



VIRTUAL TEAMS: A GUIDE TO SUCCESSFUL IMPLEMENTATION

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A Report To
The Construction Industry Institute
The University of Texas at Austin

Under the Guidance of the
Making Virtual Teams Work Project Team
Number 170

Austin, Texas

March 2002

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Printed in the United States of America.

Executive Summary

Virtual teams are receiving increasing attention within the construction industry. As companies and projects increasingly utilize multi-national and multi-organizational partnerships, the need for greater and more efficient communication alternatives is also increasing. However, little guidance currently exists to assist an organization in the successful implementation and management of these teams. In an effort to fill this information gap, Project Team 170 was formed in April 2000 to study the topic of Making Virtual Teams Work. The scope of this effort included the examination of current research on the topic, a study of current virtual team practices within the industry, the study of cases outside the EPC industry, and the development of recommendations for successfully implementing virtual teams in the EPC industry.

The immediate issue that organizations discover when approaching the topic of virtual teams is defining what virtual teaming actually encompasses. Therefore, to assist CII members in pursuing this topic, PT 170 developed the following virtual team definition:

A virtual team is a group of people with complementary competencies executing simultaneous, collaborative work processes through electronic media without regard to geographic location.

The important concept is that virtual teams allow individuals or groups to collaborate on a project in real-time through electronic media. In this manner, the virtual team operates as an integrated team whose members may happen to be located in different parts of the country or world. The potential advantages of this type of collaboration are numerous including:

- Efficiency of project execution,
- Removal of physical boundaries,
- The integration and optimization of competencies, and
- The ability to form new partnerships.

The promise of these advantages has resulted in the majority of CII members believing that virtual teams will be a primary mode of project execution within five years. Concurrently, PT 170 also discovered that the construction industry in general and CII companies specifically, have not studied the full spectrum of issues associated with implementing virtual teams. Given that virtual teaming has not become a principal mode of communication within the construction industry, PT 170 set its focus on providing a set of guidelines and recommendations for virtual team implementation. The conclusions from this research can be summarized in the following statement:

**Technology is not the barrier to successfully implementing virtual teams –
Although technology can lead to virtual teaming failures, sufficient
technology is available to successfully implement virtual teams. Rather,
revising traditional management practices is the key to successfully initiating
and implementing virtual teams.**

Although the management and technology issues presented in this research are not exhaustive in their coverage of the impact that virtual teams may have on an individual organization, they are designed to provide a foundation for individuals and organizations to begin examining their own readiness for successfully implementing virtual teams. Based on this research effort, the organizations that successfully address these issues will similarly achieve virtual team success.

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1.0 Introduction

The time has come in your organization to implement a virtual team. A project requires multiple individuals and groups to collaborate on a single solution. However, the groups are distributed throughout your operating regions. The solution appears to be an electronic collaboration solution – a virtual team.

The introduction of new communication technologies such as the Internet and high-speed communications are creating unique opportunities and demands by project constituencies for EPC project teams to develop new coordination and communication strategies. Of particular interest is the capability of teams to interact remotely through a virtual team environment. Initial research has demonstrated that the time required to perform project management functions such as project planning and control, design coordination, and procurement can be significantly reduced if project teams can increase communication and reduce time, space, and physical barriers. Within a virtual team environment, these issues can be addressed for as little as \$100 per person as project teams leverage communication advances to increase collaboration and communication between all project constituents. However, to prepare for the next generation of project collaboration technologies and avoid unnecessary technology expenditures in the hundreds of thousands of dollars, EPC organizations must focus on the successful initiation of virtual team environments and the development of efficient methods for modifying existing *organizational, technical, and social* structures.

With virtual team technologies becoming both financially and technologically viable for every size office or project, the time when virtual teaming will become a part of standard operations

has almost arrived. However, as demonstrated in research efforts by the PI and others, the difference between successful and unsuccessful virtual teams can be the result of a few, but costly, mistakes and assumptions by the participating organizations. For example, assuming that the infusion of the technology alone will make virtual teams work is a fallacy. In reality, the introduction of virtual team technologies without the proper training and organization modifications can actually reduce the effectiveness of the virtual teams, thus turning a competitive advantage into a competitive liability. Understanding these underlying needs of virtual teams is a fundamental requirement for the future of EPC project teams. Although many EPC organizations are investigating the use of virtual teaming technologies, very little independent analysis and guidance has been developed on virtual team initiation, operation, and collaboration.

In an effort to fill this information gap, Project Team 170 was formed in April 2000 to study the topic of Making Virtual Teams Work. The scope of this effort included the examination of current research on the topic, a study of current virtual team practices within the industry, the study of cases outside the EPC industry, and the development of recommendations for successfully implementing virtual teams in the EPC industry. The intent of this research was to provide a set of guidelines, assessments, and best practices to assist organizations in the initiation of this emerging form of collaboration while concurrently highlighting the potential drawbacks of initiating virtual teams without appropriate organization modifications.

The primary benefit of this research is to provide CII member companies with a guidance document that provides a methodology and tool for initiating and coordinating virtual teams to

improve project communication and reduce costs borne from distributed project participants. A second primary benefit is the set of guidelines and lessons learned from which to evaluate the effectiveness, benefits, and return from an investment in virtual team technology.

It is anticipated that owners, engineers, and contractors will benefit from this research. The development of virtual team guidelines will enhance communication and collaboration on both small and large-scale projects while reducing the likelihood that organizations will invest needlessly in specialized technologies that cost tens or hundreds of thousands of dollars. The use of the virtual team concept is not dependent on a particular sector, project, or organization size. Any organization interested in initiating virtual teams as part of the project management process will benefit from the results contained in this research document.

1.1 Purpose, Scope, and Objectives

The purpose of this research is to develop a methodology for initiating, implementing, and coordinating virtual teams to support project management functions and project collaboration. Additionally, this research seeks to provide EPC organizations with a set of lessons-learned from initial efforts in the development and use of virtual teams in the EPC environment including cost, productivity, and management effectiveness.

The scope of this research includes the study of current virtual team techniques and technologies fielded by CII member companies as well as commercial tools being offered by software vendors. The selection of CII organizations is divided into a sample of owners and EPC organizations to obtain perspectives from both types of organizations. The research team is

comprised of individuals from both groups to facilitate the research process. Within this participatory environment, the research effort focuses on virtual teams that encompass construction-specific, engineering-specific, and life-cycle collaboration to determine the unique requirements of each teaming arrangement. A detailed study of CII “Best Practices” from field, office, and organizational perspectives was conducted to convey benefits of implementation and organizational hurdles that must be overcome. Based on this input, the research evaluates and enumerates the issues associated with the new generation of virtual team collaboration environments.

The research objectives established for the Virtual Team project team focus on producing results that can be applied in any EPC or owner organization. Specifically, the following are a summary of the objectives established for this effort.

- **Identify the major characteristics of a virtual team** – The definition and clarification of the virtual team concept and its relationship to current information technologies and management practices.
- **Determine the initiation and coordination issues associated with virtual teams** – The management and technology issues associated with virtual and distributed teams.
- **Evaluate the current state of hardware/software to successfully support a virtual team** – Does the virtual team concept work with available technology resources?
- **Evaluate current Best Practices from early attempts to implement virtual team collaboration in both field and research environments** – What is currently being done, or has been done, in the field of virtual teaming?

- **Capture the organizational issues that may prevent a transition from traditional project collaboration methods to virtual team collaboration** – How does an organization transition from virtual team initiation to virtual team success?
- **Develop a single Resource Guide for project managers that contains both a Best Practices component and an implementation guide for the initiation of virtual teams.**

This document represents a complete report of the research findings resulting from the PT170 effort. As documented in this report, the previous objectives were achieved to varying degrees based on findings during the course of the project. A summary of the degree to which these objectives were met and documented in this report is as follows:

- 1) **Identify the major characteristics of a virtual team** – The definition and characteristics of the virtual teaming concept were fulfilled and are documented in Chapter 3.
- 2) **Determine the initiation and coordination issues associated with virtual teams** – The virtual team issues were established for both management and technology concerns. These concerns are separately documented in Chapters 4 and 5.
- 3) **Evaluate the current state of hardware/software to successfully support a virtual team** – This information is summarized with common system characteristics in Chapter 5.
- 4) **Evaluate current Best Practices from early attempts to implement virtual team collaboration in both field and research environments** – This objective was modified early in the research effort due to a lack of current virtual teaming practices in the EPC

industry. Therefore, rather than focusing exclusively on the EPC industry, this overview was extended to include other organizations including Boeing and NASA.

- 5) **Capture the organizational issues that may prevent a transition from traditional project collaboration methods to virtual team collaboration** – Discussed previously in point 2.
- 6) **Develop a single Resource Guide for project managers that contains both a Best Practices component and an implementation guide for the initiation of virtual teams** – This focus was changed to the development of a short “How-To” guide and a more traditional research report. The previous was published in Spring 2002 and the latter is the current document.

1.2 Research Approach

The research approach adopted for this project is a continuation of the CII focus on technology and information as a key component of project development. Active CII teams are exploring the use of technology in 3D modeling, simulation, and RF tagging. Previous CII research teams have addressed components of this topic including RT 132, which initially identified the World Wide Web as an emerging technology in construction communication as part of their focus on Information and Communication technologies for the Construction Industry. Similarly, RT 105 provided CII member companies with the Communications Project Assessment Tool (COMPASS) that evaluated the communications occurring within a project. From this background, the current research extends the CII focus on technology and construction by examining the hypothesis, *“Construction organizations can increase project coordination*

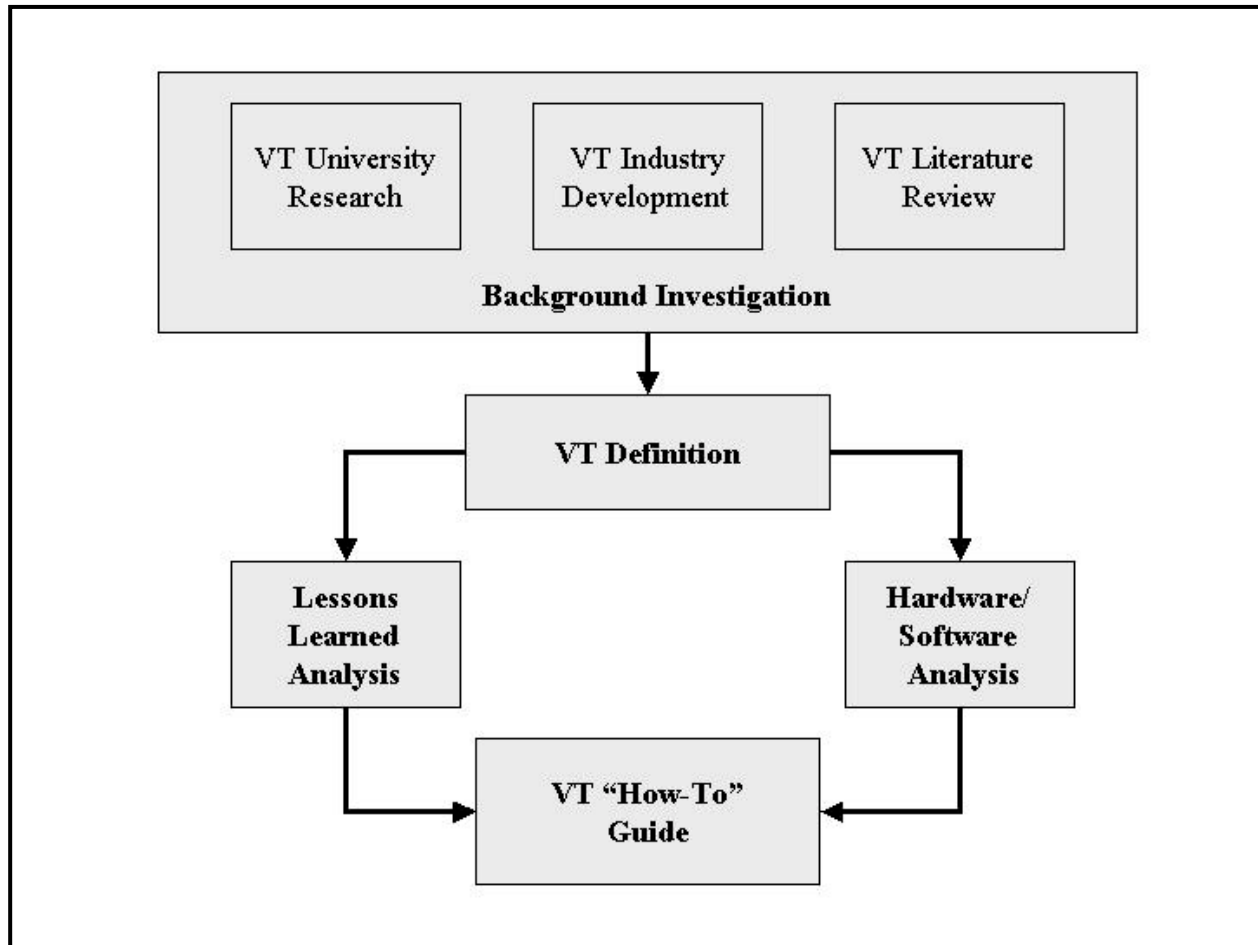


Figure 1.1: Overview of research process adopted by PT 170 to investigate virtual teaming and develop “How-To” guide for EPC organizations.

effectiveness and reduce costs based on miscommunication by initiating virtual team environments.”

To validate this research hypothesis, the research approach outlined below and illustrated in Figure 1.1 was adopted. A complete description of this approach is provided in the following chapter.

- Background investigation into past CII research efforts was conducted as well as a focus on complementary research efforts being conducted by universities including Stanford, Georgia Tech, and Carnegie-Mellon.
- A definitional effort to fully define virtual teaming within the context of the EPC industry specifically and distributed collaboration in general.
- At the completion of the definitional effort, the research team focused on two concurrent research efforts. In the first effort, the research team conducted a lessons learned analysis of CII member organizations to collate both positive and negative virtual team experiences.
- In parallel to the Best Practices analysis, the research team initiated a hardware/software analysis. In this effort, the research team contacted vendors to collect the latest data on software/hardware components for virtual team environments.
- At the completion of the previous analysis efforts, the research team concluded its efforts with the development of the How To component of the resource guide. In this effort, the team combined the technical, organizational, and social findings from the research into a single guide that addresses the perspectives of each member of the virtual team arrangement.

1.3 Guide Reference

As highlighted by the above issues, the successful implementation and performance of a virtual team is not a guarantee. Rather, this form of project execution requires consideration of both management and technology issues as well as an examination of current operating procedures.

In recognition of the numerous topics encompassed within this broad outline of issues, this guide summarizes one path to virtual team success. Designed to assist an organization in navigating these issues, the guide represents a summary of the findings produced by CII Project Team 170.

In the subsequent pages, the following chapters are presented:

- Chapter 2 – Research Methodology– An overview of the process used to conduct the PT170 research effort.
- Chapter 3 - Context and Literature Review – A definition of virtual teaming and an introduction to the opportunities, risks, barriers, and benefits surrounding the virtual team concept. Additionally, a summary of the research findings from previous virtual team research is included.
- Chapter 4 - Management Issues – The key management considerations required for the successful implementation and management of a virtual team environment.
- Chapter 5 - Technical Issues – A summary of the technical concerns that can enhance or defeat the implementation of a virtual team.
- Chapter 6 - Current State of the Industry – Brief overviews of the use of virtual teaming at The Boeing Company and NASA and what lessons can be extracted for the EPC industry. This section also includes key data gathered from the virtual team survey conducted by PT 170.
- Chapter 7 - Key Items for Success – The checklist for enhancing the opportunity to achieve virtual team success.
- Chapter 8 - Conclusions

The combination of these chapters provides an organization with a detailed foundation for pursuing a virtual team solution to current or future problem solving requirements. However, the chapters should not be interpreted as independent requirements. The issues identified in this report can each lead to a breakdown of the virtual team environment. Therefore, an organization must anticipate investing in all aspects of the virtual team solution to place the organization in the best position for virtual team success.

2.0 Research Methodology

2.1 Point Of Departure

The point of departure for the virtual teaming research focuses on bringing the implementation and successful management of virtual teams into the context of the EPC industry and broadening the context of virtual teams from the domain of project factors to the overall concerns of an EPC enterprise. This research effort examines the adoption of a focus on virtual teams as a combination of technical and managerial challenges that must be addressed to implement successful virtual teams.

As will be illustrated in Chapter 3, virtual team research has crossed from a pure technical pursuit to a complete organization effort encompassing management and technical personnel as well as the project participants. Furthermore, this focus is continually reinforced in a number of industries that are adopting the virtual team concept, from manufacturing to design (Chapter 3). Following the research methodology employed in these previous virtual team applications, the current research effort employs fundamental approaches that enable previous virtual team results to be transferred to the EPC industry.

2.2 Research Strategy/Methodology, Method, And Plan

The research strategy/methodology is the overall idea that sets in place a broad path for the research effort. Research strategy defines which qualitative and/or quantitative scientific-based research process is utilized to obtain the project objectives (Rogers and Nicolaas 1988, Playa 2000).

The specific research strategy and methodology utilized for this effort is a combination of qualitative and quantitative scientific approaches in applied research. The strategy for combining the two methodologies is to capture the inherent advantages of both types of research. Social researchers from both research types, qualitative and quantitative perspectives, have stressed the need to incorporate aspects of both approaches (Rogers and Nicholas 1988). The virtual team research effort combines the quantitative aspects of survey-based research with the qualitative aspect of interviewing industry experts from organizations who have previously implemented virtual teaming technologies. The combination of these methodologies allows for both perspectives to be incorporated into the outcome.

Following the development of the research strategy, the research method provides the general approach to the problem including the means in which data is collected for the research. This portion of the research effort outlines whether surveys, interviews, scientific experiments or other approaches will be utilized to obtain data. (Rogers and Nicolaas 1988, Playa 2000)

The research method in this effort is a combination of interviews and survey. This combination is required due to the relatively new evolution of virtual team technology within the EPC industry

specifically and the engineering industry in general. This characteristic limits each of the tools individually. Specifically, surveys alone would not probe deep enough into the initial experiences of the organizations attempting to implement virtual teams. Similarly, interviews alone would not provide a broad enough perspective on the industry to determine the current state of virtual team implementation. Therefore, a combination of the tools was required to gather a complete perspective of the state of virtual teaming within the EPC industry and the barriers to expanding this use during the next five years.

An additional factor influencing the research method was the desire to obtain a representative industry sampling. If a qualitative analysis was the research goal, a case study of one organization could be executed. However, the problem definition was to provide a foundation for successfully implementing virtual teams throughout the EPC industry. Therefore, the research team was required to obtain a broader perspective of the issues associated with the technology and the current state of virtual team usage within industry organizations.

Finally, to support the research method, a research plan is required to provide a step-by-step process outlining the tasks required to reach the goal of solving a given problem. It is a systematic arrangement of parts needed to reach the answer to the defined research question. The research plan is the “how to” of establishing new knowledge. (Rogers and Nicolaas 1988, Playa 2000). The research plan for the virtual team effort is based upon the scientific method and direction outlined in two sources, *A Guidance to Successful Dissertation Study for Students of the Built Environment* (Holt) and *Designing and Conducting Survey Research* by Louis Rea and

Richard A. Parker. The input from these two sources provided the key areas for this research effort as follows:

2.2.1 Problem Domain Definition

In order to clearly define the research problem, the following steps were taken 1) identify and define the problem, 2) develop a working definition, 3) establish research context, and 4) conduct a literature review.

Identify the Research Problem. The identification of the research problem was previously discussed in the above sections of this chapter as well as an overview in Chapter 1.

Develop a Working Definition. During this phase, a definition of virtual teaming was developed to provide a foundation on which all subsequent research could be based. As will be discussed further in Chapter 3, the context of this definition emphasizes the need for collaboration and interaction in electronic environments rather than the traditional message exchange technologies adopted for decades within the industry.

Establish Research Context. The relatively new state of virtual teaming in the EPC environment required a research context including opportunities, barriers, and benefits to be established specifically for virtual team implementation. This context is presented fully in Chapter 3 with the results of the virtual teaming literature review.

Conduct Literature Review. Finally, an extensive literature review was conducted including a review of current and significant professional publications on the above-noted topics. Chapter 3 outlines the literature review from both technology and management sources both within and outside the EPC domain.

2.2.2 Problem Solution

Once the definition and context for virtual teams was established, PT170 was able to focus on capturing the managerial and technological issues associated with successfully implementing the technology with and engineering or construction organization. To accomplish this task, three primary efforts were undertaken by the team.

Development of Virtual Team Issues. The literature review sources found in the previous stage provided the foundation for the development of the virtual team issues. However, to finalize and validate the issues, a series of project team meetings were held to discuss the issues based on personal experience and interactions with other industry organizations. The result of these meetings and discussions are the issues presented in Chapters 4 and 5.

Conduct Field Studies to Validate Proposed Issues. Validating the list of proposed virtual teaming issues required Project Team 170 to investigate the experiences of organizations that have previously undertaken virtual team experiments or implementations. This investigation incorporated two components, an analysis of organizations represented on the project team and field studies of two organizations, NASA and Boeing that were outside the confines of the project team. In terms of the former, interviews with team members and organization personnel provided feedback on the issues identified by the team and reinforced the managerial side of the problem as often overlooked by organizations initially investigating the use of virtual teams.

In terms of the latter, the field studies provided invaluable insights and data on the manner in which virtual teams had been developed outside the EPC industry. The results of these studies are summarized in Chapter 5 together with the data obtained through the survey instrument.

Survey Development. The preparation of the survey for the virtual team investigation was guided by *Designing and Conducting Survey Research* by Louis Rea and Richard A. Parker. This established guide enabled the research team to develop a survey tool that met the needs of the project and the need to retain scientific accuracy in the survey process. The questions were a direct result of the early investigations and represent a cross-section of technology, management, and general organization inquiries. The complete survey is presented in Appendix A.

Mail Survey to CII Organizations. The CII membership was selected as the study group for this research effort because of the cross-section of owners and EPC organizations that are found within the group. Individuals that were reselected by their organizations as data contacts were used as contact points for the surveys. To assist the respondents in replying to the survey, an electronic form of the survey was developed and deployed on the World Wide Web. The address of this site was then sent to the CII contacts through electronic mail with a request for participation and a description of the research effort. The respondents were given two-weeks to respond to the effort at which time a follow-up request was submitted by electronic mail.

2.2.3 Analysis and Dissemination

The final component of the PT170 research effort was the analysis of the survey, field, and team data and the compilation of the data into a single reference and resource list of principal findings

and issues. This compilation effort was followed by a dissemination effort, of which this report is the last stage.

Receive and Analyze Research Results. A synthesis and analysis of the survey and field data was conducted from which conclusions could be formulated. The survey results are presented in Chapter 6.

Develop Checklist for Successful Implementation. Following the analysis of data, a checklist for implementation success was developed to allow any individual reading the documents to have a guideline that provided a foundation for virtual team success. The full version of this checklist is presented in Chapter 7.

Disseminate Research. The research from this effort is disseminated to the CII, professional, and academic communities in several avenues. First, a presentation of the research results was provided to the attendees at the 2001 CII annual conference. Second, a resource book and this research document were made available to the profession through CII. Finally, journal and conference papers have been developed to expose a broader audience to the issues associated with the implementation of successful virtual teams.

2.3 Chapter Summary

Because of the intensive focus on immediate needs of a project, long-term analysis of virtual team issues are often overlooked during the implementation phase. In response to this issue, the PT170 research effort put in place a research methodology to identify the key managerial and technological issues associated with implementing virtual team technology. Research objectives, strategies, plan, and methodologies were formed in order to successfully achieve this goal. With

a combination of qualitative interviews and quantitative survey instruments, a strategy for reaching a problem resolution was developed. With research strategies guiding the effort, a methodology or process was formulated and followed as outlined in the following chapters.

3.0 Context and Literature Review

The decision to introduce virtual teaming into the EPC organization appears on the surface to be insignificant. The technology appears ready and the team has previously demonstrated an above average ability to coordinate and produce solutions within the given constraints. However, these surface characteristics are only the beginning of a larger set of considerations that must be made prior to implementing a virtual team environment. Specifically, the decision to incorporate virtual teams should not be made without an understanding of the potential impact, opportunities, risks, and barriers that are associated with this form of operation. Additionally, an understanding of virtual team issues as defined by previous attempts at implementation is beneficial as it provides insights into the potential hazards that an organization may encounter during the implementation and execution process. The following sections highlight these issues with a focus on the EPC user.

3.1 Context

The decision to introduce virtual teaming into the EPC organization may appear on the surface to be insignificant. The technology appears ready and a potential team has demonstrated an above average ability to coordinate and produce solutions within the given constraints. However, these surface characteristics are only the beginning of a larger set of considerations that must be made prior to implementing a virtual team environment. Specifically, the decision to incorporate virtual teams should not be made without an understanding of the specific definition of a virtual

Table 3.1: Spectrum of electronic interaction technologies as divided into three primary collaboration categories for this research.

Spectrum Category	Interaction Technology	Description
Communication		
	Phone/Teleconferencing	Traditional analog, oral communication
	Fax	Digital or analog text communication
	E-mail	Digital text communication
Cooperation		
	Project Web Sites	Digital repository for project data and communications
	Discussion Board	Electronic message center for archiving text communication
	Work Sharing	Asynchronous data exchange and project solution process
Collaboration		
	Videoconferencing with data sharing	Synchronous discussion with ability to exchange project information
	Virtual Teaming	Real-time data manipulation and exchange.

team, an understanding of previous results from the technology, and the potential impact of successfully implementing virtual teams.

3.1.1 Definition

As illustrated in Table 3.1, virtual teams represent one end of an electronic interaction spectrum.

As defined by PT 170 to assist in the development of the virtual team research, interaction technologies can be grouped in three categories as follows:

Communication Technologies

The first level of interaction technologies is the group comprising communication technologies.

These technologies, while still central to the function of team interaction today, are based on an

ages-old concept of providing another individual with a message that communicates a thought regarding the current issue under discussion. These messages can be asynchronous such as in the case of e-mail and fax technologies, or synchronous as in the case of telephone conversations or teleconferencing (Figure 3.1). In either case, the underlying similarity between the technologies is the sole focus on message communication. No data outside of that contained in the message itself is transmitted and no manipulation of the project solution is accomplished directly. Rather, the message transfers a thought or action concerning the project solution, thus requiring the recipient of the message to implement the change or suggestion to the actual project documents. The limit of these technologies is thus defined by their focus on communicating thoughts rather than manipulating project data.

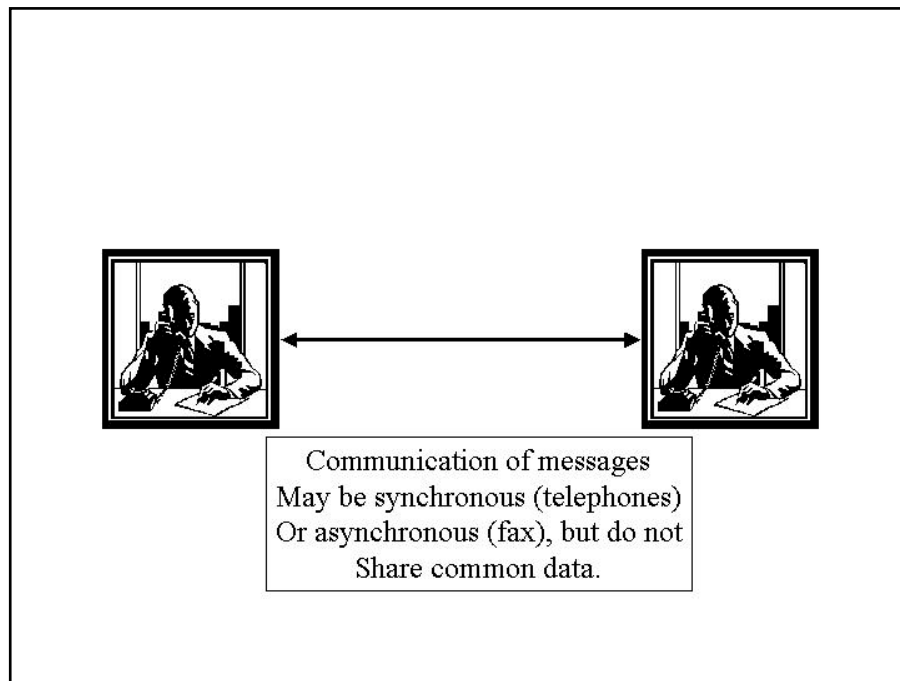


Figure 3.1: Communication technologies permit individuals to transmit thoughts either synchronously or asynchronously, but do not permit sharing of data.

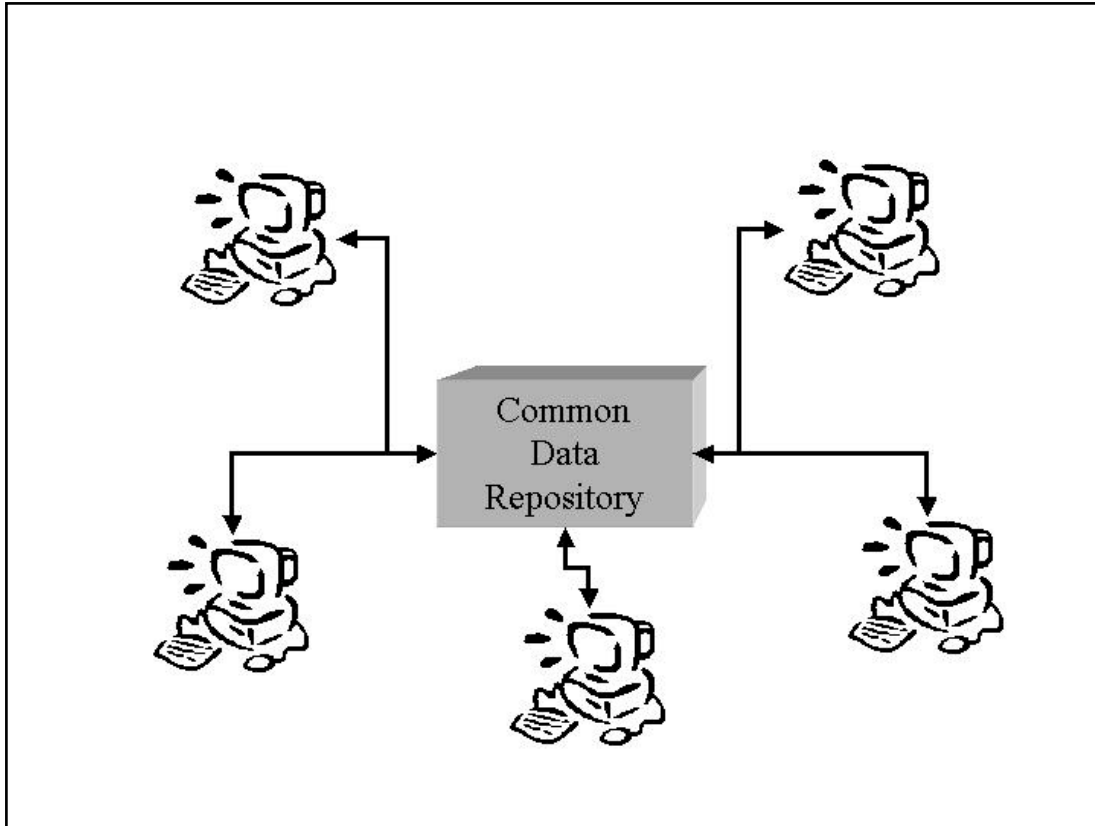


Figure 3.2: Cooperation technologies permit individuals to access a shared data repository, but do not allow manipulation of data in a real-time mode of operation.

Cooperation Technologies

The second level of interaction technologies is the group comprising cooperation technologies (Figure 3.2). These technologies are an electronic advance over the previous category and represent introductions to the construction and engineering industry over the last decade as computing technologies have similarly increased in power and presence. The central focus of these technologies is the ability for a group of individuals to asynchronously interact and manipulate project data. In this category, individuals may access a central project Web site to exchange project documents, exchange information on specific project components through central databases (work sharing), or develop an ongoing discussion of specific project concerns

that incorporates project document revisions (discussion boards). In either of these cases, project participants are accessing original project data, but do not have the ability to manipulate the data in a shared, real-time experience. The manipulation of the data is restricted to asynchronous access, manipulation, and posting.

Collaboration Technologies

The final level of interaction technologies is the group comprising collaboration technologies. It is in this group that virtual teaming is located at the end of the interaction spectrum. In contrast to the preceding cooperation technologies, collaboration technologies are characterized by their capability to permit synchronous, real-time manipulation of common project data. Specifically, the teams that incorporate an electronic collaboration focus have the ability to synchronously access and manipulate project data from a central location. In the optimum scenario, project participants have the capability to visually and orally communicate in addition to the shared data exchange and manipulation capability. In this sense, project participants are recreating an electronic meeting space that allows participants to experience the complete range of human interaction that occurs during a project interaction with the exception of the physical interaction.

The definition of these three categories provides the foundation for the virtual team research effort. The current focus is restricted to analyzing the potential impact, barriers, and requirements for technologies in the final interaction category. The results from this research effort have been developed to successfully introduce this technology into project teams. The recommendations are not intended to enhance or modify interactions that routinely encompass the communication and cooperation technologies. Based on this foundation, the research team

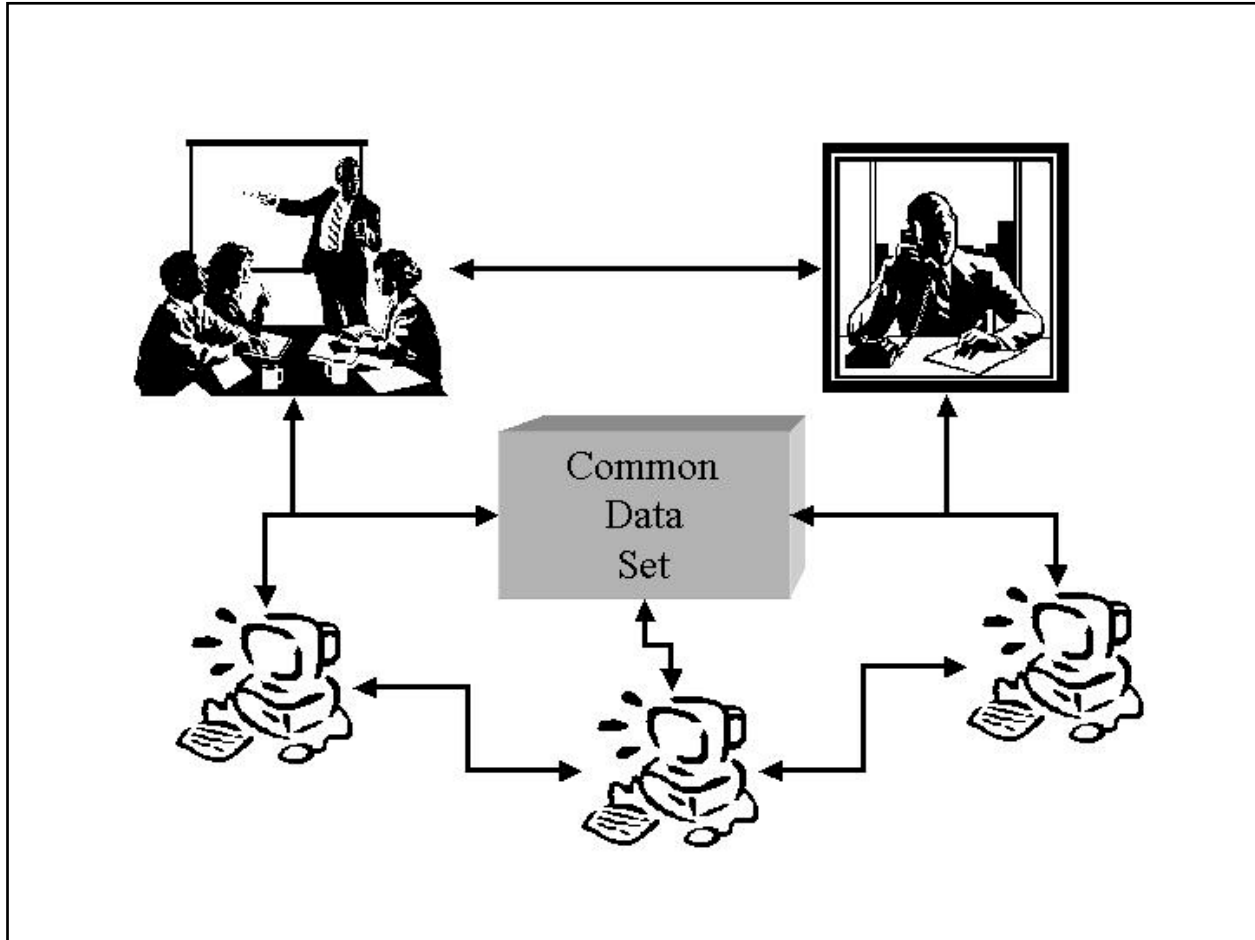


Figure 3.3: Virtual teams work on a common data set and interact electronically with any member of the team at any time regardless of geographic location.

consolidated and synthesized the fundamental aspects of virtual teams into the following, specific definition for use by potential implementing organizations (Figure 3.3):

A virtual team is a group of people with complementary competencies executing simultaneous, collaborative work processes through electronic media without regard to geographic location.

The important concept in this definition is that virtual teams do not refer to traditional work sharing, electronic communications, or other forms of dividing projects that require individuals or groups to work independently. Rather, **virtual teams allow individuals or groups to**

collaborate on a project in real-time through electronic media. In this manner, the virtual team operates as an integrated team whose members may happen to be located in different parts of the country or world.

As stated previously, the virtual team definition developed in this research effort represents a synthesis of current research and previous findings. Prior to moving to the specific opportunities and barriers related to the EPC industry, the following section introduces the previous work in virtual teaming as an additional foundation element in the development of virtual team implementation strategies.

3.2 Background

3.2.1 Early Work

The introduction of virtual teaming as an interaction technology and workspace innovator has been addressed by management and computer science researchers for over a decade. Early work on the management impact of virtual teams discussed the impact on trust, organization form, and organization process (Davidow and Malone 1992; Gersick 1988; Miles and Snow 1986). These studies highlighted the distinct differences between virtual teams and traditional co-located project teams. Of particular interest to these authors was the need to alter traditional management styles to accommodate off-site project members (O'Hara-Devereaux and Johansen 1994). These researchers quickly identified that communication between distributed teams was characterized by distinctively different patterns than that demonstrated in traditional teams. Issues such as trust, social interaction, and group performance moved to the forefront of concern as organizations

struggled to adapt to the introduction of virtual teams as integral components of organization process (Straus and McGrath 1994).

Of particular interest in this early work is the identification of two issues that were to become a continuous concern for organizations implementing virtual team technology. The first of these issues focused on the networking technology available to virtual teams. Although internal networks had become a standard feature of office computing, the ability to communicate over wide-area networks (WANs) was still in its infancy. The ability to send e-mail had been around for several decades. However, the ability to transfer data real-time and manipulate common data repositories was relegated to research labs or organizations with very expensive dedicated networks between offices. Therefore, the ability to work in a virtual environment faced a primary barrier in the ability to connect all of the individuals in the team.

A first step in addressing this technical issue was the restriction of virtual teaming to internal organization teams. This restriction reduced the difficulty of communicating with outside organizations, but did not eliminate the technical difficulties of where data should be stored, how to communicate on a real-time basis, or how to ensure that applications would translate and communicate data correctly. These issues were intensified by the PC culture that was permeating the business environment in the 1980s. In this culture, data was personalized and decentralized to focus on individual ownership and storage of documents (Laiserin 2000). Although the benefits of the PC have been identified numerous times and are evident in the majority of organizations, these benefits

did not transcend to virtual teaming. It was not until the introduction and expansion of Lotus Notes in the early 1990s that the concepts of collaboration and coordination were successfully integrated into the PC world of the business environment. It was this introduction that provided the early concepts of groupware and the capability for the initial technical forays into virtual teaming.

Parallel to this early technological development of virtual teams, the issues of managing virtual teams became apparent. Specifically, the traditional concepts of hierarchical organizations and information flow were found to be insufficient and obsolete in the world of virtual teams. Teams were no longer restricted to obtaining information from team leaders or having information filtered by other individuals. Rather, networks provided the opportunity to communicate directly with any other individual in an unfiltered and open communication channel (Lipnack and Stamps 2000). This hyperarchical form of communication challenged conventional management practices and theories.

Of particular concern in this changing information environment was the challenge of retaining control over the amount and content of information being distributed on a given project. For some organizations, these concerns were security based where management did not want corporate secrets to be made available to outside individuals or organizations. For other organizations, these concerns focused on the challenge to long-established information management practices. Finally, for others, these concerns focused on the question of how to control the amount of excess information flow through

the team. However, in every case, the common thread was concern over the rapid change in management practices and styles that must be implemented in the virtual team environment. Although some of these questions were addressed early in this introductory phase, the majority of these issues remained unanswered throughout the early stages of virtual team implementation.

3.2.2 Virtual Team Evolution

The progression of virtual team research provides a foundation for the development of introduction guidelines into the construction and engineering industries. As recognized in continued virtual team research, the issues of communication exchange and interpretation require significant analysis prior to the final introduction of a technical interaction solution (Walther and Burgoon 1992). The development of guidelines and warnings for organizations attempting to implement virtual teams is a common thread in virtual team research over the last decade (Pape 1996; Wardell 1998; Maruca 1998; Wenger and Snyder 2000). In each case, the research demonstrates that managerial issues require equal attention to the technical implementation questions addressed by the organization.

However, the technical component of virtual team implementation was not overlooked by researchers developing a foundation for this new form of organization interaction. Rather, issues such as interface interaction, security, and transfer rates proved to be stumbling blocks requiring attention before this technology could achieve its intended

impact (Romano et al. 1998; Igbaria et al 1999; Yager 1999). As such, the second phase of virtual team research focused intensively on solving technical issues associated with virtual team implementation.

The search for technical solutions to virtual teaming was assisted significantly by the widespread introduction of Internet technologies. Specifically, the introduction of the Internet and the World Wide Web as accessible organization technologies began to remove the internal organization restrictions witnessed in early virtual team development. As documented in Chapter 5, commercial applications began to emerge to assist organizations in general and EPC organizations specifically in the development and execution of virtual project teams. However, the technical solutions offered during this formative period were primarily asynchronous in nature. The solutions emphasized the development of resolutions such as project Web sites to serve as central information transfer portals. These portals thus supported cross-organization communication, but did not emphasize real-time collaboration as a key component in their technical capabilities.

Although videoconferencing technologies became prevalent during this period of time, the practical affordability of these solutions to small and medium organizations served as a barrier to cross-organization virtual teaming. Thus, although this technology was an advance, it did not provide the foundation required for widespread virtual team implementation. Similarly, data transfer specifications began to proliferate during this period to allow both graphic and non-graphic information to be transferred among organizations. However, the accuracy of these translations often did not live up to the

requirements of a practical working environment. Thus, once again, a technology was introduced that demonstrated promise, but failed to provide the foundational element required for virtual team implementation.

It is difficult to pinpoint an exact impetus during this period for the development of virtual teams, but several items are noteworthy as background elements. First, the widespread acceptance of World Wide Web technologies including Netscape Communicator and Microsoft Internet Explorer transformed the Internet from a novelty to a valid business resource. Second, the introduction of technologies such as Microsoft NetMeeting provided small and medium size organizations with the opportunity to participate in virtual team communications. Finally, the expansion of the networking infrastructure from private and public organizations enhanced the bandwidth that was available for virtual team communications. Although these changes individually did not provide for the expansion of virtual team implementation, the combination of these advances provided the basis for practical implementations of virtual team activities in the late 1990s.

3.2.3 The Virtual Team Application

The combination of the management and technology research contributing to the virtual team evolution has been incorporated in several

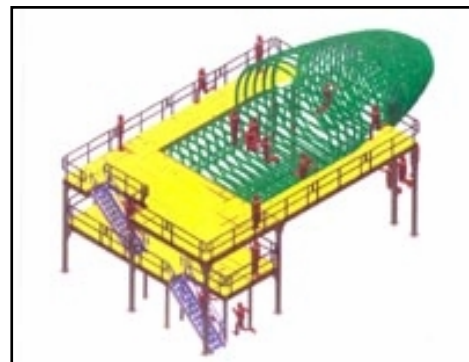


Figure 3.4: Boeing used electronic mock-ups on the 777 to enhance collaboration among design team members.

industries. The manufacturing industry in particular has embraced the virtual teaming concept. Highlighted by the notable success of Boeing on the 777 aircraft project in the aerospace manufacturing industry, virtual teams are now receiving extensive examination by manufacturing organizations (Holusha 1991). The reason for this examination is made clear by the Boeing experience. In the effort to reduce costs and increase efficiency of bringing products to market, Boeing recognized the opportunity of using virtual models and collaboration rather than physical mock-ups (Figure 3.4). Although this required a transformation of long-held organization practices, the organization at every level was committed to the success of this endeavor. In the end, the organization demonstrated how an aircraft could be designed and manufactured in a complete virtual environment that was accessible by in-house and external project participants. The project reduced cost, time, and mistakes by providing a collaboration environment that met the needs of all project participants. However, manufacturing is not the only industry to focus on remote collaboration as an avenue to competitive advantage. Today, technology companies such as IBM, petroleum companies such as Dutch-Shell, and numerous contractors that support manufacturers and designers are testing and incorporating some form of virtual teaming into their enterprise operations.

Although these outside examples of virtual team testing appear to be growing in numbers, the research team has found that the evolution of virtual teaming in the EPC industry has been lagging. Specifically, the application of virtual teams as coordination and communication mechanisms between organizations is taking a longer path to implementation than witnessed in the other industries (See Chapter 6 for statistical details). However, this does not imply that no progress is being made in the EPC industry. Rather, the commercialization of collaboration tools

for this industry is proceeding at an increasing rate in accordance with advances in communications technologies. As documented in Chapter 5, examples of these commercialization attempts include numerous project Web sites, visualization capabilities over networks, and field data applications that can instantly transfer schedule updates to project participants (Laiserin 2001).

These early implementers are setting the path for the introduction of virtual teaming technologies into the construction and civil engineering industries. However, continuing concerns regarding technological and managerial adjustments within the organizations appear to be extending this path on a regular basis. The guidelines in the following chapters reflect these concerns and attempt to change the direction of the path from continuing concern to a focus on successful trial and implementation. The following chapters reflect the three phases of virtual teaming research and implementation by extending the virtual teaming concepts to the specifics of distributed project teams in the EPC context and addressing the specifics of management and technology barriers to the concerns of EPC managers.

3.3 Impact, Opportunities, and Risks

3.3.1 Impact

The development of virtual team technology over the last two decades has witnessed numerous initial steps and forays by EPC organizations into virtual team implementation. As highlighted in the previous sections, many of these efforts were hampered by either incomplete technologies, or management structures that were ill-prepared to accommodate such operational changes. However, these initial difficulties have not stopped the industry from exploring virtual team

technology. The question for this drive is why continue the effort with little results to show for it. The answer to this question lies in the potential impact and opportunity that virtual teams present to the EPC industry. As businesses continue to find that they must compete in a fast-paced global market place, the need to team in a virtual environment becomes more evident and imperative. Product innovation, development and production can no longer be accomplished in a single conference room, if it is to be an accepted and a profitable product.

The Engineering, Procurement and Construction community has been working toward a virtual project execution environment for a number of years with the early approaches utilizing a work transfer to what were called Low Cost Engineering Centers (LCEC). This effort entailed performing the initial engineering and preliminary design in a centralized domestic engineering office, and subsequently transferring the entire design package for a facility to a LCEC for execution of the detailed engineering and design. The primary purpose of this effort was to reduce the cost of the engineering component of project execution. This work splitting effort has gradually been moving toward a work sharing effort whereby the design has an element of interaction, but the concept of teaming is still not a reality on these projects.

The impact of the virtual team concept on the EPC community is the ability to move beyond the work sharing concept and develop a true interactive arrangement with all project participants. This shift in the execution model for both owner and EPC organizations will fundamentally alter the way that EPC projects are executed. In a very short period of time, this technology will become the accepted form of project execution and owner interaction. Thus, the impact of virtual teaming will not be isolated to the development of technical solutions, but rather, virtual

teaming will impact the fundamental concepts of how EPC projects are initiated, executed, and delivered as well as how EPC-owner relationships are maintained over extended periods of time.

3.3.2 Opportunities

The opportunities associated with virtual teaming are broad and cover every aspect of the EPC project. From project constituent interaction to process improvement to knowledge management, the concept of virtual teaming can impact traditional concepts of project execution and management. Broad examples of these opportunities include:

- Virtual teaming can be viewed as an opportunity to reduce structural costs within the corporation. Specifically, travel, co-location, etc., are all items that directly impact the bottom-line of any company. The ability to work virtually reduces these costs and, therefore, allows companies to be more competitive within their industry.
- Co-location of project teams has always been a large issue in the EPC industry and one that is extremely expensive. At times, potential partners are not given an opportunity to participate in a project due to proximity to a project, the owner, or other members of the team. Virtual teaming and virtual communication helps to reduce many of these barriers and may give an owner the potential to have new and different partners on his/her project.
- Virtual teaming allows for collaborative team communication and better definition of work flow process. Each team member better understands his/her role on the project and

the process and communication for effective interaction are better defined (because these roles and responsibilities MUST be better defined for the effort to be successful).

- When teams are located throughout the world, virtual teaming allows work on the project to occur continuously throughout the twenty-four hour day. This will potentially allow for shorter project schedules (in essence two-, or even three-shifting engineering, depending on location around the globe) and reduced cost (no premium paid for work going on in another time zone while those in the US are sleeping).

These broad themes are ones that have probably been addressed in a given organization as drivers for exploring the use of virtual teaming. However, broad themes do not generally provide the impetus to alter the manner in which an organization executes projects. Therefore, the following examples focus on the issue of ‘Problem Resolution Time’, or the elapsed time from problem identification to problem resolution. Problem resolution time is not only reserved for problems, it can also address a process as well. In EPC-based businesses where revenue is a function of time to market, the shorter the problem resolution or process completion time then the greater the revenue for the enterprise.

Example one. Consider a production facility half a world away. It is not cost effective to keep the company experts or consultants on site awaiting a problem to be resolved. Consider further that a vital equipment item fails and it is costing the company lost revenue. The failure is beyond the working knowledge of the on site-site personnel to remedy. The clock starts on the problem resolution time. How can the right resources be brought to the right place to bring the

facility on line again in the shortest time as possible? Normally there would be exchanging of faxes and telephone calls attempting to diagnose the problem. Typically the problem diagnosis would not be conclusive until the manufacturer's service representative and/or a consultant(s) arrived at the site and conducted an evaluation. At that time, if necessary, parts would be ordered, and repairs could commence upon replacement parts delivery. This is a significant amount of lost time and revenue. In contrast, a virtual team could be established with the manufacturer's representatives, company expert(s), consultants and site personnel shortly after the determination that the problem was beyond the capability of the site resources. Imagine they are all inked real-time to diagnose the problem and plan the repair. On-line they could discuss the issues, supplemented with digital photos, drawings, sketches, parts manuals, etc. In bringing together these resources, it is quite likely that the problem would be diagnosed and an action plan implemented. If required, the manufacturer's representative could travel to the site with the replacement parts necessary to conduct the repair. Problem resolution time is reduced in this manner. The problem resolution time would be even less if the on-site team could be directed to conduct the repair themselves.

Example two. In an EPC project, if the time from initiation of design to start up of a facility could be reduced then project economics will be more attractive. Consider all the meetings and processes necessary to execute this type of effort. Resources are typically located all over the world. Now consider how the overall schedule could be reduced through virtual teaming. Frequent meetings with manufacturers could mean earlier coordination and start of design rather than waiting for certified drawings. For critical design concept reviews where company/ in-house experts are to review designs, the review could be conducted with that expert from