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Managing Interdisciplinary Project Teams Through the Web[1]

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Abstract: The introduction of new communication technologies such as the World Wide Web are creating unique opportunities for AEC project teams to develop new coordination and communication strategies. Of particular interest is the capability of teams to interact remotely in a virtual team environment. However, this evolution of project team interactions is introducing a diverse range of new issues in project management and process control which requires a new generation of management frameworks. This paper introduces the requirements of these management frameworks as developed through studies of interdisciplinary, virtual project teams working together over the World Wide Web.

Category: Category K3: Computers and Education

1 Introduction

Project teams in the AEC industry are unique entities, created through a complex integration of factors. These entities are comprised of a network of interdisciplinary players, with varied roles, responsibilities, goals, and objectives. They are created to produce complicated project solutions through the sharing of highly specialized knowledge. However, the manner in which AEC project teams interact is rapidly changing. Project teams are increasingly becoming virtual teams; groups of individuals formed on the basis of global collaborative efforts, using information exchange and technology as a common thread to bind themselves together. This collaboration methodology is a fundamental difference between AEC virtual project teams and previous AEC project teams. The evolution is transforming how project players communicate, collaborate, and cooperate in their project undertakings. At the core of this change is the manner in which teams are exchanging and sharing information. In response to this transformation, new approaches to project management

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must be developed which address both the managerial and organizational issues associated with virtual project teams [Handy 1995].

One approach to this evolving project management requirement is currently being examined by the Construction Engineering and Management program at Georgia Tech. In this effort, an integrated, quality-based managerial framework is being developed to facilitate the remote communication and coordination requirements of interdisciplinary project teams. At the core of this framework is an emphasis on evolving technologies as conduits for remote communications. Specifically, the researchers are focusing on the capability of the World Wide Web to serve as a facilitator of remote team interaction. Based on this focus, this paper introduces the managerial framework research and its unique use of the World Wide Web as a communication device to study interdisciplinary project team coordination within the classroom.

2 Framework

The interdisciplinary project team research explores the dynamic interactions that affect the decision-making processes of project participants in virtual AEC project teams. The premise being that although there is a great deal of theory and practical effort directed toward understanding the managerial and organizational dynamics of project teams, the increased use of new technologies within the project process is far less understood. The introduction of these advanced communication technologies is straining traditional management structures and procedures. For example, technologies including digital videoconferencing and concurrent design studios are presenting businesses with the opportunity to break down the traditional barriers of space and distance. Given these opportunities, a shift is emerging in business to emphasize decentralized communications, offices, and processes [Mintzberg 1996]. However, to understand the impact of this shift, the evolving project processes must be studied in the context of how they impact project team interaction and the resulting decisions reached by the project participants. Similarly, a new management framework emphasizing new project communication and coordination techniques must address two primary elements: 1) the dynamics associated with the remote interaction of project players during decision making processes, and 2) the new organizational structures required for the planning phases and activities of AEC projects.

Each of the management framework issues is directly dependent on understanding the unique interactions associated with virtual teams. Given this interdependency, the virtual team research effort is initially focusing upon a study of the impact of technology on interdisciplinary interaction within a project circumstance. Specifically, the study is emphasizing the need to understand how the introduction of communication tools is impacting the manner in which virtual team participants communicate and coordinate throughout a project life-cycle.

3 Classroom Investigation

To facilitate the virtual team study, a controlled environment was required to minimize the number of external, non-controlled variables. The environment selected was the graduate level construction management course within the Construction Engineering and Management program at Georgia Tech. The course focuses on the interdisciplinary team requirements at the commencement of a development project including the development of work breakdown structures, project organizations, and projected schedules. The course contains an average of 35-45 students each year from a variety of professional backgrounds including construction management, civil engineering, and architecture. This diversity of backgrounds provides the essential element of interdisciplinary cooperation required to conduct the research experiments.

The use of the classroom environment provided the research team with the advantages of controlling both the information that the students received and the diversity of the project teams. This control was necessary to ensure that each class received the same design scenario and each team was created with members having similar attributes including experience, technology awareness, and personality. Given this project environment, the research team undertook the exploration of the dynamics associated with coordinating virtual project teams in their development of a bid proposal. Specifically, the focus of the first phase research effort centered on the effects of utilizing the World Wide Web to share information among project participants.

Over the last two years, the authors have compared the communications and coordination mechanisms put in place by the construction management students. During Year 1, the project teams were restricted to face-to-face communications to provide a baseline communications profile. During Year 2, the teams were given access to the Web as a communications device. While students are not a direct corollary to project professionals, the use of graduate students with a diverse set of professional backgrounds represents a significant step in preparation for expanding the project into the realm of professional designers. Based on this project basis, the research team has created a unique environment in which to observe the impact of new communications technologies on interdisciplinary project interactions.

3.1 Project Scenario

The Web experiments focus upon the development of a 20,000 square foot educational facility. The students are provided with an assignment to complete the design, create the schedule, and provide a cost estimate for the facility. The classroom simulation required the expertise of architects, engineers, and construction managers within each team. Two consortia were formed, each comprised of five interdisciplinary teams—foundation, concrete, masonry, roofing, and finishes—responding to specific components of the project. Each

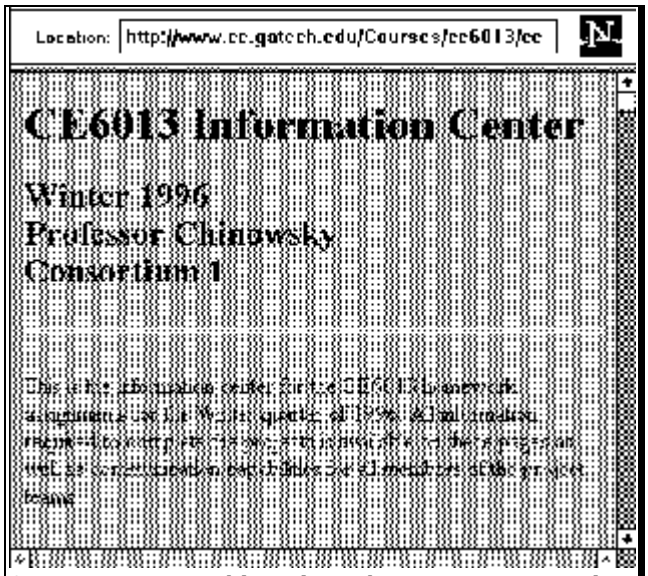
team consisted of 4-5 students with diverse backgrounds and experiences. The five teams in each consortium were required to collaborate on the development of an organizational framework, work breakdown structure (WBS), and cost estimate for a bid proposal. The critical element of the project being the focus on communication and coordination. The division of responsibilities between the five teams within each consortium required the teams to cooperate throughout the project in order to complete the overall tasks. Two central themes faced the teams as the basis for the project: 1) the establishment of management mechanisms to organize and coordinate project players, and 2) the development of technical solutions to the stated issues.

The two issues are closely linked in that the successful generation of technical solutions is directly dependent on the establishment of coordination and communication mechanisms between the teams. While the students are presented with both issues as tasks which must be completed, the connection between the tasks is not provided. It is left to the teams to make this link and understand the implications of successfully setting up the coordination structures. To facilitate the study of this coordination process, each team is required to retain a log of every face-to-face meeting conducted throughout the project. Additionally, copies of all electronic communications are retained within the system to monitor remote communications between group members.

3.2 Project Communications

While initial research has demonstrated that the Web can be an effective medium for one-way communication of information from professor to student within a course environment [El Kordy 1994], the effectiveness of the Web as a two-way communication mechanism between interdisciplinary teams is less apparent. However, previous use of telecommunications technologies in classroom settings including newsgroups, e-mail, and discussion centers provided a foundation from which the current study could extrapolate fundamental elements required for the successful support of interdisciplinary teams [Hong and Leifer 1995]. Specifically, the use of a centralized communications center, the development of mailing lists, and ease of use were identified as critical elements in the successful implementation of a remote communications facility. Although many factors and issues including familiarity with technology, age of participants, location of team members, and access to technology will combine to additionally influence the effectiveness of the facility, initial emphasis was placed on ensuring access and availability of the technology for the project teams.

Access and availability to the communications center was facilitated through the development of a Web site accessible by all members of the class [Fig. 1]. The site provided two essential elements for each consortium; 1) access to individual pages containing project information required by each team, and 2) a communications center where electronic mail messages could be sent to any



0*Figure 1: A World Wide Web page was created to permit each team member access to information and communications.*

team within the consortium, or to the entire consortium. Each student in the class was given access to the site and given instructions on how to use the communications center to ensure that knowledge and access could be eliminated as external factors influencing the study.

3.2.1 Project Information Pages

The decision to use the World Wide Web as a project information center generates important issues regarding the amount and type of information to be placed on the pages. In developing the project information pages for the current study, the authors retained an underlying objective of providing the students with as much information electronically as feasible. However, in an AEC context, this translates to providing information in multiple types of media including building plans, specifications, and site photographs. While text-based specifications and still photographs present few difficulties, the placement of building plans on the Web presented a severe obstacle to the project. The combination of size and detail made electronic access by the students impractical. Specifically, if the plans were kept at an acceptable level of detail, then the download times were unacceptable. Similarly, if the plans were reduced in size to optimize download times, then level of detail was unacceptable. Ultimately, a hybrid approach was adopted where specifications were made available electronically, while building plans remained in traditional

blueprint form. Although this compromise was acceptable in the classroom environment, the electronic plan issue is a prime concern for AEC researchers.

3.2.2 Project Communication Center

In contrast to the difficulties associated with establishing project information pages, the establishment of Web-based communications presents developers with several viable options. Electronic mail, bulletin boards, and videoconferencing each represent possible solutions for AEC projects. However, to ensure that the current study retained a focus upon communications which are available in all companies with Web access, and require no additional equipment such as video cameras, the decvision was made to employ an electronic mail-based communications solution. A minimal preparation effort was required to provide every team with an individual alias and access to group-wide communications.

4 Initial Results

The introduction of the Web into the construction management course represents a transition step within the overall study of the Web as a communications and coordination tool for interdisciplinary project teams. To ensure that the study could accurately gauge the impact of the Web as a communication device and as a coordination facilitator, the students were given the option of using the Web communications center or conducting face-to-face meetings. This option was provided to ensure that the Web was being used as a voluntary communications medium and not as a forced requirement which could have corrupted the study results. For comparison purposes, the same project was given to last year's class, but without the aid of the Web as a communications tool. Similarly, next year's class will be provided the same project with the requirement that all communications must occur through use of the Web. The combination of these three stages will provide a complete comparison of the impact of the tool within the student project teams. Subsequently, the study will be expanded to include professional teams to compare the results obtained within the classroom to those obtained within the professional domain. However, at this time, the project team has completed the first two stages of the project and has obtained sufficient data to summarize several observations and trends. The following sections highlight results obtained from each class based on the assignment to develop company and consortium management structures together with work breakdown structures and construction schedules for the given facility.

The use of the Web as a communications and coordination device assumes that project participants will use the device effectively. However, determining what characterizes effectiveness can be an arbitrary criterion. Thus, the authors propose three elements as preliminary statistics for evaluating effectiveness:

the total number of communications between project participants, the focus of communication topics, and the time when communications took place.

4.1 Total Communications

The first of the Web analysis indicators, total communications, analyzes the number of communications which occurred during the project. This is an important analysis factor based on the hypothesis that electronic communications should facilitate additional communications and thus facilitate better coordination among team members. [Figure 2] provides a summary comparison of this information from the test groups. In this graph, several pieces of information emerge as interesting data points. First, the overall number of meetings between last year's team and this year's team is significantly increased. Prior to an in-depth analysis, this fact appears to uphold the hypothesis that the Web facilitates enhanced coordination and communication. Second, the fact that the number of face-to-face meetings held by the Web-based consortium was greater than the number of communications conducted through the Web indicates that the security of face-to-face meetings

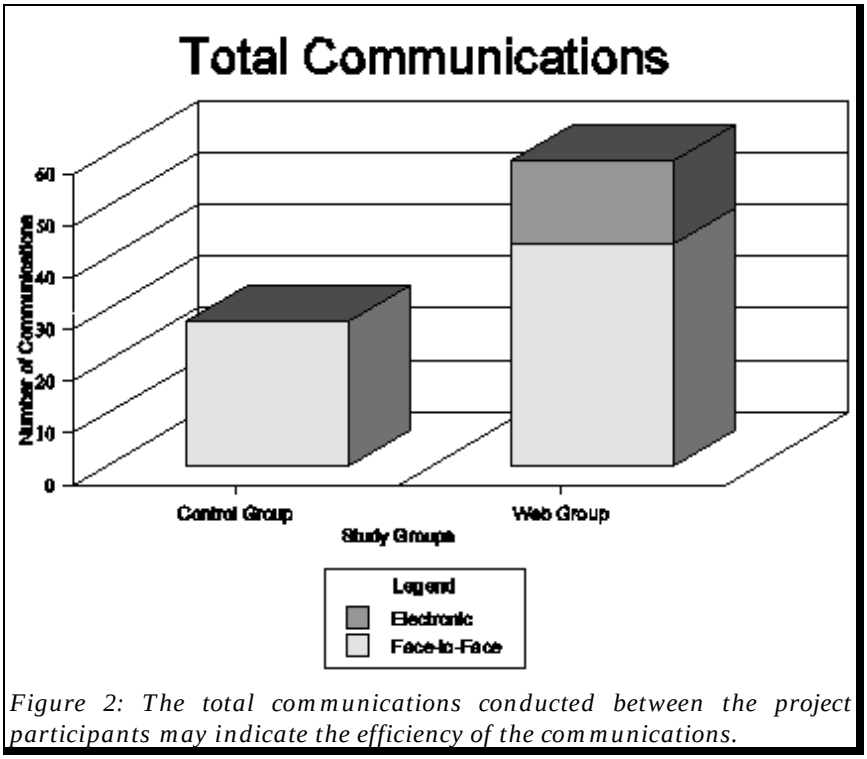


Figure 2: The total communications conducted between the project participants may indicate the efficiency of the communications.

is still a strong communications consideration for project teams. Finally, a comparison of this year's consortia meetings indicates a distinct difference

between the number of face-to-face meetings held (43) and the number of meetings conducted electronically (16). This discrepancy leads to the second area of analysis, the focus of the project communications and meetings.

4.2 Communication Focal Areas

The number of meetings called in any project can lead to one of two results—excessive amounts of time lost due to unproductive meetings, or the reduction of project-related unknowns. The result obtained for any specific project is highly dependent on the leadership of the team and the cooperation obtained between team members. One indicator which may be used to determine this level of cooperation, and ultimate focus on critical project issues, is the number of times a project group focuses on management issues versus technical issues. [Figure 3] provides an overview of this measurement from the focal groups in this study. Whereas last year's group had an almost 50% split in terms of management versus technical issues, this year's group dropped to 38% in the number of focus discussions on technical issues. This significant decrease in technical focus must be examined to determine the answer to the following two questions: 1) Is the decrease an indication of greater friction within the teams which is surfacing through electronic mail messages; or 2) Is the decrease a result of increasing communications on the roles and responsibilities within the consortia?

The first of these two questions directly addresses the issues of team dynamics and team facilitation. Specifically, researchers have found that the impersonal nature of electronic communications reduces the inhibitions of team members when it comes to sending messages of a personal and often combative nature [Guzdial et al. 1995]. If this trend is carried forward into the AEC realm, then the introduction of electronic communications could rapidly disintegrate into a tool for the interdisciplinary teams to initiate in-fighting and drawn out disagreements. This result would be in direct contrast to the intended purpose of the tool. The second of the two questions relates directly to the type of communications occurring during the project solution phase and sets the stage for the next phase of data analysis.

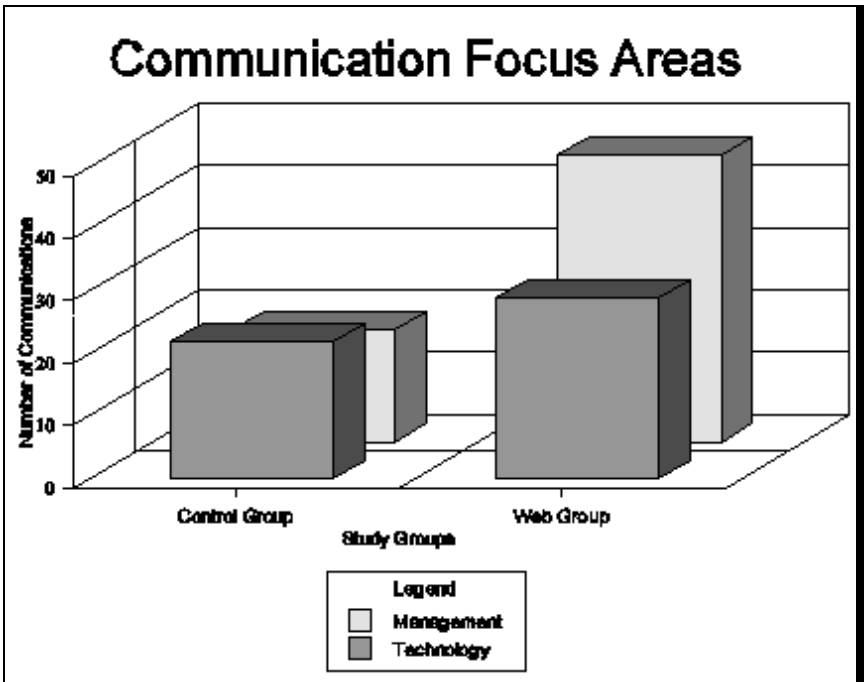


Figure 3: Communication focus areas provide insight into a teams ability to organize and the focus on a problem solution.

4.3 Timeline Focus

The final area of focus is a timeline analysis resulting from the management and technical discussions. In an optimum situation, teams should rapidly decide on a management organization and then focus the majority of their efforts on solving technical issues [Bounds et al. 1994]. However, the personalities and individual goals evident within every interdisciplinary team cannot be overlooked [Katzenbach and Smith 1993]. These external issues constantly create friction within project teams [Krackhardt and Hanson 1993]. The research team established an hypothesis that the introduction of the Web communications center should reduce the time required to focus on management issues since the friction associated with face-to-face organization meetings would be reduced. Given this hypothesis, the research team expected the management-technical curves to emerge as a pair of inverse curves. Specifically, the management curve should start at a high level and then drop off as the focus switches to technical issues, while the technical curve displays inverse traits of starting low and moving up later in the project.

As [Figure 4] illustrates, the actual results from the study only partially validated the hypothesis. When faced with a traditional face-to-face only coordination scenario, last year's consortium displayed the expected

communication characteristics. Management communications dominated early, and then dropped as the team focused on developing a technical solution. Conversely, the Web-based consortium diverged completely from the expected hypothesis. In the Web group, the management discussions continued throughout the project while the technical discussions dropped off well before the management discussions ended. The reason for this discrepancy is unknown at this time. Follow-

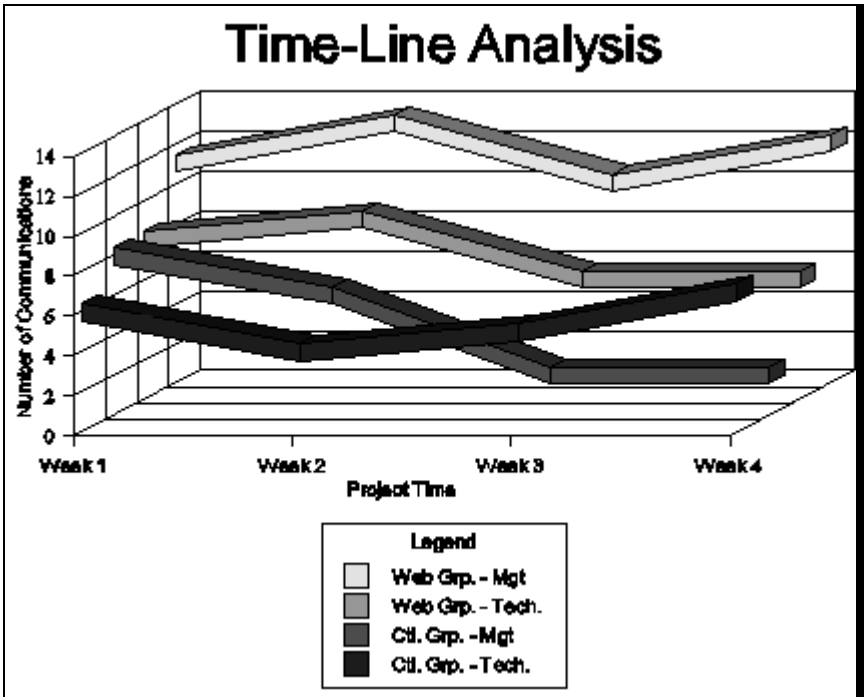


Figure 4: A time line analysis illustrates the focus on technical vs. management issues throughout the solution process.

up discussions with the project participants indicated several potential reasons including one notable focal point: the ease of conversation through the Web enabled the team to continue management discussions whereas these discussions would have ceased in a strictly face-to-face scenario. The noted discrepancy represents a divergence from the initial project expectations and sets the stage for critical follow-up study.

5 Analysis

The introduction of new communication and coordination technologies into the project management domain is creating unique capabilities for interdisciplinary

teams to approach given problems. However, the introduction of the tools does not eliminate the need to effectively communicate and coordinate throughout the project. The initial results obtained from the current study indicate that the introduction of electronic communications does enhance the number of communications that take place within a project. However, the results also indicate that the issue of management coordination does not subside with the introduction of the Web capability. Rather, the Web provides the teams with the ability to continue management discussions throughout the project without having to meet on a face-to-face basis. The issue thus arises as to whether or not the introduction of virtual communications exacerbated friction within the team and/or reduced the effectiveness of the team's efforts.

The questions regarding the effectiveness of the Web as a communication and coordination tool represent the greatest hurdle facing technology developers advocating the use of the tool as an interdisciplinary team facilitator. The slightest hint of questionable value of a new tool is detrimental to the introduction of the tool into the classically conservative AEC industry. Thus, it is important for Web developers to acknowledge several potential barriers to the introduction of the tool into the mainstream AEC industry including; perceptions of efficiency, knowledge of users, and receptiveness of non-technical stakeholders.

5.1 Perceptions of Efficiency

The first of these issues, perceptions of efficiency, focuses on the image of the Web within the general population. In contrast to computer-aided design and drafting systems which were introduced specifically as industry-based productivity tools, the Web has rapidly mutated from a researchers tool to a research/entertainment/education/business tool for every sector of the population. This approach of being everything to everybody could rapidly create a perception within business that the Web is over-hyped and could never live up to the public claims. Hesitant partners in small firms could view the Web as a negative impact on efficiency rather than an innovative method for establishing project communications and coordination. In this situation, companies which previously had hesitations about integrating technology into their firms receive additional reinforcement for their hesitant viewpoints.

5.2 Knowledge of Users

The second potential barrier facing the introduction of the Web is the diverse technical knowledge levels evident in the AEC industry. Whereas some firms and industry leaders may be visionary in their development and integration of new technologies, many others choose to wait until the technologies are proven by others. This diversity of knowledge splits the industry into two classes of users - informed and influenced. The informed users debate, weigh, and

intelligently make decisions on the new technologies such as the Web. The influenced users follow advice from an often confusing array of advisors, often resulting in technology paralysis where no decisions are made and status quo is retained. With this array of potential technology users, technology providers face the barrier of often wondering which population should be served as the basis for long-term technology transfer.

5.3 Non-Technology Stakeholders

The diversity of participants within any AEC project includes a range of technology knowledgeable stakeholders. The design component of the team includes stakeholders such as the architect and structural engineer. These stakeholders often are technology knowledgeable by necessity. The demands of users for computer-based drawing formats has forced these stakeholders to integrate technology into day-to-day practice. However, non-technology stakeholders still exist in many project teams. Specifically, many construction management firms view technology as a hinderance and extravagant overhead. The number of field offices equipped with the technology to utilize Web-based communication is notable small. Breaking through this barrier of technology resistance may be the most difficult faced by Web proponents.

In addition to the primary issues related to barrier reduction and efficiency, the initial results from the Web study have provided several indicators for additional investigation. Specifically, traditional methods for coordinating project players, sharing information, and managing teams need to be measured against the interactions of the virtual approach on the basis of traditional management criteria. These comparative assessments are beneficial to the continued development of the Web-based coordination techniques, providing an ability to evaluate the cooperation and collaboration among AEC project participants. These findings will clarify the extent to which information is exchanged and effectively utilized within an interdisciplinary, virtual environment.

6 Conclusion

The development and introduction of Web-based coordination and communication facilitation components represents an innovative and progressive step forward within the domain of interdisciplinary AEC projects. This sentiment is a fact which is difficult to argue with when viewed in the perspective of technology potential and technology capabilities. However, the introduction of the Web may also be viewed as an initiator of ineffective and trivial communications within projects facing increasingly smaller profit margins and increasingly tighter schedules. The viewpoint selected is highly dependent on the implementation, introduction, and use of the technology within any given interdisciplinary team. Unfortunately, the early claims made

by the Web-based industry have set lofty goals which must be reassessed and restated in terms of realistic goals for the AEC industry. With these restated goals, interdisciplinary project teams will have the opportunity to set in place the guidelines required to obtain significant benefits from the introduction of the Web. Subsequently, when combined with traditional project interactions, AEC project participants may develop innovative new strategies for collaboration, information sharing, and project coordination.

References

[Bounds et al. 1994] Bounds, G., et al.: "Beyond Total Quality Management. Toward The Emerging Paradigm"; New York: McGraw-Hill (1994)

[El Kordy 1994] El Kordy, O. M.: "The Application of Multimedia and Knowledge-Based Systems to Computer-Aided Engineering Instruction"; MS Thesis, Georgia Institute of Technology (1994) N. Baker, advisor.

[Guzdial et al. 1995] Guzdial, M., Vanegas, J., Mistree, F., Rosen, D., Allen, J., Turns, J., and D. Carlson: "Supporting Collaboration and Reflection on Problem-Solving in a Project-Based Classroom"; Proc. Second Congress on Computing in Civil Engineering (ed. J.P. Mohsen), ASCE Publishing, New York (1995), 334-343.

[Handy 1995] Handy, C.: "Trust and the Virtual Organization"; Harvard Business Review, May-June (1995). 40-50.

[Hong and Leifer 1995] Hong, J. and L. Leifer: "Using the WWW to Support Project-Team Formation"; Proc. Frontiers in Education 25th Annual Conference (ed.D. Budny and B. Herrick), IEEE Publishing (1995), 2c5.1-2c5.5.

[Katzenbach and Smith 1993] Katzenbach, J.R. and D.K. Smith: "The Wisdom of Teams; Creating the High Performance Organization"; Boston: Harvard Business School Press (1993)

[Krackhardt and Hanson 1993] Krackhardt, D. and J.R. Hanson: "Informal networks: The company behind the charts"; Harvard Business Review, July-August (1993). 104-114.

[Mintzberg 1996] Mintzberg, H.: "Ten Ideas Designed to Rile Everyone Who Cares About Management"; Harvard Business Review, July-August (1996). 61-67.