for the task rather than any technical barriers.

Jana is concerned about the impact of the new structural proposal on her project control systems. SD&B's project engineer assures her that their new plant tracks each component through every stage of fabrication and that this information is fully compatible with the information exchange standard that Jana's job tracking system uses. He also explains that once they are in the field, the new composite-plastic structural members will have the same materials-identification tags as the traditional steel or precast concrete members and that their installation can be tracked with the existing computer vision data collection systems.

Jana is now almost convinced that the proposal should be accepted, but as a final check, she schedules a session in the full-scale walk-through video simulation room so that she can personally inspect the new design at various stages of construction.

COMPUTER APPLICATIONS FOR PROJECT MANAGEMENT

Respondents were asked to identify the role that various computer applications will play in 2010. Table 1 provides the responses recorded for each category in percentage form. Virtually all respondents believe that each of the above computer applications will be used for project management. A majority think that computers will play a fundamental role in project estimating, scheduling, performance monitoring and control, document control, CAD, and communication of design information.

Respondents were also asked what they think is the most important way that computers will change the way project managers work by 2010. Three themes predominated: information supply (referred to in 37% of responses), communication, and decision support. Typical statements of the most important change include the following:

Provide better information [and be] better able to control present and forecast future aspects of operations.

Table 1: The role of future project management computer applications

In 2010, what role will the following computer application areas play in supporting project management?	*fundamental* 1	2	*useful* 3	4	*no role* 5
General Business Application Areas (e.g., writing, accounting, financial planning, etc.)	55%	32%	14%	–	–
Project Management Applications:					
- project estimating	60%	23%	13%	–	4%
- project scheduling	60%	27%	8%	–	4%
- planning & design of construction operations	38%	21%	33%	4%	4%
- coordinating construction operations	38%	19%	35%	4%	4%
- project performance monitoring and control	54%	25%	13%	4%	4%
- document control	63%	25%	13%	–	–
- CAD	63%	21%	15%	2%	–
Communications:					
- communications between owners, designers, & contractors	42%	29%	25%	4%	–
- communications between on-site participants	46%	17%	25%	13%	–
- communication of design information	50%	25%	21%	4%	–
AI/Expert Systems:					
- advisor systems for construction methods	21%	23%	44%	13%	–
- legal advice systems	13%	27%	40%	21%	–
- cost/schedule/productivity analysis	29%	40%	23%	8%	–
- field automation & robotics	8%	21%	48%	23%	–

Gathering information on site and interface for communication.

Providing real-time detailed status of construction projects with diagnostics and capabilities to project future course of actions.

Linkage between construction operations and computer models of design and construction will provide much greater analysis and understanding than today's tools.

Informed decision-making will be the norm.

Improved decision support (not decision making!).

Greatly more reliant on systems than gut feel or experience.

After Jana returns from the walk-through room, George reports that all of the simulations have been completed. "Can you summarize the results for me?" asks Jana.

"Yes." replies George.

"Please do." instructs Jana, wincing at the subtleties of speech that George has yet to master.

"Compared to precast concrete, the composite-plastic members have a lower probability of assembly error, require fewer resources to install, will reduce the supply and installation cost by 5% to 7%, 19 times out of 20, and should shorten the whole project by 12 days." reports George. "Also, I have found that $85,000 of project overhead and Delta/IAA shared savings can be realized by expediting several parallel activities."

Jana begins work on her recommendation to IAA by copying SD&B's proposal. George obtains approval for this and quickly revises the title and introduction. Jana adds an explanation of the project overhead savings and includes a link to the contract clause which explains how savings are shared. George has been running a check on the legal and environmental implications in the background and reports a clean search.

Finally, Jana rearranges the stack to include the 3-D views of the two alternatives in the main proposal and sends it off. She then tells George to contact her as soon as a response comes in and closes the remaining windows to clear off her desk-screen. "Not a bad morning's work," she thinks to herself as she heads down the hall for a cup of tea. "Not a bad morning's work," George thinks as he turns off the lights after her.

SUMMARY AND CONCLUSIONS

The following points summarize our speculations about the future of computers and project management based on the questionnaire results:

- The management, design, and construction of projects will increasingly be performed by fewer organizations, each of which will be large partnerships of prime project management companies and numerous associated specialty firms. Increasingly, fragmentation in the facilities engineering and construction industry will be replaced by integration.
- Computers will be orders of magnitude faster than today and in many cases they will leave the desktop. Their wealth of power will be used for managing information exchange, supporting very high-level programming languages, graphics, and artificial intelligence.
- Computers will be transparently interconnected to the extent that telephones are today. Most project information will be available to all project participants and its exchange will be facilitated by the use of intelligent data objects and industry-wide information standards.
- Computer users will be able to use "program generators" or purchase software from commercial developers who create applications by assembling lower-level software objects.
- Graphical user interfaces will be standard, while paper, voice, and video interfaces will be common. A wide variety of techniques will be available for collecting data from construction sites.
- Numerous computer applications will generally play an important role in supporting the human project manager.

Our overall conclusions from this study are that the computer will support future project management in the following three roles: First, the computer will be a supplier of, and medium for, information. Second, it will act as a device for multimedia communication and coordination. Third, the computer will be used for processing information. While information processing will be absolutely vital (an enormous amount of processing will be required just to access, filter, and refine information), it will no longer play the dominant and often sole role that it does today.

Another conclusion is that in twenty years, the hardware and basic software capabilities of computers will, without doubt, be awesome. However, progress that requires united industry-wide cooperation—such as standard data exchange models—is less certain.

We believe that these results can provide some guidance for construction and project management research today. As researchers, we must continue to investigate how computers can be used as information tools for the management of design and construction. However, rather than devote the majority of our effort to developing specific new applications, we should work toward building a solid foundation for the advanced capabilities to come. By investigating topics such as robust formal models of our environment and standards for representing and communicating project information, we can ensure that when advanced new computing platforms become available, we will be capable of using them to improve our industry.

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Appendix I: The Questionnaire

Future Trends in Computers for Project Management

Name:_____ Address:_____

Position:_____ _____

Company:_____ _____

Phone:_____ Fax:_____

This questionnaire examines your speculations about how computers will be used to support project management 20 years from now. Our main interest is construction management, but comments on any other aspects of managing constructed facility projects are equally welcome. First, please take a few moments to imagine what a project management team might be like in the year 2010. Consider what role computers of that time might play in their work. Don't be too concerned with how realistic or practical your ideas are–remember that most of the computer technology we take for granted today would have seemed improbable 20 years ago. Now, based on this mental image of the future, try to answer the following questions. Please add as many additional comments or ideas as you can. In return for your contribution, we will be happy to send you a copy of our resulting paper on computers and project management in the year 2010.

1 Computers & the Project Management Environment

1.1 In 2010, will the number, size, and type of companies involved in construction projects, as well as the relationships between them, be essentially the same as now?

yes no If no, what will be the major differences?

1.2 In 2010, will the success of companies offering project management services depend largely on their computer and information technology capabilities?

yes no comments?

1.3 Which of the following best describes *who* will be using computers for project management in 2010?

_____ everyone in the PM team

_____ only those team members that are directly involved in highly computer-supported activities (e.g. schedulers)

_____ computer specialists

_____ data entry personnel

1.4 By 2010, will new computer technologies have a significant positive or negative impact on the following aspects of project management companies?

	positive			*no impact*		*negative*
profitability	1	2	3	4	5	
comments:						
effectiveness in managing projects	1	2	3	4	5	
comments:						
working environment and job satisfaction	1	2	3	4	5	
comments:						

2 *Hardware & Operating System Environments*

2.1 By 2010, what percentage of project management applications will be performed on the following computer hardware platforms?:

- mainframes _____ %
- mini computers and workstations _____ %
- personal computers _____ %
- lap top/notebook computers _____ %
- other _____ _____ %

total *100%*

2.2 Do you expect the speed, memory capacity, and relative economy of computers to increase over the next 20 years at the same rate that they have over the past 20?

yes *no* *comments:*

2.3 In 2010, how often will computers used for project management tasks be networked in the following ways?

	always		*usually*		*often*		*occasionally*		*rarely*
- throughout a company's head office	1	•	2	•	3	•	4	•	5
- throughout a company's site office	1	•	2	•	3	•	4	•	5
- between a company's head offices and its various site offices	1	•	2	•	3	•	4	•	5
- between the various companies working on a project	1	•	2	•	3	•	4	•	5
- between industry-wide communications and information services	1	•	2	•	3	•	4	•	5

3 *User Interfaces*

3.1 In 2010, how often will the following user interfaces be used for project management tasks?

	always		*usually*		*often*		*occasionally*		*rarely*
General I/O:									
- paper printouts	1	•	2	•	3	•	4	•	5
- graphical user interfaces (e.g.windows, icons, mice or other pointing devices)	1	•	2	•	3	•	4	•	5
- voice input and output	1	•	2	•	3	•	4	•	5
- "electronic pen" handwritten input	1	•	2	•	3	•	4	•	5
- video input and output	1	•	2	•	3	•	4	•	5
- "Virtual reality" interfaces (e.g. 3 dimensional video goggles, feedback from sensor gloves)	1	•	2	•	3	•	4	•	5
- other _____	1	•	2	•	3	•	4	•	5
Devices for obtaining input from the field:									
- direct tracking of resources (e.g. with bar-code scanning)	1	•	2	•	3	•	4	•	5
- portable data entry devices (e.g. "electronic clipboards")	1	•	2	•	3	•	4	•	5
- data collection through sensors on "smart tools"	1	•	2	•	3	•	4	•	5
- input from computers used by equipment operators or other craftsmen in the field	1	•	2	•	3	•	4	•	5
- computer vision for field input	1	•	2	•	3	•	4	•	5
- other _____	1	•	2	•	3	•	4	•	5

4 Software Development & Programming Languages

4.1 What do you think will be the most important development in programming languages by 2010?

4.2 How much effort will the development of new software take in 2010 compared with the present?

significantly less		*slightly less*		*about the same*		*slightly more*		*significantly more*
1	•	2	•	3	•	4	•	5

4.3 What percent of software used by project managers will originate from each of the following sources?

- commercial developers of software for general uses	_____ %
- commercial developers of software specifically for project management	_____ %
- software developers within the project manager's company	_____ %
- software developers within the project management team	_____ %
- project managers themselves	_____ %
total	*100%*

5 Applications

5.1 In 2010, what role will the following computer application areas play in supporting project management?

	fundamental				*useful*				*no role*
General Business Application Areas (e.g., writing, accounting, financial planning, etc.)	1	•	2	•	3	•	4	•	5
Project Management Applications:									
- project estimating	1	•	2	•	3	•	4	•	5
- project scheduling	1	•	2	•	3	•	4	•	5
- planning & design of construction operations	1	•	2	•	3	•	4	•	5
- coordinating construction operations	1	•	2	•	3	•	4	•	5
- project performance monitoring and control	1	•	2	•	3	•	4	•	5
- document control	1	•	2	•	3	•	4	•	5
- CAD	1	•	2	•	3	•	4	•	5
Communications:									
- communications between owners, designers, and contractors	1	•	2	•	3	•	4	•	5
- communications between on-site participants	1	•	2	•	3	•	4	•	5
- communication of design information	1	•	2	•	3	•	4	•	5
AI/Expert Systems:									
- advisor systems for construction methods	1	•	2	•	3	•	4	•	5
- legal advice systems	1	•	2	•	3	•	4	•	5
- cost/schedule/productivity analysis	1	•	2	•	3	•	4	•	5
- field automation & robotics	1	•	2	•	3	•	4	•	5
Other Existing or Future Application Areas:									
- _____	1	•	2	•	3	•	4	•	5
- _____	1	•	2	•	3	•	4	•	5
- _____	1	•	2	•	3	•	4	•	5
- _____	1	•	2	•	3	•	4	•	5

5.2 What is the most important way that computers will change the way project managers work by 2010?

6 *Connectivity, Integration, and Standards*

6.1 Typical computer programs of today could be described as being largely stand-alone applications that "own" their own data and have some limited ability to exchange data with other programs through specific file formats. Which of the following do you think describe the programs that will be typical in 2010?

_____ applications that are essentially the same
_____ applications that are similar, but with more standardized and widely accepted formats for exchanging information
_____ applications with the ability to exchange all forms of data with other applications on demand
_____ applications that operate on bodies of information that they don't "own" such as project databases.
_____ programs that are not stand-alone applications, but perform a specific function within an overall integrated system.
_____ other_____

6.2 How common will the following data standards be in 2010?

	very common				*often used*				*rarely used*
- defacto industry standards allowing certain programs to exchange data (eg. .DXF, .WKS, .RTF)	1	•	2	•	3	•	4	•	5
- company-wide work breakdown standards allowing all applications used by a company to share data.	1	•	2	•	3	•	4	•	5
- project-wide work breakdown standards allowing all participants on a project to share data	1	•	2	•	3	•	4	•	5
- industry-wide standards for construction related information allowing data sharing between any system used by any project participant (eg. PDES/STEP).	1	•	2	•	3	•	4	•	5

Any other comments concerning what you think will be the most important developments or most critical concerns for computers and project management over the next 20 years? (use back of page if necessary)

Thank you for your time!

Please return by Feb. 28 to:

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Appendix II: Summary of Questionnaire Responses

Future Trends in Computers for Project Management: Summary of Responses

The following is a summary of responses received from the "Future Trends in Computers for Project Management" questionnaire. The questions asked are shown in Helvetica font while the responses are shown in Courier font. Where appropriate, numerical summaries of responses are given. For yes/no questions or those that asked respondents to rank various statements, the numbers shown are the tabulated number of responses in each category (expressed as a percentage of total responses). Where questions asked for respondents to enter a percentage, the number given is the average of the values given. Where appropriate, comments are prefaced by the numerical or yes/no responses selected by the respondent. The questionnaires were completed by the following people:

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1 Computers & the Project Management Environment

1.1 In 2010, will the number, size, and type of companies involved in construction projects, as well as the relationships between them, be essentially the same as now?

yes no If no, what will be the major differences?

Yes: 33%, No: 67%

(No) Probably smaller; robotics and automation will decrease the size of construction companies.

(Yes) There may be some movement towards design-construct work with less need for CM in bldg.field.

(No) The number will become smaller. Companies will be well-organized by large company.

(Yes) Essentially yes. If cause function will be changed.

(No) Competition from international firms will increase; only a select few large U.S. construction firms will make significant progress in foreign markets; makeup of U.S. competition sees no drastic changes.

(No) Robotics & network.

(No) More "quasifirms"-close knit networks of autonomous firms with long term cooperation (like Japanese keiretsu, but more independent).

(No) Relationships will be partnerships like Japanese. U.S. companies will be smaller.

(Yes) Company's size will decrease specially design firms. The size of contracting companies will also decrease. Most of administrative work will be automatically performed by computers. The major change in relationship will be in communication.

(No) In Canada somewhat more in number even more specialist subcontractors.

(Yes) However the general contractor as we know him today will cease to exist in favor of the project manage or "broker".

(No) There may be less—larger companies, but most likely these will operate in integrated fashion (design-build-manage) and will exchange data in electronic format between them.

(No) More integration of services eg. design-build of construction management.

(Yes) But many of the players will change.

(No) Smaller number of companies.

(No) As for size, the industry will probably stay the same, but companies will have to streamline their practices to be more efficient. Since competition will be fierce due to the fact that 90% of our structural buildings are already in place, what little work is done by a company will have to be done very efficiently in order to maintain some sort of profit on their proposed bid.

(No) Type will depend on technology.

(No) More turnkey projects will mean consultants increasingly working for contractors rather than owners.

(Yes) "construction projects"—for all projects including house, commercial, etc.

(No) Significantly higher system design and system user skills. Fewer, but better run companies.

(No) Much more diverse in capability and use.

1.2 In 2010, will the success of companies offering project management services depend largely on their computer and information technology capabilities?

yes no comments?

Yes: 85%, No: 15%

(Yes) But overall management & technical abilities will remain most important. Computers aid these, but not replace them.

(Yes) They won't succeed if they don't.

(Yes) Also on their knowledge of the construction process and their ability to work with teams of people.

(Yes) All information about market, client and so on will be stored in large databases. Therefore without computer there is nothing to do.

(No) I would say informational technology will not be the deciding factor. While very significant, it would rank behind a number of other factors--financial stability, experience, qualified staff.

(Yes) Key element of quals (?).

(Yes) Almost totally on computer & information technologies, and the skill of the people who are assoc. with these technologies.

(Yes) Easy access to huge database system and industry standards; Many companies will have their own computer software to keep their in-house expertise.

(No) Depend slightly, not largely.

(Yes) Due to the complexity of the construction prices and contractual relationships, the computer will be.

( ) I think success depends on individuals not computers. I'm convinced however that the successful companies will make extensive use of computers and related technologies.

( ) Certainly this aspect will increase with time clearly what matters is getting the work done quickly and economically.

(Yes) On information tech (mgmt) capabilities, and (No) Not on computer capabilities—all micros.

(Yes) Due to the need for increased efficiency, the use of computers will enable a company to maintain this service and keep abreast of competition who will also be competing in this market.

(Yes) It is so today, why should it change?

(Yes) Largely, but not totally-management of the technology and people still very important.

1.3 Which of the following best describes *who* will be using computers for project management in 2010?

92% everyone in the PM team

8% only those team members that are directly involved in highly computer-supported activities (e.g. schedulers)

0% computer specialists

0% data entry personnel

(#1) Increased tendency in this direction.

1.4 By 2010, will new computer technologies have a significant positive or negative impact on the following aspects of project management companies?

profitability

positive			*no impact*			*negative*
1	2		3	4		5
42%	46%		8%	4%		-

Average: 1.8

(1) THE #1 competitive factor for 1990's.

(2) It will increase activity by automating many activities such as scheduling, estimating, industrial standards.

(2.5) Not significant.

(3) Companies without computer technologies will not exist.

(2) No impact when everyone uses high technology.

(4) Because too many people will default to the computer instead of thinking for themselves.

(1) By being efficient less wastage and lost time due to delays will be reduced, thus increasing profits.

(1) Price will reduce, capabilities will increase.

(2) If properly managed.

effectiveness in managing projects

positive			*no impact*			*negative*
1	2		3	4		5
38%	58%		4%	-		-

Average: 1.7

(3) People always #1.

(2) It will increase the effectiveness, but we will constantly need the human element.

(2) Helpful.

(2) If information management is properly handled—otherwise disaster.

(1) With time, the efficiency of using computers will increase thus making them more user friendly.

(2) If properly managed.

working environment and job satisfaction

positive			*no impact*			*negative*
1	2	3	4	5		
17%	48%	13%	22%	-		

Average: 2.4

(2) Computers will be used to communicate for most job functions. People will not be satisfied in they lack access to these tools.

( ) Whole range from 1 to 5, depends on how they are used.

(4) New technology creates an intense workplace. Fewer people whose brains are working harder day and night. Will continually be a smaller fraction of population who want to work this way. Hopefully a solution before year 2000.

(4) Many people will feel that they are controlled by computers. Computers will monitor their productivity, payment, quality of their products, and firing and hiring personnel.

(3) "Working environment" average 3—some advantages; some disadvantages (speakies noisy in combined office; routine); (4.5) "job satisfaction"—boredom routine nature of job.

(2) For average team member.

(2) If info mgmt is properly handled rather than the present day drudgery of poor files mgmt.

(2) The use of computers may ease scheduling problems, but limited impact at the work face will be effected. Simply because in view of construction, laborers and craftsmen are still required to do the actual work.

(4) The technology to manipulate more information has not had a positive impact.

(2) If properly managed.

2 *Hardware & Operating System Environments*

2.1 By 2010, what percentage of project management applications will be performed on the following computer hardware platforms?:

- mainframes	4 %	- lap top/notebook computers	29 %
- mini computers and workstations	22 %	-other	9 %
- personal computers	37 %	*total*	*100%*

(Others: 0%) Parallel processors. But of course these categories will not then exist as we know them.

(Others: 100%) mini super computers.

These distinctions may not be relevant by 2010.

Personal computers and workstations: 80%

No difference between PC's and mini's by 2000.

Mini's & workstations: 100%, I have no idea.

(Others: 100%) Mobile personal office systems (developed 2004).

2.2 Do you expect the speed, memory capacity, and relative economy of computers to increase over the next 20 years at the same rate that they have over the past 20?

yes no comments:

Yes: 48%, No: 52%

(Yes & No) Similar, but not quite as fast as past 10-20 years.

(Yes) Transfer over to voice I/O. Many areas to move into.

(Yes) Perhaps faster as large RAM storage becomes cheaper.

(No) Faster.

(No) More rapidly.

(No) I expect the one to increase from now on at the more significant rate than before.

(No) Keyboards, monitors, disk drives now control cost.

(Yes) And by a 10x-100x factor.

(Yes) We will see the optical diskette with capacities of 60-100 MB, the hardware will be on the same line of advancement.

(No) Much cheaper, faster, (almost) infinite capacity (1999).

(No) Steady increase is predictable, but at a lower rate. Already in the case of speed and memory capacity, top-of-the-line PC's (eg. 486 33 Mhz) offer more than required for many average size engineering applications.

(No) While I am sure many improvements will occur it is hard to believe that the next 20 will match the last.

(No) Since the computer age is a relatively new tool in the construction industry, the major breakthroughs have already been established. This is based on the fact that a learning curve shows that the greatest concept of learning something new is established at the beginning of a trend, then as time passes, the increases in the learning is much smaller.

(No) Slower rate.

(No) Faster, look at the prognosis and expectations of mobile 2000.

(Yes) At least.

2.3 In 2010, how often will computers used for project management tasks be networked in the following ways?

	always 1	•	2	•	*usually* 3	•	*often* 4	•	*occasionally* 5	•	*rarely* *Avg*
- throughout a company's head office	61%	4%	22%	–	4%	–	4%	–	4%		1.6
- throughout a company's site office	61%	4%	30%	–	–	–	4%	–	–		1.5
- between a company's head offices and its various site offices	48%	4%	35%	–	13%	–	–	–	–		1.6
- between the various companies working on a project	30%	–	26%	–	26%	–	13%	–	4%		2.4
- between industry-wide communications and information services	29%	–	13%	–	21%	–	29%	–	8%		2.8

Some items/others; assumes 1990's computer state of the art.

Has to be through phone/radio lines.

3 User Interfaces

3.1 In 2010, how often will the following user interfaces be used for project management tasks?

	always 1		*usually* 2		*often* 3		*occasionally* 4		*rarely* 5	*Avg*
General I/O:										
- paper printouts	25%	–	25%	–	17%	–	25%	–	8%	2.7
- graphical user interfaces (e.g.windows, icons, mice or other pointing devices)	54%	4%	25%	–	17%	–	–	–	–	1.6
- voice input and output	13%	4%	46%	–	17%	–	17%	–	4%	2.5
- "electronic pen" handwritten input	8%	–	50%	–	17%	–	17%	–	8%	2.7
- video input and output	21%	4%	25%	–	21%	–	13%	–	17%	2.7
- "Virtual reality" interfaces (e.g. 3 dimensional video goggles, feedback from sensor gloves)	–	–	19%	–	14%	–	33%	–	33%	3.8
- other _____										
Devices for obtaining input from the field:										
- direct tracking of resources (e.g. with bar-code scanning)	29%	–	29%	–	21%	–	17%	–	4%	2.4
- portable data entry devices (e.g. "electronic clipboards")	29%	–	29%	–	33%	–	8%	–	–	2.2
- data collection through sensors on "smart tools"	25%	–	29%	–	17%	–	17%	–	13%	2.6
- input from computers used by equipment operators or other craftsmen in the field	25%	–	33%	–	21%	–	17%	–	4%	2.4
- computer vision for field input	17%	–	22%	–	13%	–	30%	–	17%	3.1
- other _____										

(Other: 3) 2D tracking systems from radio signals, lasers, or satellites.

(Other: 1.5) 1. Mobile personal office systems; 2. Satellite interfacing; 3. Magnetic levitation; 4. superconductor; 5. voice modulated systems

(Other: 3) More elec. data interchange (eg. material delivery to site will be ratified/invoiced/paid electronically; man-hours from payroll will be available for monitoring productivity).

4 *Software Development & Programming Languages*

4.1 What do you think will be the most important development in programming languages by 2010?

Descendents of current generic environments like spreadsheets and databases, but probably with much better integration.Augmented by things like NeXT interface builder, etc.-much less in things like Pascal and C.

Some sort of advanced object-oriented programming.

Combination of objects + 3D CAD + knowledge systems.

User friendliness.

If the user interface is rich, we don't need to care for the programming language.

Programming language will not be so important to development.

Extensive dynamic capabilities, etc.

Maturity of user interface code; insulation from operating system characteristics/quirks; CASE tool maturity.

More widespread use of high level OOP programming environments to allow end users to build and modify apps.

OO.

The advancement of AI programming languages like LISP and prolog. More symbolic reasoning languages.

Spoken word.

Ease of learning (English commands).

Very high-level languages, close to natural languages, and capable of self-diagnosis, self-debugging, self-linking to various I/O devices, protocols, formats, etc.

Ease of use.

Conversational language ie. WYSIWYG.

Higher-level language environments.

The ability for voice activated systems so the interface between user and computer becomes less intimidating, thus encouraging their use much more among computer illiterate users.

Support for user interface.

The fact that they won't look like programming languages—ie. application generators rather than programing languages.

A hypermedia base to support voice, handwriting, and vision.

Further user friendliness enhancement, natural voice I/O, putting the keyboard in the museum.

Whatever follows object-oriented.

4.2 How much effort will the development of new software take in 2010 compared with the present?

significantly less		*slightly less*		*about the same*		*slightly more*		*significantly more*
1	•	2	•	3	•	4	•	5
35%	–	30%	–	9%	–	4%	4%	17%

Average: 2.5

(1) For equivalent levels of programming capability.

(1) For same task. But tasks will be 100x in scope.

(1) There will be huge data base of programming modules that can be use for different software.

4.3 What percent of software used by project managers will originate from each of the following sources?

- commercial developers of software for general uses	33 %
- commercial developers of software specifically for project management	40 %
- software developers within the project manager's company	15 %
- software developers within the project management team	7 %
- project managers themselves	5 %
total	*100%*

(#3: 8%) e.g., with macros.

5 *Applications*

5.1 In 2010, what role will the following computer application areas play in supporting project management?

	fundamental							*useful*				*no role*	
	1	•	2	•	3	•	4	•	5	*Avg*
General Business Application Areas (e.g., writing, accounting, financial planning, etc.)	55%	–	32%	–	14%	–	–	–	–	1.6
Project Management Applications:										
- project estimating	58%	4%	21%	–	13%	–	–	–	4%	1.7
- project scheduling	58%	4%	25%	–	8%	–	–	–	4%	1.6
- planning & design of construction operations	38%	–	21%	–	33%	–	4%	–	4%	2.2
- coordinating construction operations	38%	–	17%	4%	33%	–	4%	–	4%	2.2
- project performance monitoring and control	54%	–	25%	–	13%	–	4%	–	4%	1.8
- document control	63%	–	25%	–	13%	–	–	–	–	1.5
- CAD	63%	–	21%	–	13%	4%	–	–	–	1.6
Communications:										
- communications between owners, designers, and contractors	42%	–	29%	–	25%	–	4%	–	–	1.9
- communications between on-site participants	46%	–	17%	–	25%	–	13%	–	–	2.0
- communication of design information	50%	–	25%	–	21%	–	4%	–	–	1.8
AI/Expert Systems:										
- advisor systems for construction methods	21%	–	21%	4%	42%	–	13%	–	–	2.5
- legal advice systems	13%	–	25%	4%	38%	–	21%	–	–	2.7
- cost/schedule/productivity analysis	29%	–	38%	4%	21%	–	8%	–	–	2.1
- field automation & robotics	8%	–	21%	–	46%	4%	21%	–	–	2.9
Other Existing or Future Application Areas:										
- _____										

(Other: 1) Integrated packages that include most of the above.

5.2 What is the most important way that computers will change the way project managers work by 2010?

1. Provide better information; 2. Better able to control present & forecast future aspects of operations.

Linkage between construction ops & computer models of design & construction will provide much greater analysis and understanding then today's tools.

Gathering information on site and interface for communication.

Hand-held computers, integrated software.

Improved decision support (not decision making!).

Unknown. If possible, I want to know the answer.

Support group work, networking. Sharing knowledge across disciplines, lifecycle (I believe in CIFE!).

Greatly more reliant on systems than gut feel or experience. Not sure well have "project managers" in 2010. 2010 is a long way off.

Easy access to industrial standards with automatic search procedures; The use of robotics for hazards construction activities and repetitive work; Communication—drawings will be sent by computers.

Mobile personal office system (computers only part of system).

Informed decision-making will be the norm.

Providing real-time detailed status of construction project with diagnostics and capabilities to project future course of actions.

More information will be available and it will be available sooner.

Total project environment capability with voice communications which make I/O easier. Information management potential.

Quicker access to information and decision-making advice.

The ability to access information which is accurate and correct, so such information can be applied directly thus reducing costly time delays which can exist on many of todays projects.

It won't change construction, just liberate them from paperwork and phone tag.

Enhance decision making ability through reduction of labor in assessing very large databases.

Provide information for decisions. Facilitate coordination.

6 *Connectivity, Integration, and Standards*

6.1 Typical computer programs of today could be described as being largely stand-alone applications that "own" their own data and have some limited ability to exchange data with other programs through specific file formats. Which of the following do you think describe the programs that will be typical in 2010?

0% applications that are essentially the same
24% applications that are similar, but with more standardized and widely accepted formats for exchanging information
57% applications with the ability to exchange all forms of data with other applications on demand
63% applications that operate on bodies of information that they don't "own" such as project databases.
54% programs that are not stand-alone applications, but perform a specific function within an overall integrated system.
0% other_____

At leading edge companies.

#2 by 2000, moving towards #4 by 2010.

6.2 How common will the following data standards be in 2010?

	very common 1	• 2	• 3	• 4	• *rarely used* 5	*Avg*
- defacto industry standards allowing certain programs to exchange data (eg. .DXF, .WKS, .RTF)	45%	27%	18%	5%	5%	2.0
- company-wide work breakdown standards allowing all applications used by a company to share data.	52%	22%	13%	13%	-	1.9
- project-wide work breakdown standards allowing all participants on a project to share data	30%	39%	22%	9%	-	2.1
- industry-wide standards for construction related information allowing data sharing between any system used by any project participant (eg. PDES/STEP).	39%	13%	26%	17%	4%	2.4

Any other comments concerning what you think will be the most important developments or most critical concerns for computers and project management over the next 20 years? (use back of page if necessary)

As part of your paper, you might look back at the last 20 years to see how fast things change in computers. E.g., no microcomputers at all until about 1975; no practical applications of micros in construction until Visicalc about 1980 and very few even then;little construction computer use-except for accounting and payroll and a bit of CPM-until about 1985,especially in the field.

Very hard to project hardware and software to 20 years out.

Relatively likely that the good folks in construction will be much the same 20 years out. (e.g., look back over 50 or even 100 years and there has been little change in fundamentals of construction and human relations, and even the types of materials and equipment used).

Enabling technologies still required for: 1) data models 2) Large object databases 3) More flexible KB design systems 4) links between PM systems & 3D CAD models.

1. More complex and demanding working environment; 2. Internationalization; 3. Fewer working hours; 4. Better educated workforce; 5. More powerful and flexible machinery; 6. Reduction in overall construction workforce; 7. Computers leave desktop; 8. Instruments widely used; 9. Integration of several computer language features and capabilities into new language.

I don't think we can see the yr. 2000 very well, let alone the yr. 2010. There are several major concepts that will prevail in the year 2010 which we haven't thought of or talked about yet.

Communication between different parties will be more efficient through computers. Change orders will be made, processed, and approved through computers; The establishment of projects remote control system to monitor productivity and quality; Robotics; The advancement of storage capacity will allow easy access to industrial standards

Computers (name not now used) are only sub part of personal mobile office-satellite systems.

I believe the most significant development that will occur over the next 20 years will be the integration of design, construction and management of the constructed facilities. I expect that the bldg codes will be built in for designers indeed approx cost may be in the corner of their screen as they . Contractors will no longer need to take off most quantities. Designers and property managers will have a good database on how product function which should weed out inferior product.

Computers may cause people to default to the computer and not perform their own thinking. When something goes wrong then, chaos may result & fixups will be expensive &time consuming. Danger is that system dominates people instead of the opposite.

Voice communication w/arbitrary translation: Large, comprehensive international databases including design systems conforming to international standards: fully implemented vertical/lateral transparent connectivity between major systems and database depositories: Vastly more competent and refined modelling capabilities including synthetic rule based optimal design.