VIRTUAL TEAMS, PROJECT MANAGEMENT PROCESSES AND THE CONSTRUCTION INDUSTRY

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ABSTRACT: Process is the "action of going through, a progressive forward movement from one point to another, with the goal of reaching an end point" [1]. Project managers in the construction industry tend to regard process as the completion of separate technical tasks to reach an end. What project managers do not ask is, what happens in the process of communicating that contributes to a successful or poor project. The answer remains elusive because project managers expend energy finding better management tools and techniques, not communication processes to help expose and overcome limitations and inefficiencies of projects. Some tools provide a means to examine overall project success, but typically discrete time phases are examined in projects. Deming's teachings are clear in that improvement in the quality of projects demand improvements in processes. One of the key process improvements that the construction industry needs to make is the area of communication to facilitate the transfer of knowledge between teams and projects. In the future, the industry will find it more difficult to rely on tacit knowledge (on the job know-how) of organizations or individuals in virtual environments.

Global trends to outsource work and downsize employee pools combined with the widespread availability of telecommunications devices continue to push organizations into considering 'virtual employment'. Despite knowing that additional full-time employees often cause greater negative utility, the construction business continues to lag behind in use of communication technology and in the development of virtual teams. In the future, a shift to virtual teams will be a consequence of the need for high speed communication of new ideas among experts world-wide, for a competitive edge. Challenges are in using telecommunications tools to overcome geographic and psychological distance in managerial and technical communication.

This paper discusses the future need for virtual teams in the construction industry. Some useful communication processes and technologies that facilitate a transition to virtual teams are introduced. These include: desktop videoconferencing, public video networks, Group Decision Support Systems, and the Internet. Advances in procurement capability is discussed to show impacts on the construction industry.

KEYWORDS: Virtual teams, Processes, Virtual communication

1.0 VIRTUAL: ORGANIZATIONS AND TEAMS

Virtual teams are groups of working professionals, separated by geographical, psychological, and temporal distance. These groups use telecommunications tools for business and social communication to satisfy business requirements of working toward and reaching common goals. Communication is defined as the primary envelop of information that is gathered, processed and shared among team

1 Websters International Dictionary

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members during the accomplishment of business tasks. Virtual teams may work on either unstructured or structured sets of tasks to accomplish simple or complex work, on short or long term projects.

Electronic networking by virtual teams is fueling a unique organizational culture called a spider's web (Reich, 1991). Tucker, Meyer and Westerman (1996) define culture as part of physical structure called "New Organizational Forms" (NF) and Management Technologies (MT). New organizational structures themselves are sometimes referred to as: modular, cluster, learning, network, perpetual matrix, or spinouts (Bartlett and Ghosal, 1989; Miles and Snow, 1986; Quinn, 1992; and Rodal and Wright, 1993). Similarly, Jan Hopland coined the term *virtual corporation* to describe an organizational web comprised of small, globally dispersed, ad hoc teams that form an enterprise (Rodal and Wright, 1993). A virtual corporation's web consists of individuals working toward a common goal, but without office buildings, physical plant, or other characteristics of a traditional industrial age corporation. A virtual corporation can marshal resources that include customers, competitors and independent companies to quickly exploit brief windows of opportunity characteristic of unstable materials markets.

New Organizational Forms are unique in that they promote the formation of flexible, fluid alliances to facilitate quick and professional execution of multiple projects, anywhere, anytime and anyplace. The teams comprising NFMT's are know as: virtual teams, Distributed Global Workteams, spin-offs, skunkworks, turbo task forces, or autonomous work groups outside existing organizational structures (Jessup, 1996; Mezias and Glynn, 1993; Knoll and Jarvenpaa, 1996). Although the label varies, the common element is that geographic location is no longer a traditional context for social interaction. Thus, evaluation of team member's responses to stress, deadlines and conflict is more challenging, but not impossible to mediate. Because there is essentially no avenue for face-to-face (f+f) 'hallway' talk, inexperienced virtual teams are uncomfortable about how to gather informal psycho-social cues about team member's attitudes and behaviors.

Virtual teams are a novelty, and the newness offers dimensions to communication that given practice, may provide more positive interactivity potential than traditional linear modes (i.e. telephone and f+f meetings). The major change is that the "reader-audience member-sender" shoulders a lot more joint responsibility (Newhagen and Rafaeli, 1996). The focus on organizing principles such as turn taking shifts in electronic communication to interactive participation. Participants then have personal responsibility to keep their own gates.

2.0 THE SHIFT TO VIRTUAL

Through the 1980s, organizations locked themselves into finding cheaper natural resources and hiring more labor to keep up with increased work loads (Guss, 1996). Today, it is the fundamental capabilities rooted in knowledge and organizational communication systems, not natural resources and labor that is quickly becoming its own business (Stewart, 1993; Hornback, 1995; Tucker, Meyer and Westerman, 1996). Because the construction industry still holds a resource-based viewpoint, it continues to see its capabilities as rare, valuable and non substitutable. Thus,

communication is overlooked as a competitive advantage. The result is that the industry is actually degenerating its future work capability. Although in the short term work may be abundant, contractors will have to

collaborate with owners on projects and start to ask fundamental questions about re-distributing resources or even abandoning non-value adding projects. The right tools or people for the job is secondary to strategic questions about the worth of the job itself.

2.1 Organizational Climate

The 1990's propel the construction industry into an era of rapidly changing technology, more time constraints, and increased business costs in a network of global competition. Large, hierarchical organizations once segmented by executive management strata are starting to flatten in response to the 'borderless' transfer of knowledge. This resulting multi-directional flow of information creates a potential for a whole organization to learn. Learning potential is created among professionals within and between different organizations, in contrasting positions, and in the same and different industries.

The consequences are that accepted inefficiencies in communication and tools project managers used to protect themselves or projects no longer make sense. Restructuring organizations to resemble collaborative 'entities', removes psychological borders between professionals and departments so that communication stigmas can be dealt with on an individual rather than a corporate level. In the future, cross-functional teams formed by entrepreneurs (self-managing professionals) will commonly be retained on personal contract arrangements, as projects are available (Guss, 1996).

The groundwork is already done to encourage the construction industry's transition to new and diverse kinds of culture and structural arrangements. The time has come for the construction industry to mentally see the value of communicated knowledge as a source of competitive advantage, in order to exploit the world of virtual teams. Researchers are not asking the construction industry to take a leap of faith: empirical evidence points to communication of knowledge as probably the single most important source of competitive advantage into the 21st Century (Daft and Lewin; 1993, Grant, 1993; and Tucker, Meyer and Westerman, 1996).

Today, the construction industry is content to use office and site meetings or airline flights to bring team members together f+f to make strategic project decisions. These mediums are not always practical or cost effective and they are not always successful in helping teams achieve the required speed and coordination to manage schedules and resources. In the future, budget limitations, and hyper-fast-track schedules may force even the small construction business to change its modes of communication. For example, "virtual offices" are beginning to replace geographically bound answering services that are typically used by independent contractors [2]. Virtual offices provide global, rented (by hour) physical space and communications connections to track projects and clients 24 hours a day.

2.2 Use of Virtual Teams

The impact that the construction industry has by using virtual teams can only be speculated upon at present, on the basis of select cases. One related case is the Tampa Bay Arena in Florida, USA. The project is currently being conducted through a Web-based construction partnering project [3]. The $150 million dollar project demonstrates the potential of project team collaboration through the Web. Project news, databases, schedules, progress reports, pay requisitions, time sheets, Email, etc.is available anytime, anywhere to any project member with a security code. Results are not publicly available, but an internal survey by the

project managers found that owners and contractors are very satisfied with issues such as cooperation, response time, teamwork, follow-up, and communication of problems.

One of the major benefits of virtual teams is that they do not have to be bound by the rules governing traditional employees or unions. Virtual teams can quickly reshape their core and supporting members (valences) in response client demands, or political and environmental conditions. Additional members or even other teams can join a spider web network for a time period *when* they can add value. For example, virtual teams formed over-night, and comprised of strangers will immediately set out to solve highly technical, political or environmental problems (Knoll andJarvenpaa, 1996).

2.2 Implications for Virtual Team Behaviour

Because of its importance in organizations, teams are the key focus for research on the impacts of technology on communication (Poole and Holmes, 1995). Although numerous communication technologies exist, few guidelines are targeted at building virtual teams. Knoll and Jarvenpaa (1996) found that recruiting is difficult, and long lead times are needed to create virtual teams. Once virtual teams form, researchers find that participation is the most important factor in collaboration and learning (Knoll and Jarvenpaa, 1996); Alavi, 1994; and Leidner and Jarvenpaa, 1994).

To participate in accomplishing goals, virtual teams must learn the social and technical aspects of communicating by means other than f+f interaction. Knoll and Jarvenpaa (1996) found that every other obstacle to virtual learning such as the need for more information or glitches in technology can be eventually overcome. Reinsch and Shelby's (1996) results show support in that only 5 out of 344 responses concerned a need for more or better information to communicate effectively, and 51 responses pointed to the need for more self-confidence to improve communication.

Another important factor in virtual teams is cohesion. Knoll and Jarvenpaa (1996) found that virtual teams working toward a common goal (that was also challenging) showed more satisfaction with the process and the final product than those with no common goal. Also, teams with no common goal experienced more conflict, (although all levels of conflict were all very low). Interestingly, conflict concerned process issues (how the team functioned) but the teams attributed the conflict to product issues. In practice in the construction industry, many project difficulties are social, not technical in nature. A recent study with one of Mobil Oil Canada's facilities engineering projects in Calgary, Alta. supports this finding. The data show that of the 203 individual written comments collected as part of the post project assessment, communication and team processes were the root causes of more than half of the problems, although initially the team thought the technical problems were the primary cause (Wells, Solinger, Guss and Dilger, 1995).

Traditional project management focuses on coordinating fragmented technical tasks rather than integrating beginning-to-end technical and communication processes. The result is that evaluation of the technical baseline overshadows management and evaluation of the people who created the system (team) processes (Wells, et. al., 1995). Part of the problem is that neither traditional project management in practice or most literature clearly establishes that team and technical processes are distinct, yet necessarily concurrent in practice.

[3] **http://www.gcn.net/arena (or use an Internet browser and type in "Tampa Bay Arena")**

2.3 Measuring Success in a Virtual Environment

Project managers in the construction industry often create difficulty in understanding communication flows because the communication process is important mostly in its delivery of a project's technical information. This seems counter-logic to evidence pointing out that 72 percent of all contract claims are the result of design changes, extra work and errors, despite more precise and better technical information than ever before available to project teams (Jergeas and Hartman, 1994). However, assumptions of the benefits of virtual communication are largely untested, and the relationship of knowledge and communication process as a source of competitive advantage is difficult to relate to the bottom line (Tucker, Meyer, Westerman, 1996). Research in the area is lagging, but it is starting to gain momentum at Stanford University, Centre for Facility Engineering. Their work on the application of virtual computer assistants to aid in communication and decision making links processes such as reduction in project costs and time.

Traditional resource-based industries argue that procuring or developing a resource set will allow them to perform better or produce superior products. Indicators of project success have traditionally been quantitative (cost, time, amount of quality) targets set out by project owners. These indicators are monitored, but they are generally not closely tied to process measurements during a project's life. In contrast, the "Process School" asserts that internal strategic capabilities have the potential to create competitive advantage (Tucker, Meyer and Westerman, 1996, p. 57). The complex patterns of coordination and cooperation among team members, or the "how" a project is being carried out defines these internal capabilities. Amit and Shoemaker (1993) refer to these capabilities as intangible "intermediate goods" that are created over time through developing, carrying, and exchanging information through human capital (1990, p. 4).

Thus, one key ingredient of project success is in the internal capabilities of transferring communication loads (information) through communication tools (load transferring devices) rather than in configuring resources and capital. Knowledge management then refers to use of loads, and the flow and stocks of knowledge where a stock can be altered by derivation and acquisition of knowledge (Holsapple, Johnson, and Waldron, 1996). Furthermore, this model does not view the computer as simply a channel for relay information. The computer is considered *a knowledge worker* that processes its own ability to represent and process knowledge. This view, is a key in accepting computers as part of decision making rather than as a means to and end. Accepting this view would mean that electronic communication would be equal to (or surpass) the value off+f interaction in decision making.

3.0 VIRTUAL TECHNOLOGIES

Few organizations can afford to develop internal technological expertise that will provide competitive advantages in the future. In the past, only the larger and more powerful organizations in industry could request radical changes to relationships with contractors, suppliers and team members to provide advantages. However, the even small businesses and contractors can assemble the right balance of technology for communication anywhere, anytime, for a competitive advantage.

One of the major barriers is *perception* of the effectiveness of communication technology. Newer theories are beginning to tested the logic that computer-mediated communication reduces personal influence. Recent research by Walther (1996) found that anticipation of future interaction (a team knew if it would work with a client again) accounted for the

differences between use of virtual communication and f+f interaction on "the immediacy, similarity, composure and receptivity of group members" (pg. 12). Researchers are beginning to find that electronic media can facilitate 'hyperpersonal" (better than f+f) communication (Walther, 1996, Reich, 1991; Knoll and Jarvenpaa, 1996). For example, Reinsch and Shelby (1996) found that although f+f was the most common channel, the incidents that negatively challenged respondents most were exclusively oral.

Traditional research focuses on technological characteristics such as the volume of information, and number and diversity of non-verbal cues carried via a communication channel describe it as 'rich' or 'lean' (Sullivan, 1995; Clampitt and Meyer, 1995). Rich channels provide multiple communication avenues for decision making, instant feedback, and personal focus. Lean channels provide a route to report and exchange routine information. Clampitt and Meyer (1995) found that the "social presence" of a channel is the most important aspect. For example, visual channels may offer more cues, but provide less perceived psychological closeness than exclusively oral or written channels. These points are important in assessing the usefulness of the following technologies used in virtual teams.

Table 1: Some Technologies for Virtual Teams

Technology	Common Uses
Group Decision Support Systems (GDSS) and Groupware	Computer, decision, and communication technologies combined to support group decision making. Groupware for electronic brainstorming, bulletin boards, newsgroups.
Public Video Systems	Specific rooms that conferencing takes place for making group decisions.
Desktop Videoconferencing	Personal computers and workstations outfitted with cameras to provide synchronous communication, work on documents, transfer of project information, and aid in group decisions.
Internet	Web-based team building and project management tools, Email platform to transmit Computer-Aided Design (CAD) documents, import text, graphics and programs, electronic meetings, electronic marketing, electronic customer support, Electronic Data Interchange, and Email.

3.1 GDSS

Group Decision Support Systems are computer tools that assist groups in decision making (timeliness, quality and member commitment to decisions). A GDSS is operated through a PC system, giving the key functions of freely assessable information exchange, information processing and group management (Poole and Holmes, 1995). Poole and Holmes (1995) found that teams using GDSS had longer and more effective decision paths, but not better organized paths. Part of the difficulty in determining if the computer provides a better way to make decisions is that orderliness correlates highly with *perceived* quality of decisions.

Another potential difficulty is that traditional GDSS tools are developed for same place, same time teams and research is thin in assessing its effectiveness in virtual teams (Jessup, 1996). Jessup suggests that traditional GDSS tools come close, but are not ideal for virtual teams. These tools need to be better suited for distributed group member use, and they need to be facilitator-less and easily accessible.

The Vineyard groupware package is a notable product that provides virtual teams with the big picture (Kramer, 1996). Vineyard is a personal and team information management tool that provides *object-oriented*, drag and drop capability in a Windows environment. Pieces of information (concrete or conceptual) are represented by objects that can be viewed visually (mind-map linkages, or in a list), providing the capability of accessing the root document or

[4] **http://www.ast.cam.ac.uk/ralf/vguide**

drawing by double-clicking on the objects (icons) to launch applicable documents (Kramer, 1996).

3.2 Public Video Systems

Public videoconferencing offers dial-up public network capability so that meetings among co-workers can take place in one room (Sharp and Lukasiak, 1995). Mercury and BT are the two national telecom operators currently being used. Public videoconferencing offers a relatively low cost substitution to travel and frequent f+f meetings for geographically distant team members.

The single largest application of this technology is 'Tele-Engineering'. Engineering firms use videoconferencing to discuss prototypes, models and drawings to minimize mistakes, and reduce or avoid costly-inperson meetings (Tele-Engineering, 1996). Also, this technology is especially relevant in reducing product to market cycle times. Despite the benefits, public video conferencing is not particularly suited for virtual teams in the construction industry. Specifically, small contractors who do not require frequent use of videoconferencing, may be reluctant to invest in this technology.

Videoconferencing drawbacks are that salient cues (those that stand out from others) are harder to pick up than in f+f communication because the communication is 'hyper' formal. That is, responses are brief, structured and very formal (Storck and Sproull, 1995). Participants tend to rely less on task competence and more on communication competence (Storck and Sproull, 1995). As well, technological limitations such as low bandwidth (capability to transfer amounts of information), slow video frame rate, poor resolution contribute to difficulties in application to virtual teams. Despite the problems, Martin (1996) reports that approximately 46 countries in over 850 cities have video conference capability for hire to the general public[4].

[4] **http://www.ast.cam.ac.uk/ralf/vguide**

3.3 Desktop Video Conferencing

Desktop capability is the new era of video conferencing that does not require participants to leave their own PC's. Bandwidth is the bottleneck or technological limiting factor because it takes about 17 minutes to transfer a megabyte file over a telephone line (Hudson, 1995). This option offers the choice of Integrated Services Digital Networks (ISDN) or Ethernet channels. The former is a circuit switched bandwidth not shared by all users who want to access it, and the later is packet switched whereby the bandwidth shared by all users. Although ISDN is better for videoconferencing, it can only handle a limited number of frames per second, giving lower quality 'freeze frame' communication. Hudson (1995) reports that user's perception of communication quality is linked to frame rate.

However, this tool is more suited for the construction industry because of the person-to-person or one-to-many capability, portability and ability to operate in a Windows environment (and also as a subset of the Internet). Furthermore, there are many Web resources to support desktop video conferencing. Common videoconferencing products, too numerous to list are found on the Internet[5].

3.4 Internet

The Internet is a powerful tool for use in virtual teams, especially in achieving collaboration and participation (Jessup, 1996). The Web is supported by freely-accessible Hypertext Markup Language (HTML) editors and share-software so that Web-based collaborative applications can be built and used at a very low cost. Web-based products are well suited for use in virtual teams because they provide direct, quick and easy global connections (remote access via lap-top and modem).

A noteworthy Web-based tool is TCBWorks Webware for Teams from the University of Georgia [6]. This Webware is similar to GDSS software, but is accessible through any Web browser such as Netscape. A first-of-its kind application called "TEAMWORKS: The Virtual Team Assistant", is currently being developed by the Sloan Center for Asynchronous Learning Environments [7]. TEAMWORKS can assist virtual teams in understanding and solving group communication and coordination problems (particularly in engineering design). TEAMWORKS is a Web-based modular aid for virtual teams to help them resolve group communication strategies through text in a Windows environment, links to World Wide Web sources, and external facilitators. The tool provides:

- On-line conferencing among design team members
- Jointly-accessible data bases
- Selection of diagnostic and team evaluation tools
- Access to a staffed (10hrs/day) , on-line virtual 'Consulting Center'

Another application of the Internet that brings people from diverse locations together is Electronic Meetings. A secured room can be set up for these meetings using Internet Relay Chat for either text based, or graphic and sound interface through Multi-User Dimension (MUD) technology (Hornback, 1995). Electronic marketing and customer support can provide sound, graphics, and text to communicate plans and ideas to potential clients in the construction industry.

[5] http://www3.ncsu.edu/dox/video/products.html
[6] http://ginger.mgnt.uga.edu: 8001
[7] http://www.spcomm.uius.edu/projects/vta/teamwork.html

Limitations of the Internet are more social rather than technical. Once the appropriate hardware and software is chosen, free updates and share-ware is widely available on the Web to assist in keeping the technology capable. A relatively steep learning curve is needed to understand the expansive capability of the Internet, and because the technology is always evolving continuous learning is necessary. This may be annoying to the construction industry, who's foundation lay in trades and technical skills that do not require continuous, and rapid cognitive upgrading.

Email is a useful tool for virtual teams to exchange information one-to one (or in conversations in the chat feature), within or outside of the Internet medium. Cohen (1995) suggests that communications are a cross between formal correspondence and trucker's C.B. radio language. Because communication is less rigid than videoconferencing, more salience is sometimes experienced despite the lack of visual cues. Sullivan (1995) found Email to be the preferred channel of communication when low-level attributes of writing (i.e. need for routine document delivery) is combined with high-involvement attributes (i.e. need for speed of interactivity). However, Cohen (1995) suggests message tones are problematic for the receiver to interpret since 'emoticons' (symbols) to express emotion are not universally used or known :.).

4.0 BUSINESS IS UNUSUAL - PROCUREMENT EXAMPLE

Virtual teams functioning necessitates changes in business relationships through what Hornback (1995) calls supply chain management. This next phase of business evolution referring to the flow of resources (people and material) from suppliers to customers across electronic boundaries. In this arrangement, the only customer is the one who consumes the product or service. This essentially forces participants to work closely in the supply chain to eliminate weak links. Cohesion is important because one weak link can limit the value of the supply chain (Hornback, 1995).

Web-based communication through Electronic Data Interchange (EDI) provides virtual teams with connections to businesses application systems such as procurement across other teams and even small organizations within a supply chain. For example, a project's materials inventory can be communicated through supplier(s) to contractor(s) from point of delivery (or sale) information transaction. When a contractor's inventory level goes below a pre-established level, a *supplier* issues an electronic purchase order to communicate a 'virtual" order (Hornback, 1995). Forecasting is then limited to what is needed to predict future customer demand, reducing project uncertainty because suppliers demand is known.

4.1 Financial Electronic Commerce in procurement

Electronic Commerce (EC) is the popular term for the expansion in communication into the 21st century (Hornback, 1995). The potential to decrease redundancies and decrease cycle time in financial electronic commerce is unlimited. Current methods include Electronic Fund Transfers, Lockboxes, and Evaluated Cash Receipts. Electronic Fund Transfers are made among suppliers, contractors, and financial institutions. A Lockbox is another tool to eliminate check-writing because financial institutions process payments, credit the supplier(s) account(s), and debit amounts from the customers financial institution. Evaluated Cash Receipts is a method that eliminates the invoice altogether because the contractor pays the supplier(s) at the time of receiving the goods or services by using an electronic medium.

Each of these methods can improve cash flow , reduce or eliminate paper work, and reduce the number of people involved in each transaction. Trust among participants can be enhanced because electronic traces provide an excellent source of tamper-resistant document logs. The cost savings potential in procurement alone may encourage the construction industry to experiment with financial electronic commerce in virtual teams or NFMT in larger networks.

4.1.1 CHALLENGES IN PROCUREMENT

Connecting virtual teams though virtual procurement networks is not a simple task for the construction industry. Construction professionals are technically competent but lag behind in communicating across disciplines. Cross-functional communication strategies must be implemented with full participation of suppliers to establish proprietary and standardized communication protocols (Hornback, 1995). Of major importance, and perhaps the source of most resistance in the construction industry, is in sharing inventory, or supplier data bases among partners.

Willingness aside, small, unaffiliated companies and independent contractors linked only through short-term contracts already have difficulty coordinating efforts. Despite the problems, Hornback (1995) warns that the information highway and EC are not idealistic concepts, and that those who do not wake up will find their customers and market have switched to organizations that operate in value adding virtual networks. Those who do not have EC systems sill have the option of accessing the same information through EC-to-Email, or EC-to-fax supplied through Value Added Networks. Hornback suggests that in the future, all these Networks will be better interconnected to provide small contractors with capability to cost effectively link Email, the Internet and EDI capabilities world-wide.

5.0 CONCLUSION

This paper provides a catalyst for further discussion concerning a future need for virtual teams in the construction industry. Some common communication processes and technologies that facilitate the transition to virtual teams are desktop videoconferencing, public video networks, Group Decision Support Systems, and the Internet. Although technologies all have drawbacks, the construction industry should expect that no alternatives are capable of perfectly replacing the status quo. The construction industry has to be willing to take risks in finding the right mix of communication technologies for specific contexts. The success of the industry will largely depend on its ability to continually learn and adapt quickly to technological change. Inevitably, virtual communication will dominate the construction industry, whether it is a participant or not. At best, the future will encourage project management to measure virtual communication capability as a processes that provides a unique form of competitive advantage.

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