PROJECT MANAGEMENT OF GEOGRAPHICALLY DISTRIBUTED SOFTWARE TEAMS

by

CHRISTIAN G. MANASSEH

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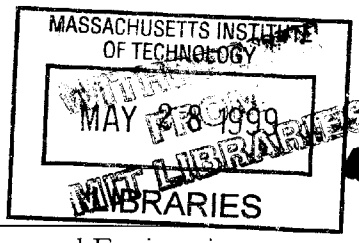

Signature of the Author _____
Department of Civil and Environmental Engineering
May 18, 1999

Certified by _____
Dr. Feniosky Peña-Mora
Associate Professor, Department of Civil and Environmental Engineering
Thesis Supervisor

Accepted by _____
Professor Andrew J. Whittle
Chairman, Departmental Committee on Graduate Studies

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ABSTRACT

Until a few years ago, project work was thought of as a group of co-located activities involving several face-to-face interactions between group members. Meetings were dependent on having team members available at the same place and time. Technology and globalization now have revealed an environment in which teams can comminute and collaborate virtually, across boundaries of time, geography, and organizations. Project work has shifted from co-located activities to geographically distributed, virtually-achieved activities.

Communication and collaboration are the two most important factors in team success. A geographically distributed team environment fundamentally transforms the ways in which teams operate. Crossing geographic boundaries also affects the way in which virtual teams communicate and collaborate. The differences in cultures and social backgrounds affect how different members interact with each other and with the project.

Although we have the technological capabilities to work across time and distance, the fact is that we need new competencies and practices to do so. Leading and working in virtual teams requires much more than computers and technology. In fact, owning and being competent in the special practices that allow you to manage a virtual team is what determines your success. This thesis will provide a first step in providing tools, techniques, and decision-making strategies to help team leaders manage successful geographically distributed software development teams.

Thesis Supervisor: Feniosky Peña-Mora
Associate Professor, Department of Civil and Environmental Engineering

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER ONE

THE VIRTUAL ORGANIZATION AND THE FUTURE ORGANIZATIONAL STRUCTURE

1.1 The Concept of Virtual Organizations

The convergence of computer networking and telecommunication technology is making it possible for groups of companies to coordinate across geographically and institutionally distributed functions forming a single virtual organization capable of achieving powerful competitive advantages. Collaborative applications such as computer-based conferencing, shared databases and applications, workflow management, project management, and video-conferencing can be used to support dispersed people to work together.

Some people are saying that collaborative working is the way to work in the future. "As business spreads out around the globe, information proliferates and competition grows ever more intense, computer-supported collaborative work will become perhaps the most important source of competitive advantage" [Dew et al, 1995].

Collaborative working systems also create an environment where people within organizations can interact, pool skills, and share information and knowledge. Such an organization can be called a 'Virtual Organization'. Virtual organizations can be classified as Virtual Working Environments in the sense that the people working within these environments are linked to a communication network.

The term 'virtual organization' is often known by other names – for example 'virtual corporation', 'virtual enterprise', or 'virtual company', though they all refer to the same concept, there is no consensus on the definition of a 'virtual organization'. All of these terms, however, have five main attributes in common which can characterize a virtual organization. These attributes are [Grimshaw et al, 1998]:

- Alliance for a common goal
- Underlying Information and Communication Technologies (ICT)
- Vertical integration
- Globalization
- Collaboration

1.2 Attributes of a Virtual Organization

As the concept of 'virtual organization' is still evolving, different authors and researchers have different definitions of what constitutes a 'virtual organization'. Their definition may vary from small-scale collaboration within different departments or business units to large-scale collaboration spreading across big corporate or national boundaries. In order to understand and appreciate the concept of virtual organization, this discussion examines five important attributes.

1.2.1 Alliance for a Common Goal

Goldman (1995) and Wolff (1995) described a virtual organization as a group of companies in alliance (or co-operation) to attain a certain goal so as to produce a particular product (or complete a specific project) or services with their combined resources.

"In a virtual organization, complementary resources existing in a number of cooperating companies are left in place, but integrated to support a particular product effort for as long as it is economically justifiable to do so." [Goldman et al, 1995]

"Virtual organizations are distributed 'business processes'. These processes may be 'owned' by one or more organizations acting in partnership. For a specific project, resources are assembled to perform a business process on behalf of the project owner(s), and then disassembled on completion of the contract." [Wolff, 1995]

So the major attribute for the existence of a virtual organization is to have two or more working bodies combining to produce a certain product. By doing so they hope to cut down on their expenses and take advantage of the complimentary skills provided by each body. The working bodies can be geographically distributed companies, organizations, groups, or even individuals.

1.2.2 Underlying Information and Communication Technologies (ICT)

What makes the virtual organization concept existing today is the growing ease with which physically distributed, complementary competencies can remain dispersed and still be synthesized to a coherent productive resource. Coates (1994) and Fisher (1993) emphasized that ICT would be an important facilitating mechanism for the concept of virtual organization.

"The key to understanding the virtual operation is the profound effect that information technology has as it distorts traditional relationships of management and work to time and space." [Coates, 1994]

"Increasingly, executives are turning to alliances, partnerships and joint ventures, often formed to produce particular products and then disbanded. These enable costs to be shared, development times to be shortened and effective use to be made of design, manufacturing and marketing skills inside and outside the company. Such linkages - variously described as virtual corporations or agile enterprises – are made easier by computer technology." [Fisher, 1993]

The definitions from Coates and Fisher showed how information and communication technologies can be used to exploit the dimensions of time and space in a virtual organization.

1.2.3 Vertical Integration

Pastore (1993) and Klein (1994) extended the concept of virtual organization to include vertical integration. They suggested that companies involved in virtual organizations should include both core suppliers and long-term customers into their virtual organization blueprints. This vertical integration can sometimes not only improve the company efficiency through close relationship with its supplier, but it can also provide better services to its customers, thereby creating higher customer satisfaction. Such integration can cut down delivery delays to customers by providing rapid responses to customer needs/demands and at the same time enable the company to get supplies from core supplier on time. This will cut down cost of inventory and provide better management of the company's resources.

"In order to have a rapid response to the market (customers), companies have to reorganize themselves around rapid response to customer demand, forging tight relational and technological bonds with core suppliers and long-term customers. That is the shape of the corporation of the future, a virtual corporation." [Pastore, 1993]

"Virtual corporation consists of the company that faces the customer and a network of other companies that co-operate to achieve what non of them could achieve alone, this arrangement permits each participant to concentrate on what each does best and to limit the risks and investments to its core competencies." [Klein, 1994]

By integrating the missing skills that each company has from its counterpart, the company will be able to efficiently work on producing the product without incurring extra costs to leverage its organization by providing extra manpower or equipment necessary for the task at hand.

1.2.4 Globalization

The concept of virtual organization is not limited to national boundaries. Wolff (1995) and Coates (1994) included the idea of globalizing virtual organizations. Various departments of an organization could be spread over several countries. With the use of the concept of virtual organization, this dispersed department can be synthesized into parts of a 'virtual' company. By distributing operations globally, the organization can exploit various features each country can provide. For example, the manufacturing plant can be located in developing countries like India or China where labor costs are low; Research and Development (R&D) in the United States where there is a strong foundation for research capabilities; and Finance in London, a world financial center. Thus, by exploiting the advantages of each location, virtual companies are able to acquire competitive advantages over their rivals [Wolff, 1995].

1.2.5 Collaboration

One important feature of virtual organizations that must be included when describing such organizations is the teamwork from people within the organization that may be distributed locally or globally. Dubinskas (1993) and Crainer (1995) highlight this feature. Instead of using the word 'cooperation', it is more suitable to use the word 'collaboration' in this context. Collaboration, unlike cooperation, signifies interaction between the various members of the company and not only interaction between the companies themselves. An example of cooperation might be the exchange of working document formats or certain managerial process between companies. That is usually achieved at a managerial level. Whereas collaboration involves the day-to-day interaction between the members who are involved in the development of the product. Such interaction includes exchange of phone

calls, email messages, meetings, and other forms of human interaction needed as part of the day-to-day activities.

"The terms 'virtual teams' and 'virtual organization' evoke the special status of groups created through the use of groupware such as computer conferencing. Virtual teams become part of the ongoing process of structuring, while also providing a new tool for organizational design. A virtual team exists through the use of groupware, but it appears to the user to have attributes and functions of a conventional social group. Virtual organization is the larger scale ordering and linking of virtual groups." [Dubinskas, 1993]

Dubinskas (1993) highlighted that the essence of a virtual organization is actually a 'virtual team'. Crainer (1995) described the term virtual team as " groups of people who are accountable for the achievement of transient or short-term objectives. The idea is that virtual teams enable a flexible and continuously evolving fit between skills, resources and immediate needs." Therefore, it is the team members that are, and should be, responsible for the collaboration through which the product is developed, and it should not be sufficient for the management and leaders alone to achieve this interaction.

1.3 Common Misconceptions of Virtual Organizations

If we were to define virtual organizations as those that possess the discussed attributes, then many of the 'so-called' virtual organizations found currently in the business environment could not be considered as examples of virtual organizations. The two types of organizations discussed in this section appear to be virtual organizations, but they lack certain features. It is therefore important to differentiate between them and the virtual organization so that no confusion might arise when we handle the issue of virtual organizations.

1.3.1 Internet Niche

Some companies purely sell their products (goods and services) over the Internet. These can not be considered to be examples of virtual organizations. Although the physical office

appearance of these companies may not exist, no collaborative work is involved. Companies selling their goods or services over the Internet are considered as a type of teleshopping or telemarketing organization.

1.3.2 Electronic Trading Environment

Inter-organizational information systems are being implemented in all types of industries to establish electronic links between separately owned organizations. Companies which are linked together through the use of an Electronic Data Interchange (EDI) system, Quick Response (QR), or Continuous Replenishment Program (CRP) cannot be considered as examples of virtual organizations. These companies use the technology to exchange data such as purchase orders, advice of delivery notes and invoices or to improve the performance of demand channel processes, but do not work collaboratively for a common goal. For example, with CRP, a retailer transmits data on warehouse shipments or store sales to vendors, and vendors determine order quantities to ship based on this information. Retailers do not place orders with CRP, and vendors are responsible to maintaining adequate inventory levels to manage stock-outs. The retailer manages vendor performance by establishing targets or objectives for inventory and stock-out levels to be achieved at the retailer's warehouse. Although collaboration between the companies exists, the essence of collaborative work with people within the organizations is not there. Such an environment can only be considered as an electronic-trading environment, not a virtual working environment.

As it was presented, this form of collaboration is limited only to the exchange of information. Each party will act on the information individually. In a virtual organization, collaboration is used to achieve a common goal. Two engineers from different companies will collaborate to design a product; different marketing departments will collaborate to form a common marketing strategy.

1.4 Telecommuting

When talking about virtual organizations, it is always imperative to hit upon the subject of telecommuting, since it is definitive of the virtual workplace. Several times companies adopting a virtual organization structure find it better to shift its employees to a telecommuting mode instead of forcing them to work in the office. This phenomena is part of implementing a virtual organization since it reinforces the idea of a virtual organization being able to acquire more skillful people not necessarily located in its offices.

Telecommuting involves working in one or more days each workweek from home or from a satellite office, instead of commuting to the central workplace. Telecommuting is being used as a travel substitution, office space cost-saver, and means of bridging the family work-gap, which is increasingly an issue as more and more women assume full-time employment. Reports indicate that telecommuting is on the rise worldwide.

Benefits to telecommuting employees can include personal control over working time and working conditions, with one of the most obvious advantages being the time, energy, and stress reduction from not having to commute long hours to the office.

For the employer, there are numerous advantages to offering the employees the choice of telecommuting. Such work arrangements can increase the organization's flexibility, and transfer from the employer to the worker the costs of the provision, maintenance, and running of the workplace and equipment (though this varies by organization). Employers also stand to gain from the ability to compete for and recruit people who are unable to take up normal office employment, who need to balance family responsibility, and those professionals who possess the most marketable skills. There are also indirect benefits of improved public relations and tax incentives [Donaldson et al, 1998].

Although telecommuting is a result of virtual organizations and it is just a possible consequence of working in a virtual organization, it should not be characterized as an attribute that defines a virtual organization nor should it be used as an indicator of virtual forms of organizational structures.

1.5 Features of the Virtual Organization

I have so far listed the attributes of virtual organizations and listed certain types of organizations that might be misunderstood as virtual organizations. I will now discuss the features of the virtual organizations. As the attributes of a virtual organization serve as a definer for the virtual trait, the features are actually certain characteristics, which have been observed to accompany the presence of a virtual organizational form.

The virtual organization can be defined as a group of companies forming an alliance through the use of ICT to collaborate in the production of a joint product; the location of the group of companies may be distributed locally or globally but they appear to function as single organization.

For a team to work effectively they must be provided with a set of common tools so that they can collaborate effectively. This can be through the Internet, through a closed company Bulletin Board System (BBS) set up for a particular event, or through an in-house network system with remote log-in capabilities. Most companies do not possess the necessary specialist skills needed to create their own "virtual working environment software." Therefore, provision of "off-the shelf" groupware, video conferencing equipment/software are important factors that decided whether a company can "go virtual".

The main criteria of the virtual organization is perhaps to have an organization with many locations (within or outside the national boundaries) and the need to communicate between those locations, to share information and to work collaboratively on that shared information to produce joint products, with the use of ICT as the facilitator. The key features which accompany the virtual organization form can therefore be described below [Grimshaw et al, 1998].

- A virtual organization is an opportunity-pulled and opportunity-defined integration of core competencies and resources distributed among a number of real organizations without the duplication or relocation of physical locations.

- In a virtual organization, a single project can run across multiple distributed branches (or companies) and still offer an integrated product.

- In a virtual organization, experts can be drawn and accessed through the network and from a "world-class team".

- In a virtual organization, participants interact with each other as team members or peers, rather than being organized hierarchically as they are in a traditional company.

- Virtual team(s) and group(s) of people communicate with each other about the project, through a common computer network, enabling a workforce to be created without relocating

- In a virtual organization, companies must be connected electronically so that people within organizations can inter-operate or intra-operate across the network, using common tools to navigate around the network and share information.

These features come as a result of adopting a virtual organizational structure and they fit into the model that describes the virtual organization as an entity. They also serve as the main characteristics that offer the benefits of the virtual organization as it will be shown in the next few sections.

1.6 The Virtual Organization Model

Hence we arrive at the virtual organization model which states that the virtual organization, by most definitions, can be a temporary one. However, it may well be one that defines itself by using, on a continuing basis, the idea of virtual teaming in its general business practice. Some companies have specifically acknowledged the adoption of the virtual organization model while others have used the concept of virtual teams in project development and management. The difficulty in maintaining a virtual organization appears to be in knowing when to abandon a project or how to transition a successful project into a non-virtual

environment, whether that is through the establishment of a new organization, a spin-off or sell-off of product or service. These findings suggest the existence of a virtual organization type that is permanent, not merely gathering around a market opportunity, but specifically designed for continuing operations under a virtual organization structure [Palmer, 1998].

In other words, a virtual organization can be adopted for a temporary period of time to facilitate the development of a project that might require the use of a geographically distributed team. On the other hand, it can also be used as a permanent form of organizational structure for companies that are continuously involved in such projects. In both cases there are some advantages and disadvantages that will affect the decision making involved in choosing the organizational form required. By listing those benefits and drawbacks, one can form a checklist that can be considered a model for choosing the organizational structure required.

1.7 Benefits of Virtual Organization

1.7.1 Increase Competitive Capabilities

One of the most valuable advantages of a virtual organization is that it gives companies highly competitive capabilities. In a virtual organization a project can cut across geographical boundaries, enabling a virtual company to work with and present a local face to its global clients. The ability to access global markets increases the virtual organizations' global competitiveness.

A virtual organizational structure provides many opportunities to companies, especially small-to-medium-sized ones. Networks of small companies are an increasingly popular strategy for competing in rapidly changing markets and as a means of adding value to virtual companies. These small companies can respond faster to changing business environments, however, they lack the necessary resources to bid for and implement projects. By forming an alliance and creating a virtual organization, these small companies can pool their resources, expertise and technology.

Virtual companies can join their core competencies together, but still remain location independent. Identifying a core competence and then complimenting it with core competencies at other firms to synthesize a complete production capability of virtual companies to compete with market changes. Ten small United Kingdom companies joined their expertise together and formed a single virtual company, UK Fine Chemicals, for the purpose of opening a new market in the United States [Grimshaw, et al. 1998].

1.7.2 Flexibility

Since a company can change its partners, organize its virtual team members in the virtual coalition, it has operational flexibility. ' Beat it, celebrate it, and disband," as Dr Nagel, deputy director of Lehigh University's Iacocca Institute, put it, "Then do it again, with the same set or different set of partners" [Bottoms, 1994]. In addition with virtual organizational structure, a virtual company would have a higher variable to fixed costs ratio compared with 'non-virtual' company, so it has financial flexibility. In a virtual organization, resources can be kept at optimum levels in each location by sharing work.

1.7.3 Greater Responsiveness to Market (Customers)

With a flexible structure, a virtual organization has greater market-responsiveness. In addition because of the flexibility of the virtual team, the organization can mix and match people when needed, enabling it to react to its customers quickly whenever there is a change in their needs. Examples from the literature include companies such as Apple Computer, MCI and Xerox who are already bringing new products to market faster and generating higher sales per employee by using this virtual concept [Klein, 1994].

Small companies that make up a virtual organization do not have the Internet red tape found in many large companies. By virtue of having no such red tape and less rigid business procedures, the virtual organization can react to customer's demands and changes more rapidly.

1.7.4 Improve Customer Service

Because a virtual organization has greater customer focus and market-responsiveness, it can provide better services to its customers. With the increase in linking clients (or customers) in business activities such as design processes and sharing marketing strategies, there is better communication between clients. Any feedback from clients can be incorporated in the business activities. In turn, less errors would be made in the process and thus, improve customer services.

1.7.5 Cost Benefits

Although it is hard to calculate the cost savings from using the virtual organization concept, numerous benefits in that domain can be identified. Most of these benefits relate to cost reduction. As virtual companies are connected electronically, skills, knowledge, resources and technology can be shared. Cost structures can be reduced by utilizing the advantages that may be obtained from using the relatively inexpensive and publicly accessible infrastructure of the global networks. In addition, a virtual team has potentially lower office and support overhead.

A virtual organization's capability is independent of its physical location. Therefore it can still communicate and interact with clients directly through the networks (if the clients are also linked on-line) without building a premise near a client's place. This saves the cost of building premises at the clients' sites. Virtual organizations are not limited by physical locations; they can access low cost resources around the world, for example use of locations in India and Philippines. Other examples of cost saving from using the virtual organization concept are:

- Improve development cycle, which results in reduced development costs
- Shorter design cycle times, which results in increased productivity
- The reduction in total design time, which results in lower project costs

1.7.6 Improve Communication and Internal Control

In a virtual organization, people work as peers or teams rather than in a hierarchy. Information can be accessed (via network) by anyone (including suppliers or customers) within organizations. Communication within organizations is improved. In addition, internal communications, documents, and reports are all available electronically through the corporate network in much more responsive and interactive mode than paper permits. Usually virtual organizations have better communication and greater control over inventory and production by using computer networks.

1.8 Drawbacks of Virtual Organization

1.8.1 High Costs

Costs are considered a drawback in virtual organizations. The main costs are initial investment in ICT and the subsequently high operational costs, including training and maintenance. In the long run, given the general trends in technology costs, this issue is likely to be of reducing significance.

1.8.2 Legal Problems

One of the key characteristics of the virtual organization is its speed and efficiency as it is set up to tackle specific projects. However, complex legal problems are slow and inefficient. Problems about future ownership rights might also arise when dealing with more than one company. Which company would hold the copyrights to the final design or products?

1.8.3 Trust and Respect

Due to the limited amount of face-to-face meetings between groups in virtual teams, it is difficult to build trust and respect among team members. This usually results in group and communication conflicts between the members that are supposed to be collaborating on a

certain part of the project. Trust is usually earned after the members have worked together on some previous project or have accomplished a common task according to predefined requirements. It is usually difficult to come up with a team whose members already trust each other from the beginning. That is because in most cases virtual organizations are often formed to tackle a particular project without detailed planning resulting in team members who have never worked together before. However, as the team works more and collaborates more, trust and respect gradually build up to the required standards although at the cost of time.

1.9 Culture Issues

In a virtual organization, working across cultures is the biggest challenge to managers. They have to transfer their business policies and culture to work with dispersed business teams – spanning organization, geography and cultures. This ends up with having a virtual team that includes people from different cultures from different companies. In order to manage the virtual team well, a set of 'virtual team policies' have to be defined to solve problems within teams. Companies which confer decision-making powers on cross-disciplinary teams must be prepared to commit substantial resources to encourage new forms of employee loyalty as they may resist this new virtual structure.

Organizational culture is another issue that a virtual organization must address. As Bill Davidow, a former executive with Intel Corporation and Hewlett-Packard Company described, "information and communication technology (ICT) provides the infrastructure for the corporation to communicate with customers and deliver information necessary for decision making... if management insists on maintaining a strictly functional organization and does not empower workers to make decisions, Information Systems (IS) will add little value." [Pastore, 1993]

1.10 Information Technology as an Enabler of Virtual Organization Forms

The proliferation of new information technologies (IT) and the rapidity of their introduction into organizations has created many organizational issues in terms of the adoption, implementation and management of technology. One response has been the virtual organization and the use of virtual teams. These organizational models allow organizations to seek advice, counsel, and information from organizations with similar questions and concerns. The establishment of these virtual organizational forms is a reflection of this interest in sharing information, developing standards, and reducing costs. In many situations, information technology has been seen as an enabler of the development of these virtual forms [Palmer, 1998].

A study by Palmer (1998) was done to analyze the use of IT in enabling virtual organizations and to identify the key elements in the information technology infrastructure, including use of mainframe, PCs, LANs, WANs, and the Internet (see Table 1).

Table 1. Basic Information Technology Structure

Technology	*Mean*	*S.D.*	*Use*	*Do Not Use*
Mainframe	0.18	0.39	18%	82%
PCs	0.98	0.13	98%	2%
LANs	0.89	0.31	89%	11%
WANs	0.40	0.49	40%	60%
Internet	0.92	0.26	93%	7%
0=do not use	1=use			

Fifty-five organizations were analyzed. Only 18% of the organizations use mainframes. PCs were more popular in this domain. The use of the Internet was also high (93%), perhaps not surprising given the nature of the organizations and their interest in connecting with partners and using the Internet to gather, as well as to disseminate information. Internal connectivity was also high, with 89% of the organizations having a LAN. With such figures, it is important to notice the effect that IT has on the functionality of a virtual team. This is also one of the reasons that has resulted in the delay of the evolution and widespread of virtual teams. Since, although it is not the only attribute that defines a virtual organization, IT is the driving force that allows a virtual team to come alive and function properly.

The organizations are typically using mature technologies such as fax and e-mail on a regular basis. The newer technology with heaviest use are the World Wide Web. The other information technologies are still used only rarely, including Intranets, videoconferencing, teleconferencing, and GroupWare. Gopher site use is also rare, and this probably reflects the move to the World Wide Web. Several of these technologies are used more heavily in connecting with partners than in internal operations (fax, WWW, teleconferencing, and videoconferencing), reflecting the virtual organization linkages with other organizations. Although used less frequently, the internal uses of GroupWare and e-mail appear to support more internal organizational work [Palmer, 1998].

1.11 Conclusion

This chapter has reviewed five main attributes of the virtual organization concept: alliance for a common goal, underlying ICT, vertical integration, globalization, and collaboration. A virtual organization is formed to facilitate collaboration using ICT globally and may be used to form alliances and/or vertical integration. Companies wanting to form a virtual organization should identify their primary purposes, so that the bottom-line impact of doing it can be identified.

In addition, the benefits and drawbacks of virtual organizations on businesses in current practice have also been examined. Numerous benefits have been identified and realized by

companies. However, there are some areas of concern that must be addressed before implementing a successful virtual organization. The areas to take note of are:

- Organizational and cultural changes must be addressed.
- Members must develop a high degree of mutual trust and understanding.
- Technology must be integrated with people and business processes.
- People in the organization must be empowered, so that they can add value to the company.
- Projects should be the focus of the company.
- Virtual organization relationships must be abandoned when the company's strategic goals have been diverted
- When adequate levels of trust and openness cannot be achieved; no more added values can be obtained from continuing the project.

Culture is another important factor that determines the success of a virtual organization. "Companies must undergo a cultural change", said Bill Mitchell (1997). In a virtual organization, people work as peers or teams, rather then in a traditional hierarchy. Managers will no longer be on top of the hierarchy; they need to work as team leaders, as facilitators that help coordinate and provide directions and focus instead of dictating requirements.

Virtual organizations are new and dynamic. While further developments in the underlying ICT are likely to facilitate growth in virtual working, it will be the real business benefits that attract more companies to consider this new organizational form [Grimshaw et al, 1998].

CHAPTER 2

COLLABORATIO N IN VIRTUAL COMMUNICATIONS

Organizations are adopting powerful new information technologies that enable teams of knowledgeable workers to collaborate on tasks even though they cannot be at the same place at the same time. Communication and interaction among team members can be facilitated by the careful implementation of a Computer-Mediated Communications System (CMCS). This technology allows organizations to form work teams that are geographically dispersed; team members need not have face-to-face encounters in order to cooperate on joint tasks. However, in order to be effective, this system must be introduced and utilized in ways that are consistent with findings of research into the behavior of teams utilizing such a system. Only with appropriate management of this system can the real benefits of the technology be achieved. This chapter will investigate the findings of such research activities to help build an effective framework for managing a distributed team. This framework will be fully described in Chapter 3.

2.1 Information Exchange in Virtual Work Groups

In order to be effective, groups must exchange information effectively. Members of a group will have a larger pool of information (for making decisions and for supporting other group processes) than lone individuals. Not only can group members help one another recall information that an individual member may have overlooked, they may also bring unique information previously unknown to others in the group. Thus, groups are potentially able to make more informed decisions than individuals if they effectively exchange information. However, studies of information exchange in groups suggest that both virtual and face-to-face groups fail to take advantage of their information advantage [Hightower et al. 1995, 1996; Stasser et al. 1989; Stasser et al. 1985, 1987]. Groups tend to concentrate on common information and regard group discussions as a means to negotiate consensus rather than exchange information.

2.2 Information Exchange in Group Decision Making

A group decision results from interpersonal communication among its members. This interaction serves a variety of functions but one of the most important is information exchange. The information exchanged in a group is drawn from a pool composed of two elements: unique information known to only one or a subset of the group's members, and common information known to all group members. Effective information exchange depends on sharing unique information. For this sharing to take place, an individual must recall the information, have the opportunity to mention the information and be willing to mention it.

2.2.1 Information Recall

One factor affecting the group's ability to recall information is the frequency with which a person has been exposed to an information item [Stasser et al. 1989]. More exposure results in easier recall. Other factors are individual preference, familiarity with the information and

amount of information. Preferred consistent information is more easily recalled [Stasser et al. 1987]. Similarly, familiar information items are more likely to be remembered. Finally, large amounts of information reduce the likelihood of any particular item being recalled [Stasser et al. 1989].

2.2.2 Opportunity to Contribute

Opportunities to contribute information are affected by time constraints and information load, unreliable communication channels, and social influences. Time constraints or a high information load may reduce the opportunities to mention information. Group discussions tend to follow themes, "rehashing" the same information until a new theme arises [Lamm et al., 1973]. This results in an unproductive use of time and reduces the amount of information that can be contributed. Additionally only one person can talk at a time further limiting the information exchanged [Diehl et al., 1987]. When time becomes too constrained or information loads too high, some of the information may never be contributed.

Unreliable communication channels can limit a group member's opportunity to communicate on a timely basis. Classic examples are asynchronous communications systems such as e-mail. When using e-mail, the sender relies on the receiver to read their e-mail. In this case feedback is not immediately provided and the sender is not certain if the message was received and understood.

Social status may also limit a group member's ability to mention information. Often, lower status members are not given the same opportunity to speak and may find themselves bystanders to a discussion among higher ranking group members [Weisband et al. 1995].

2.2.3 Motivation to Contribute

Even after information has been recalled and an opportunity to contribute is available, a group member must choose to mention it. An individual may choose not to mention information for a variety of reasons. First, people are reluctant to mention information that counters prevailing group's sentiment [Hartwick et al. 1982]. Comments may be biased to

match the perceived preferences of the audience. Generally, the first person to speak has an inordinate influence on the group's discussion and ultimate decision. Secondly, people tend to take an advocacy role with respect to their own preferences and are less likely to mention information that undermines those preferences [Gigoneet et al. 1984; Stasser et al., 1985]. The third factor that may affect an individual's motivation to contribute relates to the member's level of commitment to the group. Individuals with little interest in the group are usually less willing to contribute.

2.2.4 *Effectiveness of Information Exchange*

The difficulty arising in achieving complete information recall and having enough opportunity and motivation to contribute when being involved in group work results in a situation where unique information may be mentioned less frequently than common information. Stasser et al. (1992) found if a group member mentioned a common information item during discussion, the item would probably be mentioned again during the group's discussion. In contrast, even when previously mentioned, unique information was rarely repeated. Stasser et al. speculated that by mentioning common information, a group member increases the item's salience to other members since they were previously exposed to it. However when a unique information item was mentioned, most group members had not been previously exposed to it. Therefore even after being mentioned, unique information is less salient than common information and is less likely to be recalled later. As a result, common information dominates discussion and has more influence on group decisions than a unique information [Gigone et al., 1993]. This means groups can fail to capitalize on their potential information resources.

2.3 CMCS and Information Exchange in Virtual Groups

Virtual groups may use synchronous or asynchronous CMCS to facilitate information exchange. Synchronous computer conferencing systems (SCCS) permit group members to communicate by typing their comments into the computer and then broadcasting the

comments to other group members. The system is interactive in the sense that the group members "meet" at the same time although they are physically separated. SCCS are one of the more restrictive forms of the CMCS in terms of the communication modalities it allows. Three characteristics of synchronous CMCS affect information exchange in virtual groups: reduced communication modalities, more uninhibited communication, and more equal participation [McGarth et al., 1994].

Reduced Communication Modalities

Many of the cues present in face-to-face discussion that help regulate the flow of conversation, provide feedback and convey subtle meanings that are not present in virtual groups. The absence of such cues reduces the amount and richness of the information discussed [Hightower et al., 1995, 1996; McGarth et al., 1994].

A number of studies has shown that the total amount of information discussed in virtual groups is less than that in face-to-face groups.Without para-verbal and nonverbal cues, virtual group members are not able to duplicate the normal give-and-take of face-to-face discussions. Comments appear to be sometimes out of context or the conversation may appear to lack focus because multiple group members are "talking" at once. This is exacerbated by the fact that people type and read at different rates. Virtual team members who type slowly or edit more thoroughly may find their comments are no longer relevant when they are ready to transmit them, Moreover, because every group member can transmit their comments simultaneously, group members may be required to process a large number of comments in a short period of time.

Another factor, which reduces the amount of information that a virtual group can discuss, is simply that members must type their comments, Siegel et al. (1986) attributed part of the inefficiency they observed to the fact that using a keyboard to enter comments takes longer and requires more effort than speaking.

The lack of nonverbal and para-verbal cues also reduces the richness of the information transmitted by virtual group members. Daft et al. (1986) define media richness as the ability

of information to change understanding within a time interval. The richness of a medium is determined primarily by the communication modalities it allows. Rich media allow multiple feedback and information cues, for example the words spoken, the tone of voice, and body language. It takes more effort by virtual group members to achieve the same level of mutual understanding in a lean medium, such as CMCS, than a rich one such as face-to-face communication.

The effect of reduced amount of information exchange and lower media richness is that virtual groups may find it more difficult to communicate than face-to-face groups. Virtual groups usually take longer to complete tasks and are less likely than face-to-face groups to reach a consensus [McGarth et al., 1994]. Virtual groups have also been found to spend more time coordinating their activities relative to face-to-face groups [Hightower et al., 1995]. These factors may make it difficult for virtual groups to exchange information effectively.

2.4 Increased Inhibited Communication

Research has shown that virtual group members are more likely to express their opinions and engage in extreme behavior towards others in virtual groups than in face-to-face groups. Siegal et al. (1986) suggest that "anonymity and lowered salience of social controls...leads to feelings of loss of identity and uninhibited behavior." Group members are more likely to respond to others emotionally in virtual groups because they concentrate more on the content of messages than on the message senders.

One result of uninhibited communication is that conflicts are typically more pronounced in virtual groups than in face-to-face groups. In face-to-face groups when the first member speaks, succeeding speakers tend to agree with the first person. This is because group members are often reluctant to contradict the prevailing sentiment in the group [Hartwick et al., 1982]. However, this is not the case in virtual groups. Virtual groups contradict one another more readily because they feel freer to express opinions [Weisband, 1992]. A

willingness to contradict one another and respond emotionally often leads to deeper conflicts in virtual groups than in face-to-face groups.

The effect of uninhibited communication on information exchange is probably positive within certain bounds. A lively debate would presumably increase information exchange but name calling may reduce task-oriented information exchange.

2.4.1 Increased Participation by Group Members

A third CMCS characteristic that may promote information exchange is that CMCS have been found to promote more equal participation by virtual group members. In face-to-face conversation when one person speaks, others must listen. When one person or few people dominate the discussion others don't get the opportunity to speak. People who are more talkative or who have higher social status tend to dominate group discussions [Weisband et al. 1995]. With virtual groups, members can "talk" at the same time so every group member has equal opportunity. CMCS may also reduce the effect of differing social status because they mask physical and social cues by which people judge others.

The extent to which these three CMCS characteristics affect information exchange probably depends on the task faced by the virtual group and the experience the group has with the medium and with each other. The communication difficulty that virtual groups experience because of reduced communication modalities can have a detrimental effect on information exchange. Siegel et al. (1986) suggest that virtual group members may sometimes get frustrated trying to support their viewpoint and will simply state their preference with minimal supporting information. This type of behavior would tend to reduce the effectiveness of information exchange. Previous studies suggest that information exchange is less effective in virtual groups using a CMCS [Highertower et al., 1995]. However, Hollingshead et al. (1993) found differences between face-to-face and virtual groups may depend more on experience with the CMCS and with group membership than on the task facing the group. Those authors were not concerned with information exchange but their findings suggest that differences in information exchange between virtual and face-to-face

groups may narrow as the group members become more familiar with the CMCS and with one another.

2.4.2 Conclusions

Hightower et al. (1998) have realized after conducting three experiments that ad hoc virtual groups exchange information less effectively than face-to-face groups especially when the information load is high. They also came to the conclusion that ongoing virtual groups exchange information more effectively than ongoing face-to-face groups.

The use of ad hoc virtual groups is often considered to be an artificial situation with no external validity. Yet, the decision to form virtual groups is often based on necessity stemming from geographic separation of group members who may have had little experience with one another prior to joining the group. In fact this ability to form groups "on the fly" has been one of the benefits attributed to CMCS. The term virtual implies something that is temporary and without a physical basis like geographic proximity. Heavy reliance on CMCS could make ad hoc groups a common organizational form.

One approach to the problem of improving information exchange starts with Stasser's (1987) information sampling model. According to Stasser's model, group members must recall information, have an opportunity to mention the information, and finally decide to mention it. In order to improve information exchange, researchers should develop systems with features to support these functions, such systems have been called group process support systems [McGarth et al., 1994].

Supporting information recall might be accomplished with tools that help group members structure or organize information. An outliner for example, might help group members to be more thorough in recalling information. A simple "white board" might help to ensure unique information is recommended when it is mentioned.

Giving all members of a group opportunities to contribute is one of the most often cited benefits of electronically supported meetings [McGarth et al., 1994]. By structuring

interaction and providing for anonymous communication, group members who feel uncomfortable or are left out have a means to contribute. Providing group members with the motivation for contributing all that they know can be accomplished in a number of ways. Often a person's membership in a group is based on knowledge they bring to the group. For example, an expert is aware that he/she is part of the group to share his or her expertise and may be more likely to share what he/she knows. Also, group members may know what information is unique and can be more effective exchanging it. On the other hand, an expert may choose not to share certain information for a variety of reasons.

Group members are usually unaware that they do not share information effectively. This raises some concerns about relying heavily on CMCS when effective information exchange is desirable. Yet, end users report that information exchange is one of the primary uses of CMCS. Also with the increasing popularity of the Internet and the accompanying awareness of computer-mediated forms in communication, CMCS will likely become more pervasive [Hightower et al., 1998].

2.5 Communication between Group Members

Information exchange, although constitutes a major and important part of group discussions, is not the only driving force behind such discussions. Group session meetings provide a rich medium of communication. A great deal can be achieved in a setting in which people can see each other and can be sensitive to one another's behavior and reactions. Someone seen tapping their fingers on the table may be clearly annoyed, someone yawing may have lost interest in the discussion, another person leaning forward and pointing may be agitated or trying to make a point forcefully. The richness of the communication media needs to be maintained. The following are some of the elements to be considered when studying group discussions.

2.5.1 Facilitation

An important member of a group meeting if the facilitator. The facilitator plays a key role in healing the group to reach decisions, in managing the shared workspace by deciding who will write on the whiteboard or other shared workspace and in facilitating communication between team members. The facilitator relies heavily on the visual cues to identify when a potential problem is developing, and hence it is important for him or her to see ot know about the human interactions initiated by each of the members in the meeting.

2.5.2 Sharing Information

Sharing of information is essential to prevent unnecessary duplication of effort, and to ensure that all members can assess the same information. The group needs facilities to support input, storage, navigation and retrieval of that information.

2.5.3 Control and Coordination of Shared Objects

Coordination and control of objects that are shared between group members is important for a number of reasons. For example, consider a requirements team attempting to develop a task hierarchy diagram. If the diagram is maintained on paper, then time will be wasted drawing and redrawing the diagram; there are delays in circulating amendments within the team; a number of versions of the diagram can accumulate and become difficult to manage; more than one person may be modifying the diagram at the same time, and there may be proliferation of associated notes, papers and diagrams which become difficult to maintain.

The team needs support such that changes are immediately available to all team members; versions of the diagram and cross-referenced documents are effectively maintained, and multiple amendments can be prevented or controlled.

2.5.4 Sharing of Workplace

Group session meetings are usually supported by the use of a whiteboard or flipchart on which people can write their ideas for other members of the meeting to see. The results of a brainstorming exercise may be recorded, or a list of important items may be developed by the members of the meeting. One person may be responsible for writing on the board, but everyone can see what is written and can suggest changes or additions. Used in this way the whiteboard or flipchart represents a shared workplace.

2.5.5 Organization and Common Understanding of the Work Process

The approach of handling the work processes in a group is what determines the agenda. In general the group will need to agree on the role of each individual, set specific objectives and deadlines, and decide upon some way of keeping informed as to how each person, and group, is progressing. The facilitator plays a key role in doing this. And based on the outcome of this organization, the work and meeting agendas can be determined accordingly.

2.5.6 Decision Making

Central to the requirements of a group is the ability of the group to reach a decision. The decision may be concerned with the objectives of the common task of the group, the method of work to be adopted by the group and the choice of the group members. The process of deciding on a certain point should be outlined and clear to all team members. The facilitator will ensure that once a decision is reached it is clear to all involved.

These elements apply to face-to-face discussions and promote the richness and effectiveness of group discussions. It is imperative that these elements or features be implemented in a CMCS when applied to virtual teams.

2.6 On Approaches of the Evaluation of Synchronous Computer Conferencing Systems (SCCS)

Evaluating how much a SCCS is contributing to the effectiveness of group discussion is a major issue to be studied and analyzed. Early evaluation of SCCS was conducted on the basis of comparing group interaction in the SCCS environment with communication in a face-to-face system [Hiltz et al., 1978]. These evaluations employed a predetermined view of the set of values that characterize an effective communication medium [Adrianson et al., 1991]. For example, Adrianson and Hjelmquist (1991) assessed equality among participants by the number of words contributed by each participant, defining dominant individuals as those who contributed at least 40% of the words. Such studies came in for substantial criticism by social psychologists concerned with the design and evaluation of computer technology, and by sociologists investigating the ways in which computer systems are used in various work settings [Button, 1993].

The general argument against these studies has focused on their rationalist assumptions about the nature of the communication activity involved in SCCS. The key implementation of these assumptions is that the medium or media will have an impact on the mechanism of communication between people. The nature of the communication activity is conceived as a well-defined general system, which is independent of the participants' own construction of their social reality. For example, it is assumed that some communication channels more efficiently facilitate communication exchange between end-users because they enable a higher rate of exchange of "task-related" information relative to that of interpersonal/social information. Such an approach appears to deny the possibility that the form of communication activity and its meaning are negotiated by people. Furthermore, the assumptions are implicitly incorporated in the research approaches adopted, with investigators defining the parameters to "measure" interactions between end-users, independently of the users' own perception of their social context of interaction.

In contrast, assuming that end users dynamically construct the context of their communication activity means that, in a any investigation of "usability" issues, one must take

account of the users' multiple perspectives. Therefore, if the aim of the evaluation is to provide SCCS designers with information about the difficulties end-users encounter, and to suggest possible solutions, it is highly likely that the goal will not be obtained by an evaluation study based simply on a predetermined set of variables for testing and measuring communication difficulties taken from face-to-face settings [Erickson, 1989].

An alternative position assumes that people in everyday work activities (which include the domain of learning) learn to use certain communication arrangements which they use effectively without being fully aware of them – until, that is, they find themselves in a novel situation (as with the introduction of as SCCS), where because of new environmental, social or other constraints they cannot apply those arrangements any longer. For instance, Heath and Luff (1991) in an observation study of end-users' interactions via a video system concluded that "certain actions appear to lose their communicative impact when performed through video..." and that "despite having the facility to witness a co-participant's usual conduct...many actions which are performed non-verbally do not achieve sequential informative significance in the interaction". These seem to be usability problems to do with social communication and or interaction [Kurlan at al., 1996].

With these thoughts and studies going on, the process of evaluating how effective SCCS systems are is still debatable and is linked to the level of flexibility in collaborative distributed work.

2.7 Coordination Breakdowns: How Flexible is Collaborative Work?

The psychology of computer users is by no means fully understood. Hence there are many uncertainties in software design, and especially interface design. Many software products succeed not because they are designed to suit their users, but because the users can adapt to suit the software. The question then for CMCS is whether collaborative work is equally adaptable.

Collaboration is not easy, even between consenting participants. Effort is needed to maintain the relationship and negotiate the nature of the task, in addition to the effort required to make progress on the task. There are two key factors that are worth further investigation:

Shared understanding: to what extent do collaborators need to develop and maintain a "shared understanding"? Furthermore, if we describe two people as having a shared understanding, what claims are we making about the mental representation and cognitive states of the two people?

Conflict: how do collaborators deal with conflict? Does conflict affect the development of a shared understanding, and if so how does collaboration proceed even in the presence if conflict?

Both these concepts lie at the intersection of causal and cognitive activities. Hence, they can only be adequately explained through a framework which integrates the social and cognitive perspectives. There have been few attempts to develop such a framework. Kuutti et al. (1993) define three perspective or "levels", which they term the work process level, the conceptual level and the technology level. They suggest that activity theory may provide an integrative framework, as it seems to offer some insight into the way in which artifacts, including software tools, are used in context.

Activity theory shifts the emphasis from individual tasks to groups and work practices, but does not account for shared understanding. In contrast, distributed cognition treats a group of individuals and the artifacts with which they interact as a single cognitive system. Methodologically, distributed cognition applies micro-level analysis to group interaction to reveal how, for example, knowledge is passed between individuals. However, neither framework adequately tackles a key problem in software design. Introducing a new software system into an organization changes that organization. For the software designer, the nature of these changes is difficult to predict. Existing analytical frameworks, including activity theory and distributed cognition, offer detailed explanations of group activities, but do not adequately predict how those activities will change in reaction to new software systems. In part, this is due to a failure to produce abstract description of collaborative behavior, which

are robust enough to predict the effects of various design solutions. The framework introduced in Chapter 3 is an attempt to provide an abstract characterization of coordinated behavior, to bridge the gap between the requirements gathering and evaluation of CMCS systems.

The next section will illustrate the problems faced by the CMCS developer, by considering the ways in which a simple communication system such as electronic mail can introduce unexpected coordination problems. The analysis of email, though brief, should serve to illustrate the emphasis on coordination breakdown as a key observable phenomenon in coordinated activity. Then the definition of the terms "shared understanding", "breakdown", and "conflict" are presented by considering the relationships between participants' mental models of a situation. Then an analysis of how the various mechanisms of interaction affect the development of shared understanding and the occurrence of coordination breakdown [Easterbook, 1996].

2.8 Email and Communication Problems

Electronic mail provides a rich source of data about the effects of group support systems, partly because its use is now so widespread. Because of its simplicity, many users overlook the radical changes it can bring to organizational behavior. However, various studies have revealed the extent of these effects.

2.8.1 Advantages of Email

Email has a number of obvious advantages over other forms of communication:

Message delivery is fast, even compared to the telephone, as there is no need for both parties of the exchange to be available, simultaneously.

Contextual information is included automatically. The header of a message contains the message's sender, audience, subject, date of creation, and possibly a reference to a previous

message in an ongoing conversation. All of this may help the recipient to interpret the message better.

Messages are not momentary. Once received, they can be read, archived or forwarded to other individuals.

Despite these advantages, or in some cases because of them, email causes misunderstanding, and can lead to greater conflict than other forms of communication.

2.8.2 Conflictual Feature of Email

There are a number of important features of email that contribute to miscommunication:

- Lack of status cues: Email messages do not convey the status of the sender, nor the social context in which the message is sent.

- Isolation from audience: Kiesler et al. (1984) point out that email fails to provide "individual details about people that might be embodied in their dress, location, demeanor, and expressiveness". Worse still, mailing lists give no indication of the range or number of people on them.

- Easy access: Anyone can send and receive email, given a terminal and the necessary organizational infrastructure. In particular, it is as easy to send a message to a large group of people as it is to a single person.

- Immediacy: composing and sending a message can be combined into a single task, with no opportunity for reflection on the content or distribution. On receiving an email message it is easy to compose and send an instant reply. This invited informality not present in other forms of written communication.

- No regulatory feedback: There is no possibility for adapting the tone or contents of a message in response to feedback from its recipients. This itself would not be so much of a problem if email did not have the immediacy and informality described above.

- Lack of inflection: Email messages are restricted, in general to text. This makes it hard to express humor, irony and sarcasm, and to convey the mood of the sender.

These features have led to a number of observed problems:

- Established organizational and cultural norms are disregarded. Messages are inadvertently sent across hierarchical, organizational and cultural boundaries where other forms of communication are restricted. Hence, messages might not contain the appropriate diplomacy, difference or tact. Furthermore, there is little clue when this happens. Social blunders and indiscretions often go uncertified.

- Messages circulate too widely. A common error is to send a message to too large a set of recipients. Messages at peers are sent to the entire organization. Messages aimed at people in the same locality get distributed across continents.

- Requester-informers imbalance. Email users find it easy to "delegate" work to others. The tasks off-loaded are often information requests, where the task of retrieval becomes trivial for the sender of the message at the expense of the receiver.

- No reflection. The immediacy of the medium encourages people to send messages which, given time to reflect, they would moderate or not send at all. In particular, there is a tendency to be overhasty in replying to messages that provoke strong emotional reactions.

- Humor and irony cause misunderstandings.

2.8.3 Coping Strategies

Email makes virtually no assumptions about the nature and structure of collaboration, and the ability to send electronic messages to one another offers a number of obvious benefits. The range of problems described above seems inconsistent with the simplicity of the medium.

Protocols surrounding the use of emails have emerged gradually, as coping strategies. These often take a long time to evolve, and rely on the flexibility of the users. Examples include emoticons (made of ASCII characters) to indicate that a comment isn't totally serious. Such devices act as a substitute for other missing cues, and help to ensure that a message is understood in the way it was intended. In other words these devices help users to maintain a shared understanding of the communication process.

2.9 Definitions

In order to predict more accurately the impact of a new software system on group interaction, a better interaction of that understanding is required. First, the definitions of the terms shared understanding, breakdown and conflict will be given then followed by the role that these play in group interaction.

2.9.1 Shared Understanding

Two or more people have a shared understanding of a situation if they have equivalent expectations about the situation. The term "expectations", in this context, refers to the predictions that team members have about how the situation may develop. It is assumed that many expectations are based on some form of mental model of the situation.

The role of the situation is crucial. Outside a particular situation, there is no guarantee that a shared understanding will hold, as there is no guarantee that the participants will generate the same expectations in different situations. By "situation", I mean an episode of interaction and the environment in which it takes place.

A shared understanding may be fragile or robust, depending on whether it still holds in different situation. If it is very robust, it may well be the case that the participants have identical mental models. However, it is expected that this may be hard to determine. In practice we do not worry about whether mental models are identical, as we do not wish to make any claims about how the participants derive their expectations. Nor can we expect to

observe reliably the application of a shared understanding to different situations, in order to measure robustness. However, we can sometimes detect when a shared understanding has failed to transfer to a new situation, in the occurrence of a coordination breakdown.

Note that shared understanding does not require the participants to know whether they have it. Secondly, we must distinguish between knowledge, as facts or assertions that are generally true about the world, and models, which are constructed by participants to explain or reason about situations.

2.9.2 Coordination Breakdown

It is often the case that a person's expectations about a situation are not borne out. A coordination breakdown is a mismatch between the expectations of one participant and the actions of another. The event that causes the breakdown may be a communication act. The mismatch might be the result of an error of the communication or of perception by either party or a difference in understanding the situation.

Our interest in breakdown is twofold. Firstly, it provides an analytical tool through which we can study the development of shared understanding, by identifying the limits of that understanding. Secondly and perhaps more importantly, breakdown has an important role in coordination behavior, as it allows participants to discover assumptions and conflicts.

The breakdown forces the participants to consider explicitly what had previously been assumed – that they share an understanding of the situation.

2.9.3 Conflict

Conflict is closely related to breakdown. Putnam et al. (1987) define conflict as "the interaction of interdependent people who perceive opposition goals, aims, and values, and who see the other party as potentially interfering with the realization of these goals."

This definition acknowledges that conflict has as much to do with perception and potential as it has to do with action and actuality: a neutral observer may find nothing of substance

underlying the conflict, but this does not make the conflict disappear. Easterbook et al (1996) present a detailed survey of the literature in conflict, drawn from a range of disciplines.

Joiner (1993) has developed a model that is based on empirical findings; the model explains the role of conflict in peer interaction. He categorizes conflict as a result of differences in representations, beliefs, or task focus.

The relationship between shared understanding, breakdown, and conflict is shown in Figure 1. Harmonizing mechanisms are the features of interaction which assist with developing shared understanding; such as dialogue rules, gesture, facial, expression, eye contact, shared focus, shared reference, and mutual knowledge.

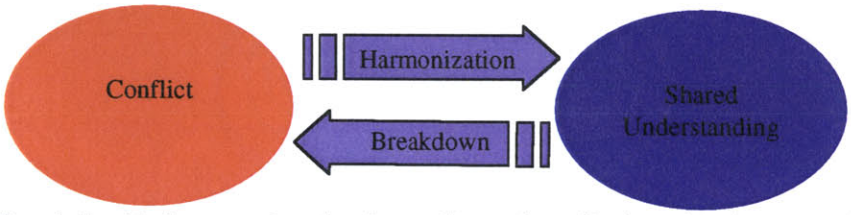

Figure 1. The relationship between shared understanding and conflict in a virtual group setting [Kurlan et al, 1996]

Having defined shared understanding and conflict, I will define some of the mechanisms by which groups react to the several situations resulting from the presence or absence of either shared understanding or conflict:

Shared understanding provides a basis for communication and coordinated action. Without a shared understanding, participants are unable to anticipate correctly the actions of their colleagues. Communication would require far more effort, as each communicative act may require explanation.

Conflict provides a stimulus to explore models, this prevents a group stagnating and promotes change. Difficult conflicts may also be the main inspiration for creativity, in that participants are forced to look outside the existing set of ideas for a way forward.

Because each condition has a number of benefits, a productive group will be in a state of flux between shared understanding and conflict. The group will be dynamically developing conflicts and using shared understanding to resolve them. However, shared understanding is not always desirable, because of the effort required to develop and maintain it. Breakdowns reveal where assumptions have been made about the extent of a shared understanding. Before the breakdown, the assumption served perfectly well. This fits with the observation that mental models are constructed only if they are needed.

Team models might be very simplistic, perhaps even not available to conscious reflection, or they might be very detailed and explicitly shared. The degree to which team models are made explicit and shared will affect how well the team can exploit breakdown and conflict. Confusion occurs when a team model is no longer accurate. This may be because the situation has changed, because individual mental models have evolved, or merely because the team model is too vague, or never was accurate.

If a new team model is developed rapidly in response to a transition, the confusion will be short-lived. If the transition is deliberate, such as an explicit, successful resolution of a conflict, the team model might be updated immediately. Note that in any case, the new team model may take time to internalize and to supplant existing models. This may prolong the confusion [Easterbook, 1996].

2.10 Organization Culture

Several cultural barriers to conducting operations in a virtual setting should be expected. These usually arise from having to define new ways of assigning credit for reports, to finding ways to keep middle level managers involved, to overcoming a historical predisposition to protect information rather than sharing it.

Analysts have always strained against the restrictions to gather information from whatever source possible, including their counterparts at other agencies. The provision of an online conferencing and document exchange tool will raise the possibility of sharing selected

information, interim analytic results, working aids, and final product among the staff across agency boundaries. This is revolutionary and will open many questions in the organization, including:

- When multiple internal elements coordinate on a product, who "owns" the final report?
- Likewise, when multiple agencies are involved, who owns the material produced collaboratively?
- What happens to the existing hard copy-oriented workflow model for analysis when everything is now exchanged online? Where is the accountability? Where is the log?
- What does it mean to work virtually? How will I know when I've completed an action?
- What role does mid-level management have in the process now? Is there a role?
- What is to keep the analysts from giving away their findings to some other analytic team?
- How will I control my people?
- How do I find someone to help with a problem? How can I find an expert in X? How can I advertise my expertise in Y?
- I have a team of solitary persons. How can I ease them into working as a team with others?

While some questions can be answered as a result of the existing collaboration experience, other questions remain unanswerable. In many cases, the old business processes cannot be re-mapped into a virtual world, and should not. Some tasks will no longer be needed as their

function is taken over by an online system. Some mid-level managers are real barriers to productivity, and virtual teaming only highlights this fact in high contrast.

It should also be noted that technology transfer is not largely a technical activity, but rather a human or organizational one. Without a doubt, technology must support the mission and be shown to be efficient, state-of-the-art, and capable. But, technology transfer, in the long run, depends on persistence. In many cases, resistance to change has to be simply outlived and worn down.

CHAPTER THREE

CRITICAL SUCCESS FACTORS FOR VIRTUAL TEAMS

The business justification for virtual teams is strong. They increase speed and agility and leverage expertise and vertical integration between organizations to make resources readily available. Virtual teams also lessen the disruption of people's lives because the people do not have to travel to meet. Team members can broaden their careers and perspectives by working across organizations and cultures and on a variety of projects and tasks.

Although the effective use of electronic communication and collaboration technologies is fundamental to the success of a virtual team, virtual teams entail much more than technologies and computers. Virtual teams and their leaders rarely mention technology as a primary reason for their successes or failures.

There are seven critical success factors for virtual teams. Technology is only one. Others are human resource policies, training and development for team leaders and team members, standard organizational and team processes, organizational culture, leadership, and leader and member competencies. These are discussed in more detail later in this Chapter.

Of course, all the critical success factors do not have to be in place for a virtual team to succeed. The implementation of virtual teams within an organization can actually push toward the attainment of critical success factors. Successful virtual teams seem to demand certain conditions, and the existence of the teams will, over time, help to create the infrastructure conditions that make them work.

3.1 Seven Critical Success Factors

Studies conducted by Duarte et al. (1999) and Haywood (1998) have revealed seven factors that affect the probability of a virtual team's success. These factors, listed below, will be used as the basis to form a step-by-step process to manage virtual teams.

- Human resource policies
- Training and on-the-job education and development
- Standard organizational and team processes
- Use of electronic collaboration and communication technology
- Organizational culture
- Leadership support of virtual teams
- Team-leader and team-member competencies

The following discussion describes the seven factors and tells how team leaders can help to create the conditions that lead to success.

3.1.1 Human Resource Policies

Human resource policies should support working virtually. Systems must be integrated and aligned to recognize, support, and reward the people who work in and lead virtual teams.

The use of career development systems, acknowledging cross-boundary work, and proving resources for virtual work are just a few of the possible tasks that can be done in this area.

3.1.1.1 Career Development Systems

Team leaders can help to support virtual team members by providing career opportunities and assignments that are comparable to those in traditional team settings. That can be done by applying promotional and career development policies and actions fairly to people who work in virtual settings. This also reinforces the perception that working virtually is an accepted career option. Virtual team members often mention that they fear that they will be looked over for promotional opportunities because they are not seen every day. This fear is not unfounded. Managers who loose visual and verbal proximity to their employees often put up the strongest resistance to alternative work and team arrangements [Apgar, 1998]. Virtual team leaders must ensure that the members of virtual teams have the same career development opportunities as the members of traditional teams.

3.1.1.2 Rewarding Cross-Boundary Work and Results

Organizational reward and recognition systems often favor individual and functional work. Virtual team members, however, frequently operate in a cross-functional and/or cross-organizational environment. Changes must be made in the ways in which people are recognized and rewarded. Leaders must develop performance objectives for team members that include working across boundaries and sharing information to support virtual teamwork.

In addition, performance measures must be adapted to reward results. In a traditional office environment, where people are seen putting in effort every day, it is relatively easy to at least partially reward people for effort as well as results. In a virtual environment it is more difficult to differentiate.

The use of formal and informal public recognition of virtual teamwork through "on the spot" awards. Bonuses and other mechanisms can reinforce the perception that working virtually is valued. You can use web-based technology, such as setting up a site for virtual

team "best practices" and advertising team successes and performance, as a way to publicly recognize people in a virtual setting. You can also mention examples of your virtual team's success in speeches, presentations, and discussions with other team leaders and with management.

3.1.1.3 Providing Resources and support for Working Virtually

Create and support policies that provide your team with technical support for working remotely. All team members should have equal and immediate access to electronic communication and collaboration technology, training and technical support. Many team leaders set a standard for technology and make certain that everyone has access to the same hardware, Intranet and Internet connections, and applications. They ask the information systems group to assist in the implementation.

3.1.2 Training On-the-Job Education and Development

Formal training in using technology is vital for success. In addition to a formal training curriculum, make certain that the team members have continual access to on-line training and technical support. It should be feasible for your department or organization to create and implement these types of systems. The training, tools, and support should be upgraded on a regular basis to ensure that they are state of the art.

Learning how to use technology is not enough to guarantee success. Team leaders should make certain that they get the training and support they need to be adept at facilitating meetings using technical and non-technical methods. Training in facilitation skills should be an integral part of a development curriculum for team leaders and team members.

Provide training and support for your team in working collaboratively across organizational, cultural, and functional boundaries. Many organizations provide direct consulting support and training to virtual teams in this area.

Create and implement systems for sharing knowledge across functions, projects, and organizations. Shared lessons, databases, knowledge repositories, and chat rooms are used in organizations that embrace virtual teamwork.

3.1.3 Standard Organizational and Team Processes

Consider developing and implementing standard team processes. The use of standard processes reduces the time needed for team startup and may eliminate the need for unnecessary reinvention of operating practices each time a team is charted. Practices need to be flexible, however, to promote adaptation to a particular virtual team's situation. Common standard technical processes, especially for parallel, project, or network teams include:

- Definition of requirements. Possible by defining an approved standard such as IEEE to be used as a baseline for defining the requirements.
- Estimates of costs. Can be done by defining a set of cost estimation equations (empirical or developed internally) to get preliminary cost estimates of product development.
- Procurement. Achieved by outlining the flowchart for procuring material necessary for the development of the product.
- Team charters. Provide a sample charter document that can be adjusted to the groups objectives easily without involving lots of formality checking.
- Project planning. Specify the project planning tools to be used in virtual teams. Such tools include software packages and scheduling techniques.
- Documentation. Controlled by a document specialist that specifies standards for version control of documents and checking-in and checking-out procedures.
- Reporting. Possible by defining the several types of reports that can be submitted, priority of each type, and method of submittal of each type.

It is a good idea to define the preferred software for each of these major processes. Many organizations use standard project management software packages so that any team, virtual or co-located, is familiar with and trained in using that package. Also have agreed-upon team processes in "soft" areas, such as the establishment of team norms, conflict resolution procedures, and communication protocols. Experienced virtual teams prepare team charters that delineate suggested team norms and communication standards. They use these as starting points to create processes suitable for their unique situations. Reinforce and expect the use of both technical and soft processes from the team.

3.1.4 Electronic Collaboration and Communication Technology

As a virtual team leader you will need to select electronic collaboration and communication technology that meets the needs of your team. You also will need to ensure that the organization is ready to support your technical needs. Introducing the electronic communication and collaboration technology needed for virtual teamwork, such as desktop video conferencing or groupware, requires that three primary organizational conditions be in place [Perey, 1997]:

1. The organization has a well-funded, respected and established information system staff, whose members are experienced in installing and supporting electronic collaboration technologies in many different locations.

2. There is a commitment by the organization to keep personal computer systems as up-to-date as possible, regardless of a person's title or duties. When systems fall behind, the cost of upgrades and the time to introduce them mounts quickly. Productivity may also fall as people spend time attempting to fix their equipment or work around it.

3. The organization has a well-maintained corporate network that has room to expand to meet the needs of more complex systems and users.

If your organization is lacking in any of these three areas, you might consider adopting a less complex suit of technology that is if they are in place. In either case it is important to select a

reasonable set of standards for your team in electronic communication and collaboration technology. Standards should meet the business needs of the team and match its mission and strategy [Perey, 1997]. A global team that needs to communicate and work collaboratively, for example, must have a minimum set of standards for technology. For communication, this includes touch tone telephones, audio conferencing equipment, voice mail, fax capability, and access to a common e-mail system that allows people to send messages and exchange files. Video conferencing, scheduling, real-time data conferencing, electronic meeting systems, collaborative writing tools, and whiteboards can be added if the strategy calls for intensive collaborative work or if sufficient information systems resources exist to make the technology work reliably. Make certain that external partners and suppliers have access to compatible communication and collaboration technologies if they are considered part of the team.

Ensure that skill in using the electronic communication and collaboration technology is equally distributed among team members from different functional area, geographic locations, and partner organizations. Often skill in, access to, and use of electronic communication and collaboration technology is more prevalent in technical functions, such as engineering and information systems, than in less technical areas, such as marketing, human resources, and finance. If this is the case, there is a risk that team members from less technical areas, if they are not able to use the technologies well, may be perceived by other teammates as having less status [Duarte, 1999].

Ensure that the technology used by each virtual team is available to all team members, wherever they are located. In some situations, the members might be located in different countries, each with a certain level of technological advancement. This provides some members with newer forms of technology which might not be attainable at the other country. And that usually results in lack of coordination and inefficiency in adopting virtual meetings using the different technologies.

Finally, factor electronic collaboration hardware and software directly into the team's budget [Duarte, 1999]. It is important to recognize that the benefits of technology grow over time.

Virtual teams do reduce costs, but often there is an up-front and long-term investment for technology and training to make them work effectively. The more people and teams work virtually, the more quickly these business practices will translate into savings.

3.1.5 Organizational Culture

Organizational culture includes norms regarding the free flow of information, shared leadership, and cross-boundary collaboration. Help to create organizational norms and values that focus on collaboration, respecting and working with people from all cultures, keeping criticism constructive, and sharing information. The organization culture sets the standard for how virtual team members work together. An adaptive, technologically advanced, and nonhierarchical organization is more likely to succeed with virtual teams than is a highly structured, control-oriented organization [Apgar, 1998].

The success of virtual teams is related to how the organization fosters or impedes trust between itself and its external partners. Treating partners as less that equal, hoarding information, forgetting to share data or results in a timely manner, and using competitive or proprietary information inappropriately can erode trust quickly.

If the organization is multinational or global, norms must honor different ways of doing business if they are to be effective. Create policies about how to do business in different cultures. Be aware that legal issues, such as who owns the copyright to product designs, can become murky when teams are working across national boundaries.

Many virtual team leaders cannot affect organizational culture with the same effect, as can senior mangers. It is possible, however, to create a "microclimate" that supports effective norms and values. Team leaders who act in a conscious manner to build trust across boundaries and to share information and power create environments in which this type of culture can grow from the ground up.

3.1.6 Leadership

For virtual teams to succeed, the organizational leadership must establish a culture that value teamwork, communications, learning and capitalizing on diversity. The key to establishing an organizational culture that promotes virtual teamwork is that managers and virtual team leaders at all levels must be open to change and must support virtual teamwork. Richard Karl Goeltz, vice chairman and chief financial officer of American Express, notes, "It's important to have a multifunction team of [senior] managers promoting and supporting a virtual office initiative right from the start." [Apgar, 1998]

Virtual team leaders and members can help managers to develop supportive behaviors. They can offer specific suggestions to management regarding the four categories of leadership behaviors that encourage virtual team performance: communicating, establishing expectations, allocating resources, and modeling desired behaviors.

First, it is critically important to communicate throughout the organization that working across time and distance and with organizational partners is not just a temporary fad but a new way of doing business, one that leverages knowledge and skills and capitalizes on diversity. This includes assigning virtual teams important and high-visibility tasks and projects and reporting benefits and results of their work so that virtual teamwork is respected in the organization.

Second, it is important to establish clear expectations about how virtual teams work. Procedures and goals must be clear, so that virtual team members know how they are to work and what their objectives are. With all the new things they must learn about operating in a virtual team, the team members of the organization also need to understand how virtual teams operate and that the teams' end goals are aligned with organizational objectives and are, in effect the same as those of co-located teams. Setting high expectations for performance also strengthens the perception that virtual teams deliver results.

It is also important to gain the support of customers and other stakeholders by helping them to see the benefits of virtual teamwork. This includes establishing expectations about virtual

work environment and how virtual teamwork is going to affect their contacts with team members. Leaders must stress the benefits, such as lower costs and what the stakeholders have to gain, and find ways to make customers part of the change. One best practice is to invite external customers who work with virtual teams to team kickoff sessions in which norms and communication plans are discussed. Customers and other stakeholders also can be offered training in team technology. Customers can be provided with software to "sit in " on team meetings. This helps customers who are unsure of the virtual team approach to become more comfortable with it.

Leaders who can work with stakeholders such as leaders and managers from other functions, or suppliers who interface with the teams, to help them understand and support the virtual team concept. They can make it clear to peers and to other managers in the organization that virtual teams work as hard and as productively as co-located teams. Leader can become adept at providing evidence, including schedule and cost data, to sway more skeptical stakeholders. Finally they can help to establish reasonable expectations about the time it takes to realize a return on the investment, the paradox is that the complexities of working across time and distance can, in the short run, lead to increased costs and longer cycle time because difficulties with operating procedures and startup issues [Grimshaw, 1998].

Third, leaders who allocate resources for training, technology, and travel send strong signals that bolster the message that virtual teams are important. Chartering virtual teams to work in an under-funded environment is a prescription for failure. Time and money must be allocated for training virtual team members in areas such as cross-cultural work, project management, and technology. Time and money must be allocated for team leaders to travel for face-to-face meetings with team members at the beginning of the team's life and then when necessary. Resources also must be dedicated to acquiring and maintaining the technology needed to facilitate the teams' work.

Forth and most important, effective team leaders model the behaviors they expect. They align cross-functional and regional goals and objectives. They work with other managers across geographic and cultural boundaries. They solicit team members' input and

demonstrate trust in their judgement, particularly in the members' functional areas of expertise. Effective team leaders show flexibility, changing as business conditions dictate. They do not expect behaviors from others that they do not engage in themselves.

3.1.7 Team-Leader and Team-Members Competencies

The seventh success factor is related to the quality of the people involved in working in a virtual setting. As in any other setting, there are only a certain type of people who are qualified to take on the job in a virtual setting, and not any experienced person accustomed to co-located groups can easily shift to distributed groups.

3.1.7.1 Team Leader Competencies

The challenges that virtual team leaders face are immense. Many report that they feel that they are the "glue" that hold their team together [Duarte, 1999]. They have to establish trust in an environment with little or no face-to-face contact or feedback. These challenges necessitate the development of an additional set of competencies that complement the skills for leading traditional teams. These competencies are as follows:

1. Coaching and managing performance without traditional forms of feedback. New methods of monitoring the work of the team members should be adopted. These methods should rely heavily on the use of CMCS and be available at all locations.

2. Selecting and appropriately using electronic communication and collaboration technologies. The choice of what type of electronic media and the type of collaboration technology has a great influence on the group's productivity. The team leader should be able to choose wisely based in the type of worked involved in the collaborative setting.

3. Leading in a cross-cultural environment. Being a leader in traditional settings is quite different than a leader in a cross-cultural environment where team members might be from different cultures that view and respect leaders to different levels.

4. Helping to develop and transition team members. Sometimes it is up to the team leader to transition a certain team member from working in a co-located group to working in a distributed environment.

5. Building and maintaining trust. Building trust between people that hardly meet face-to-face is a difficult task. And it is up to the team leader to ensure that team members respect and trust their counterparts. That can be achieved by picking members based on their reputation of delivering on time and to quality from the beginning of the project.

6. Networking across hierarchical and organizational boundaries. Working in a virtual group requires lots of support from external forces as well as from partners involved in the work. The team leader has the role of securing this support and ensure that the resources for his team are available when needed.

7. Developing and adapting organizational processes to meet the demands of the team. Being a team leader also implies being a project manager and that entails that the team leader should be knowledgeable in managing and organizing processes for product development.

Team leaders can champion their own development by deliberately undertaking training and on-the-job assignments that build competence in these areas.

3.1.7.2 Team-Member Competencies

The people who work as virtual team members have to develop their own competencies. First, virtual teamwork is not for everyone. Serving on a virtual team may seem too transitory for some individuals who need face-to-face interaction and stability in a work environment. Without the structure of a co-located setting and day-to-day contact with team members, they may feel lonely or left out.

All members of traditional and virtual teams need solid grounding in their respective disciplines. However, virtual team members need new competencies. Team leaders can help to facilitate competence development by working with team members to create learning

plans that use training and on-the-job assignments. The definitions of team members' competencies will vary, depending on the team's type, mission, and composition. There is, however, a relatively stable set of six critical competencies:

1. Project management techniques. Due to the absence of the project manager from some locations, team members should be able to manage their own tasks and stick to the overall schedule given by the team leader.

2. Networking across functional, hierarchical, and organizational boundaries. Again the team leader might be absent from certain locations which might require the interaction with managerial levels and other external organizations. The team members should be able to handle that interaction in such situations.

3. Using electronic communication and collaboration technologies effectively. Since the use of technology is the backbone of virtual teams, team members should be competent in using the technology involved.

4. Setting personal boundaries and managing time. This relates to the first competency which suggests that team members have managerial skills as well.

5. Working across cultural and functional boundaries. Sometimes it is not enough to carry out the interactions between the cross organizations as shown in the second competency. It is also required that the team member be able to act as an ambassador of his team to the external world, he or she should be knowledgeable enough about he project to be able to handle all possible situations that arise when dealing with external organizations.

6. Using interpersonal awareness. Due to the multi-nature of the tasks appointed to virtual team members, they should be aware of their major roles and be able to deliver what is required of them as a first priority.

Over time, most people can develop competencies that are needed to work virtually. Adequate training, education, and leadership support and feedback can speed up development.

3.2 Starting a Virtual Team: Six Major Steps

After reviewing the different processes suggested by Lipnak and Stamps (1997), Haywood (1998) and Duarte and Snyder (1999) I have come up with a six-step process involved in starting a virtual team. The six steps are the following:

1. Identify team sponsors, stakeholders, and champions
2. Develop a team charter that includes the team's purpose, mission, and goals
3. Select team members
4. Contact team members
5. Conduct a team orientation session that includes orientation of the task, team norms, technology planning, communication planning, and team building
6. Develop team processes

Many of the six steps are also appropriate for the traditional teams. For a virtual team, however, each step has the underlying objective of providing structure and support in bridging time and distance.

3.2.1 Step 1: Identifying team sponsors, stakeholders, and champions

Because the success of a virtual team often involves effective interaction with, and the participation of constituents from a number of functions, locations, and external organizations, virtual team leaders need to ensure from the start that they have the strong support of sponsors, stakeholders, and champions. Sponsors, stakeholders, and champions

link the team to the management power structure across locations and organizational boundaries.

3.2.1.1 Sponsors

A sponsor is the person (usually a member of management) who works closely with the team leader and who acts on the team's behalf to cross organizational barriers, resolves conflicts of interest, obtain resources, and provide a link with upper management. It is vitally important that every team have a sponsor who is strategically positioned in the organization. The sponsor should have a broad perspective, be respected by all appropriate constituents (such as external organizations and supporting functional areas), be influential, and be able to obtain resources.

3.2.1.2 Stakeholders

When a virtual team is created, it is also imperative that the team leader identify the stakeholders who have the greatest impact on the team's success and those who will be most affected by the team's results. Stakeholders may be individuals form different functional areas, regions of the world, levels of management, and partner organizations. The virtual team leader should take the time to map the team's inputs and outputs and relate them to appropriate stakeholders. If the team has an identified client or an existing sponsor, that person may be able to assist in this activity.

3.2.1.3 Champions

A champion, although further removed from the team's activities than sponsors and stakeholders, may be able to find resources, promote the team's activities, remove barriers, and provide advice. A champion frequently has a strong interest in the team and may be found in different functions, regions, and in partner organizations. It is best if the team's champion is a member of the organization's top management, because part of the champion's role is to assist in the attainment of resources and to create perceptions of the virtual team as successful and productive [Duarte, 1999].

Table 2. provides a strategy for mapping and identifying sponsors, stakeholders, and champions. It also presents a starting point for planning communication and boundary –management activities.

3.2.2 Step 2: Developing a Team Charter that Includes the Team's Purpose, Mission, and Goals.

It is necessary to have a clearly understood statement of direction at the beginning of any team. The charter serves as a point of departure for more detailed plans. For traditional teams, if the starting point is properly aimed, the day-to-day contact of the team members can add meaning and reinforce shared understanding between team members. The strategy that results from day to day interaction tends to facilitate a smooth transition from the charter to other activities. For virtual teams, the lack of physical contact may erode meaning and understandings and make the link between charter and work more difficult to achieve. For this reason, preparation must be more thoroughly planned and reinforced.

Table 2. Identification of sponsors, stakeholders, and champions [Duarte, 1999]

Requirements	*Can Remove Roadblocks*	*Has Cross-Cultural Experience*	*Is Responsible Across Functions or Organizations*	*His or Her Organization Has A Stake in the Outcome of the Team's work*	*Can Provide Relevant Technical or Political Input into the Team's Work*
Sponsor: ***Importance*** *High* **Medium** **Low**					

Table 2(Cont). Identification of sponsors, stakeholders, and champions [Duarte, 1999]

Requirements	*Can Remove Roadblocks*	*Has Cross-Cultural Experience*	*Is Responsible Across Functions or Organizations*	*His or Her Organization Has A Stake in the Outcome of the Team's work*	*Can Provide Relevant Technical or Political Input into the Team's Work*
Stakeholder: ***Importance*** **High** **Medium** **Low**					
Champion: ***Importance*** **High** **Medium** **Low**					

Names of Potential Candidates:

Sponsor	
Stakeholders	
Champion	

Most virtual teams have extended membership throughout the organization and beyond. Stakeholders, even if they are not part of the day to day work, they need to be included in creating the team charter. The task of developing the team's charter is overlaid and effected by equally important set of tasks having to do with ensuring "buy in," participation, and input. Eliciting this support early in the team's life cycle helps reduce the number of issues that may arise later and which may stem from conflicts of interest, shifting priorities, and loss of resources. Because virtual teams cross so many boundaries, the potential for conflicts of interest or priorities is great.

Many organizations use a standard set of elements for a team's charter. Some project management software packages also provide templates for team charters. The best format is one that is familiar to the team's stakeholders, clients, and team members.

Sometimes the team is provided with the charter's content. If so, all that remains is to validate the information with the team's sponsor, stakeholders, and client and to make sure that all the immediate questions and concerns are answered. It is generally a good idea to plan the validation session so that all the important stakeholders can interact in real time. If the project is complicated, a face-to-face session is especially recommended. If this is not possible, desktop video with data-conferencing capabilities for reviewing documents is the next best option.

When a virtual team has been working for sometime but does not have a well-stated charter, the "new" virtual team leader must create one. Developing a team's charter in a manner that facilitates interaction and participation from all stakeholders is best done in a face-to face or synchronous meeting, especially if the team's task may later have to address issues regarding conflicts of interest or resource allocation. A less preferable option is to conduct the session remotely, in real time, using video conference, desktop video with text and graphics, or audio conference with text and graphics. The least effective method is to use an asynchronous method, such as e-mail or voice mail, in which the virtual team develops the materials and

forwards them to each stakeholder or member of the management for comment and validation.

If a videoconference is the selected technology, make certain that the video system is of sufficient fidelity to not be a distraction for the attendees. Choppy pictures that result from the outdated or inadequate technology hinder effective interaction. Especially after the introductions, many participants find that video does not add much to ensure task performance.

Table 3 provides a suggested agenda for a meeting to validate a team's charter.

3.2.3 Step 3: Selecting Team Members

When the sponsor, stakeholders, and champions have been identified and the charter has been approved, the team leader can begin to identify team members. Sometimes, especially in the case of work teams, tam members already belong to the team. The optimal situations, however, is to have the freedom to identify and select members who meet the demands of the task and who are well-suited to working virtually.

Most virtual teams have at least three types of team members (figure 2): core, extended, and ancillary. Core team members are accountable for direct task output. Core members may include employees form distant locations, vendors, suppliers, and customers. Extended team members do not usually work with the team on a daily basis but provide expert support or advice when necessary. Extended team members may be internal or external consultants, sponsors, and stakeholders. Ancillary team members do not work on the team but review and approve the team's work and deliverables. Ancillary team members include the team's client, major stakeholders, and certain high-level managers. It is possible depending on the type of the team, the point in its life cycle, and its structure, that the team membership may be dynamic, with certain members moving from one category to another.

After identifying the team members who appear to meet the team's requirements, it may be a good idea to check the logic of the selection (and the reputation of each team member) with

the sponsor and a few stakeholders or champions. Sometimes a person has a good reputation but is not respected in other parts of the organization or in other functions. In

Table 3. Agenda for validating a team's charter - This agenda can be adapted by a facilitator for a distributed format [Duarte, 1999]

Activity	*Estimated time*
Send agenda, draft of team's charter, potential schedule, review schedule, and other relevant information to all participants at least one week before the meeting. Be certain that each person has all elements of the charter in front of him or her when the meeting begins	N/A
Begin the session by introducing yourself, the agenda, and the outcomes (approval of the team's charter, mission, purpose, and goals). Ask for feedback on the agenda. Make changes if necessary and announce team to the group	15 minutes
Have the team's sponsor provide a short overview of the team and its history. Have stakeholders introduce themselves and their roles as well as the team members	30 minutes
Go through each element of the current charter: mission, purpose, and goals, one at a time. Have each participant rate each element on a scale of 1 to 5, with 5 as "completely agree" and 1 as "not agree" with the element. Ask if there are questions regarding each element. Keep a written log of the comments and changes.	60 minutes
Work through each element one by one until you have reached agreement on it. You may have to go around a number of times. Use consensus process.	1-2 hours
Review changes, modifications, or new actions for each element	30 minutes
Discuss risks associated with the team's work and how they may be mitigated. Introduce the idea of potential conflicts of interest and resources. Briefly discuss how these might be addressed	15-30 minutes
Discuss preliminary schedule and how often work should be reviewed with each type of stakeholder or champion. Have a draft of this to present to the group, including agreement on the method of information sharing (e-mail, shared software, and so on). Select the simplest method. Understand each stakeholder's experience in using these technologies.	30-45 minutes
Set a follow-up schedule. Ask if there are any final comments. Distribute notes within 48 hours.	15 minutes

team before the end of the project. The other was that telephone calls, voice messages, and fax correspondence were not allowed.

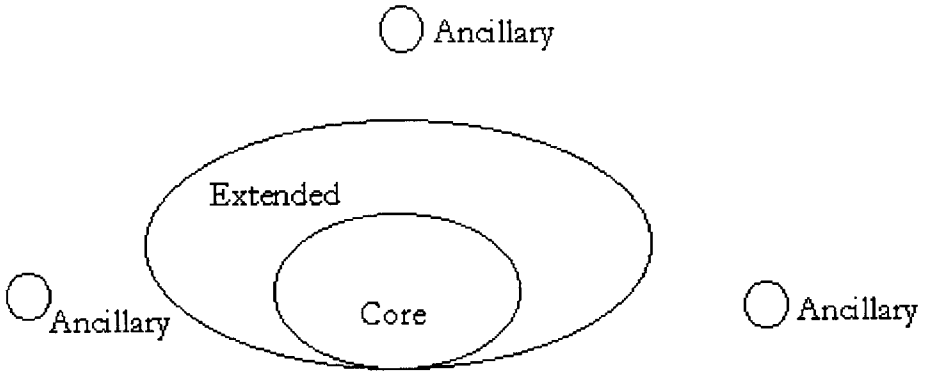

Figure 2. The several types of team members [Donaldson et al, 1998]

teams that require extensive boundary management and networking, team members who are respected and productive in a number of different geographic or functional settings can help the team to attain its objectives.

3.2.4 Step 4: Contacting Team Members

Effective virtual team leaders must pay lots of attention to the first interactions they have with their virtual team members. They must carefully orchestrate how team members meet one another ad how new members are introduced. These are some very simple practices that experienced virtual team leaders must engage in during this step:

1. Make sure that all team members understand the team's tasks
2. Arrange for appropriate amounts of interaction among team members before the work actually begins.
3. Make special efforts to facilitate the feeling of being part of the team.

The third item is complex. Because the focus in a virtual team is usually on the task, team members may feel as if too much focus on togetherness is inappropriate and non-productive. This is especially true of team members whose national cultures are low-context

and individualistic and of team members who come from engineering and science backgrounds. Highly experienced virtual team members also may have less need for activities that facilitate inclusion, especially if the task is a repetition of earlier work or if the schedule is extremely tight.

The objective of the team leader is to facilitate interaction with each team member before the team actually begins work. The team leader should make sure that each team member has at least one personal interaction with the team leader, feels welcome, and has chance to discuss his or her background and expertise. At this point, it is important not to go too far with activities that may be too personal or threatening for any team member. The team leader should be aware of cultural considerations and understand that people from collective cultures may want more interactions than individuals from individualistic cultures.

Here are some best practices for establishing contact with team members, prior to the team's formal initiation meeting [Duarte, 1999]:

1. Call or visit each team member personally
2. Provide some mechanism by which team members can find out about one another
3. Facilitate interaction between team members
4. Send all team members information about the team, including its charter
5. Make certain that a forum exists for answering team members' questions
6. Find out whether any team members have hardware or software availability or compatibility issues

These and other practices might prove to be useful for getting the team members together and encourage collaborative work. Struminger (1999) proposes the use of an online retreat

system to implement those practices described above as well as some other practices; thus eliminating the need for a face-to-face meeting of the whole team if that is not feasible.

3.2.5 Step 5:Conducting a Team-Orientation Session

The ideal orientation is a face-to-face meeting that is attended by all team members.

3.2.5.1 Face-To-Face Meeting

Currently no technology can provide the give-and-take, the feeling of human interaction, and the understanding that develops from a face-to-face meeting. Because the outcome of the session is the creation of a rather complex plan for team performance , which includes team norms and communication protocols, face-to-face communication can facilitate shared understanding. Such a session is especially important for team members from high-context and collective cultures who expect and respond to more personal contact. A virtual team leader should lobby diligently for the resources and time for a face-to-face meeting.

If a face-to-face orientation session is not possible, an audio conference or video conference is the next best choice. Virtual team members should not be tempted to use email, bulletin boards, data-only conferencing, or groupware without video capability. These tools can help in the exchange of information prior to the session or afterward but they are not as suitable for events that require extensive interaction.

3.2.5.2 The Agenda

The agenda for the orientation session, at a minimum, should feature the following:

1. An introduction to the team's tasks, including:

- An overview of the team's charter
- An opportunity for team members to react to and offer suggestions about the elements in the team charter.

- A review of each member's expertise and accountabilities.

2. Development of team norms, technological plans, and communication plans

3. Team building

3.2.5.3 Orientation of the Team's Tasks

All team members should leave the team orientation session with a shared understanding of the task of the team and their roles in completing it. Using the team's charter as a starting point is a good idea because most team members have had a chance to review it prior to the orientation meeting. The review of the charter should include the team's mission, purpose, goals, initial time lines, and deliverables. The purpose of reviewing the charter in detail is to ensure that team members understand each element of the charter and have an opportunity to ask questions. Team members often can make useful comments about and add to the elements of the charter. They also should be given the chance to identify carriers to success that may be unique between specific functions, locations, or organizations.

An important part of the outcome of this part of the agenda is for every team member to develop a clear understanding of his or her accountabilities in regard to the team's schedule and the tasks of the other ream members. The roles and the accountabilities of external partners also must be defined. The resulting clarity will facilitate smooth collaboration across organizational boundaries in the future.

Other things to be defined include who has the authority to change other people's work and who will approve final products. Often team leaders use a process in which team members' and partners' accountabilities and decision-making authority are mapped with respect to critical team outputs. This can be done using a responsibility matrix, burrowed from project management practices, to create a table for each team member's accountabilities in regard to important team deliverables and decisions. In this way, team members know who is responsible for what and when. The matrix can be placed on the team's web page and can be updated as tasks are completed or when team members change.

3.2.5.4 Development of Team Norms

Establishing team norms helps to clarify expectations about acceptable and unacceptable behaviors for all persons who work in or with the team. Team norms guide participation, communication, conflict management, meeting management, problem solving, and decision making. Virtual teams may require unique and more detailed process norms than co-located teams do. Virtual team norms include the following:

- Telephone, audio, conference, and video conference etiquette and meeting management, such as techniques for ensuring participation from all members, using the mute button when one is not talking, giving people who are using a second language time to collect their thoughts, using a meeting agenda ,taking and distributing minutes, and rotating time zones.

- Guidelines regarding acceptable time frames for returning phone calls and email messages and the use if voice mail and pagers.

- Guidelines about using email: when it should be used, when it should not be used and how email messages should be constructed – including when to flag messages as "urgent" or "important".

- Which meetings must be attended face-to-face, which meetings can be attended by audio conference or videoconference, and which can be missed.

- How work will be reviewed and approved. This includes which team members will review work and which ones can approve deliverables.

- Procedures for scheduling meetings using group-scheduling systems.

- The types of technological applications to be used by team members and the policies regarding upgrades.

3.2.5.5 Development of Technological Plans

Planning what technologies the team will use is a vital part of the team's orientation session. In planning how technology will be used, the first step is to consider the type of work the team will be doing. Work on many teams can be characterized as parallel or independent, sequential, or pooled sequential or team work [Duarte, 1999].

Parallel work occurs when team members work independently on separate parts of a document or other product. Their outputs are then integrated into a final product

Sequential work occurs when one or two individuals work on a document or product and then pass it over to other team members, who also work on it and then pass it in. This way of working is analogous to an assembly line, in which parts are added sequentially until a final product is created. It is a common way of working for teams and production teams that use workflow processes and associated software.

Pooled sequential work can be similar to a library; team members check out a document, make changes, and then return it back in. The document or product is kept in its original place (pooled) and is updated each time a team member works on it.

Each virtual team must determine how it wants to work and then select the most complementary and cost-effective technology.

3.2.5.6 Development of Communication Plan

How team members communicate with each other and with important stakeholders throughout the team's life is a critical success factor. It is the primary way in which virtual teams manage organizational boundaries. Teams that keep to themselves or engage in a low level of communication negatively affect performance. External communication needs to be carefully managed, with the goals of managing other people's perceptions of the team and their access to the teams progress and problems.

An effective communication plan establishes accountabilities for data collection, data analysis, and information sharing. It also defines the specific messages that will be delivered as well as the most appropriate communications media.

3.2.5.7 Team Building

A key part of the team's orientation is a team-building activity that is appropriate for the team's tasks and the cultural composition of the group. There is usually ample opportunity to do this in a face-to-face orientation session. Possible activities include going out to dinner as a team, engaging in outdoor activities, completing personality inventories that reveal how team members prefer to communicate and/or work, and engaging in indoor games that point to the value of team work. In an audio conference, the options for team building are more limited. In both types of sessions, the team leader should keep two things in mind: (1) the selection and use of team-building activities may be subject to cultural bias and (2) experienced virtual team members may perceive too much time spent on team building as inappropriate and a waste of time.

3.2.6 Step 6: Developing Team Processes

During the orientation meeting, the team leader should explain the process that will be used to manage and control the team's work. These often can be reviewed or developed with the team members' assistance during the orientation meeting. Project management practices to control the work can be adopted to enhance the performance of virtual teams. These practices usually provide some of the additional rigor necessary to provide visible time and distance boundaries.

The most frequent used items are templates that are used for scheduling, assigning tasks to team members, reporting work status, and obtaining data on slips in the schedule and costs. Teams also should plan how they will engage in regular, frequent reviews. This includes establishing agendas that address milestones, plans, problems, and costs.

An important step of this process is a discussion about the ways in which information about the team's history and progress will be documented, stored, and exchanged. Information such as reference materials, historical information, plans, the status of related internal or external activities, and team generated products are valuable in orienting new team members. They also are valuable resources for future teams that are performing related tasks. The team leaders must insure that distributed databases and other information-sharing applications provide equal access to all team members.

Different types of systems users – usually owners, members, and an administrator – are identified. Accounts for team members are created with passwords to ensure control over the system. Owners, perhaps of sub-teams, create folders and can invite other people to use, view, or modify the contents. In this way team members who own certain tasks or parts of the project or process maintain documentation about the project.

CHAPTER FOUR

DISEL 98 CAIRO PROJECT: A CASE STUDY

In this chapter I will describe the 9-month project conducted at MIT to demonstrate the effectiveness as well as the possibility of managing a distributed team to come up with a software product. Certain restrictions were imposed on the team members that made it difficult to implement all the steps discussed in Chapter 3. I will also show how these restrictions affected the progress and collaboration effort of the team members. Finally it is worth noting that this case study was done before coming out with the steps outlined in Chapter 3, in fact the several procedures suggested by Lipnack and Stamps (1997) and Haywood (1998) and Duarte and Snyder (1999) where modified according to the outcome of this case study.

4.1 Project Description

The Collaborative Agent Interaction and synchROnization (CAIRO) project is a research project initiated at the Massachusetts Institute of Technology (MIT) in 1995. In 1997 and 1998, CAIRO was introduced to the Distributed Software Engineering Lab (DiSEL) students to include software development in distributed teams. This was done in collaboration with Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE), a graduate university in Ensenada, Mexico.

The project was conducted in an educational setting controlled by two professors and two teaching assistants distributed between the two locations. Lectures on the different roles involved in the software development cycle were given from both locations.

The technology used to implement the virtual setting depended on Microsoft's NetMeeting[1], a video conferencing tool that allowed sharing of applications. Complimentary video conferencing tools such as cameras and microphones were available at both locations. The video, as well as the shared application, was usually projected on a screen at both locations and team members were allowed to converse with their counter members in the other location by using microphones. Figure 3 shows a sketch of the physical arrangement adopted at both locations.

4.1.1 Project Objectives

The objective of the DiSEL team, in general, was to develop a Java-based collaborative software architecture that allowed conducting real time meetings for virtual teams. The software stressed on social interaction and casual contact features which differentiated it as a new technology for enhancing human interaction in virtual meetings. In short, CAIRO was designed to be the tool that will facilitate the work of virtual teams in the future. The other objective of the DiSEL team was to depend on collaboration through a geographically distributed environment in order to arrive at the final product; and that constituted the greater challenge for the team.

4.1.2 Project Restrictions

Being located in an educational setting, the professors at both locations imposed certain restrictions on the method and means of communication between the team members. The first restriction was that face-to-face meetings were not allowed between the two parts of the

[1] NetMeeting is a product registered to Microsoft Corp.

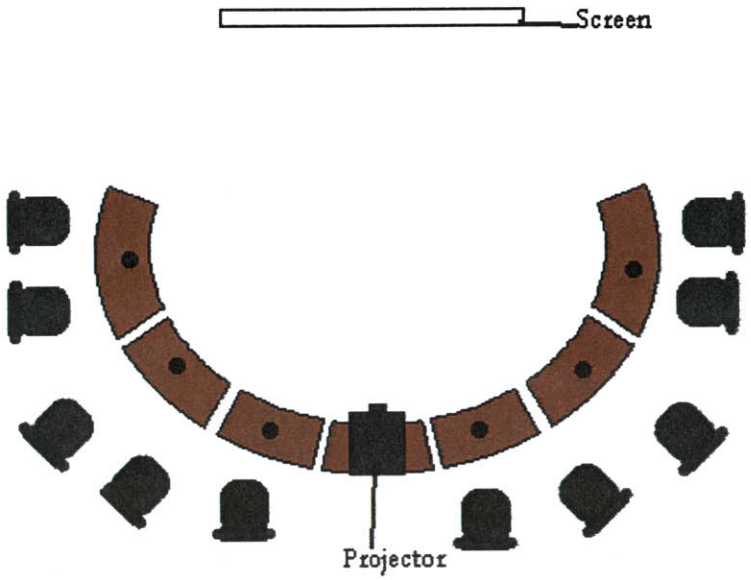

Figure 2. Physical meeting setting at MIT-DiSEL 98

Given those two restrictions, the DiSEL 98 team was not allowed to have any human interaction with the other part of the team except for the use of video conferencing which was available to use any time at both locations.

4.2 DiSEL 98 Team

The DiSEL 98 team consisted of 13 team members, four of which were in Mexico and the remaining 9 where in the US. The team was also characterized by being multicultural and international in terms of having members coming from seven different countries. Table 4 shows the team members and their location and nationality.

As can be seen in the organization chart in Figure 4, the team had two development departments to carryout the design and implementation of the program according to the project requirements. A Software Project Management Plan written by the project manager of the DiSEL 98 team is appended to this document and outlines the requirements and

description of the major roles involved in the production of CAIRO. The following section will discuss the major steps taken to arrive at the requirements and develop the process for implementing CAIRO.

Table 4. DiSEL 98 Team Memebers

Member	*Located At*	*Country of Origin*
Ricardo Acosta	CICESE	Mexico
Kiran Choudary	MIT	India
Gregorio Cruz	MIT	Mexico
Alberto Garcia	CICESE	Mexico
Octavio Garcia	CICESE	Mexico
Joon Hor	MIT	USA
Caglan Kuyumcu	MIT	Turkey
Gregoire Landel	MIT	France
Rafael Llamas	MIT	Mexico
Christian Manasseh	MIT	Lebanon
Jaime Solari	MIT	Uruguay
Sanjeev Vadhavkar	MIT	India
Padmanabha Vedam (Padu)	MIT	India

Each member in the team had two different roles. One role being the major role on which his main focus was concentrated, and another minor role on which he was always on call and supposed to know what was going on with it. The roles were distributed according to the software development cycle, with emphasis on the design and development roles be divided between MIT and CICESE. The following organizational chart shows the distribution of the roles.

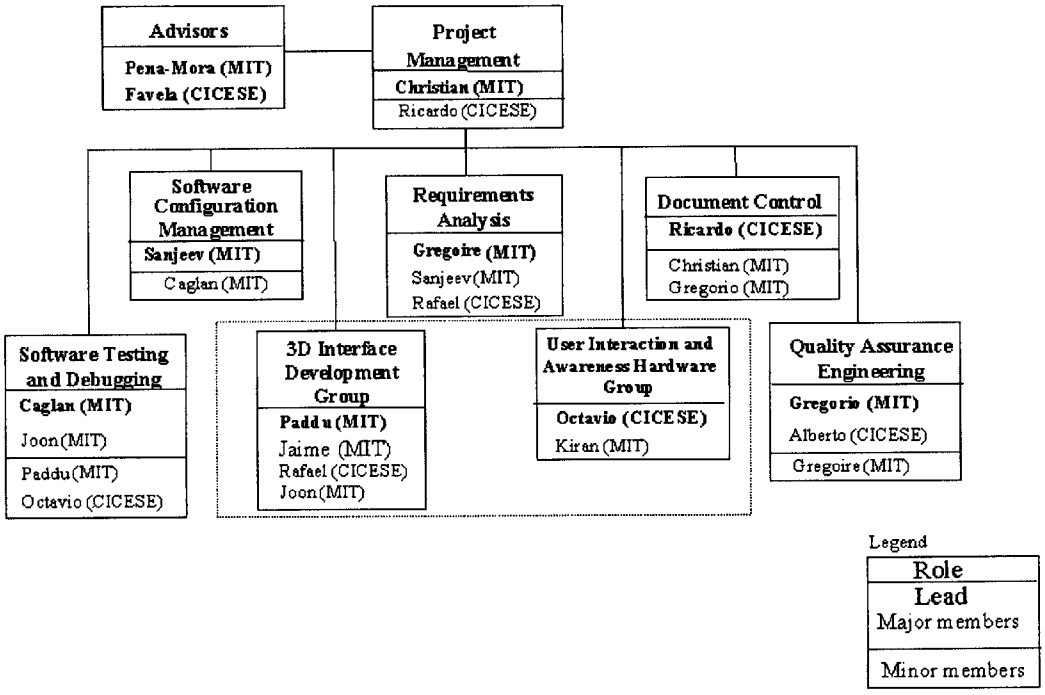

Figure 4. DiSEL 98 Organizational Chart

4.3 Project Management of CAIRO Project

The project started in September 1998, where the DiSEL 98 team was given the task of producing the new generation CAIRO. The old product was experiencing several problems in installation, running, and closing. Installing the program required the technical assistance of somebody that knows how to operate CAIRO and has already worked on some of its code. While running, CAIRO was hardly stable it would crash repeatedly and it was not

flexible in adding users. And in most of the cases, quitting the program was difficult to do without crashing the whole system.

Based on that, the DiSEL 98 team came up with a set of requirements, which involved in the first stage a thorough testing of the program to determine its major bugs and then come up with a plan to solve those bugs. The requirements also involved researching some new technologies that might be added to CAIRO as a second phase. The team was then divided into three groups for a period of three month, which constituted the remainder of the first educational semester at MIT. This period was designated as Phase I of the project and the three groups where the following:

- The Planning and Process Group
- The Technology Group
- The Testing Group

4.3.1 Planning and Process Group

The mission of the Planning and Process Group was to study the different management processes and come up with the plans for managing the group the second semester. The group consisted of Christian Manasseh, Project Manager MIT, Gregorio Cruz, QA MIT, Ricardo Acosta, Document Specialist CICESE, and Alberto Garcia, QA CICESE. The variety of the roles in this group allowed the development of the new requirements, the process model adopted by the DiSEL 98 team and the schedule for the second phase of the project which was schedule to start in January 1999.

4.3.2 Technology Group

The Technology Group was appointed the mission of exploring certain new technologies that might be implemented into CAIRO, and they were to report to the Planning and Process Group about the possibility of implementing each of these technologies into the

new generation CAIRO. The members of this team where the following: Rafael Llamas, Designer CICESE, Padmanabha Vedam, Designer MIT, Kiran Choudary, Programmer MIT, and Octavio Garcia, Programmer CICESE. The technology group researched technologies such as security logging, database hookup, 3D environment browsing, CAD application sharing, and user awareness detection. Estimates of time and ease of implementation for each of these technologies were reported to the Planning and Process Group to plan for the second phase of the project.

4.3.3 Testing Group

This group was fully located at MIT and consisted of Caglan Kuyumcu, Tester MIT, Sanjeev Vadhavkar, Configuration Manager MIT, and Gregoire Landel, Analyst MIT. The objective of this group was to test and debug the CAIRO software and to arrive at a stable version of CAIRO before the end of the first semester.

The three groups were able to complete their tasks successfully. By the end of December 1998, the DiSEL 98 team had a stable version of CAIRO, a first draft of project management plan, QA plan, and a new set of requirements for Phase II based on the recommendations of the Technology Group.

4.3.4 Phase II

Phase II of the CAIRO project started in January 1999 and was scheduled to be completed in April 1999[2]. Approximately three and a half month to design and implement the new requirements into CAIRO. The following is a brief description of the requirements for the second phase.

[2] See exact dates in Software Project Management Plan in Appendix.

4.3.4.1 Phase II Requirements

After researching the several new technologies by the Technology Group, the Planning and Process Group had to choose the technologies that would achieve the most of the collaboration effort between the two teams (at MIT and CICESE) in the short period of time available. Research was already being done at CICESE on the use of user awareness devices, and one of the CICESE team members was already writing a thesis on the topic. No specific research was being done by any of the team members at MIT, except that lots of time had been spent in researching the 3D browsing environment by a couple of members in the Technology Group. In addition to that, a new member was added to the group by the beginning of February. The new member had an architectural background with knowledge of VRML and 3D modeling. The choice was then set on choosing the user awareness detection and the 3D browsing as the new technologies to be added. The major reason behind the choice was that those two technologies would allow for the maximum collaboration between the team members since they needed each other to compliment their knowledge about those technologies.

A new requirements document was written based on these requirements, and Project Management and QA plans were adjusted to fit the needs of the new requirements. The first month of Phase II was spent in developing the plans for testing and managing changes in the project as well as a first draft of the design was submitted. The remaining time of Phase II was spent in developing the product.

The development process adopted was the spiral method (Figure 5) which allowed the DiSEL 98 team to develop the product through three cycles. At the end of each cycle the product was tested and a new design document was drafted for the implementation of the following cycle.

4.3.4.2 Delays

The delays encountered in the development of Phase II can be separated in to two types: external delays, and collaboration delays.

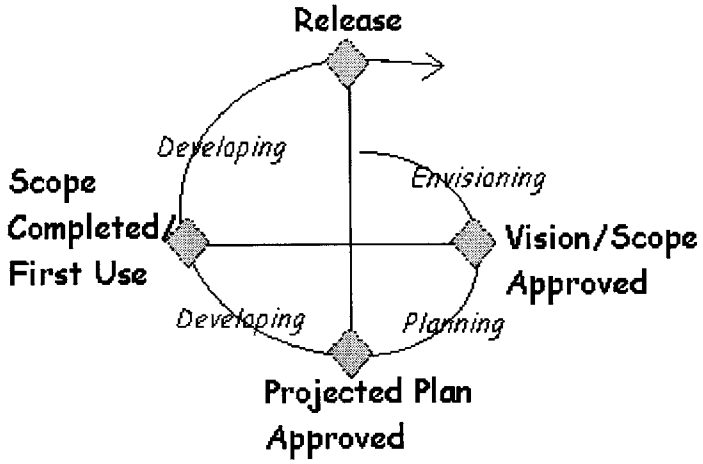

Figure 5. The Spiral Method adopted by the DiSEL 98 Team

The external delays were due to some external factors that affected the progress of the work, these delays might have been encountered even if the team had not been distributed. Such delays were due to other activities in which the team members were involved mainly the participation of the 50K MIT Entrepreneur Competition that came as an unexpected activity due to winning the 1K MIT Entrepreneur Competition.

Collaboration delays are the delays due to the team being distributed. These delays are worth considering in detail and I will discuss them and their causes in the following section.

4.4 DiSEL 98 Team vs. Virtual Teams

The DiSEL 98 Team can be classified as a virtual team since it satisfies the five attributes discussed in Chapter 1. These attributes are implemented in the CAIRO project as follows:

4.4.1 Alliance for a Common Goal

The two team parts (MIT and CICESE) are in this project for a common goal: to produce the new generation of the CAIRO system. All team members share the same goal of achieving credits for the course which they are taking and their collaboration constitutes a

major part of the course evaluation. Hence the team members are in alliance for a common goal.

The organizations hosting the project: MIT and CICESE are also in alliance for the sake of the research that each of the universities is conducting in that field. Hence the organizations are also in alliance for a common goal.

4.4.2 Underlying ICT

The project is being supported by the most effective technology, in this case without resorting to expensive video conferencing equipment. Although the DiSEL team was short on having the most advanced technology, all team members had access to the same type of technology, and all were trained and able to achieve a connection independently when necessary.

4.4.3 Vertical Integration

The DiSEL 98 Team supported vertical integration in assigning the project manager from one of the students; thus not giving him any extra privileges or powers. This can also be viewed as assigning management tasks to the several members which require each team member to manage his own task and be responsible directly to the instructor.

4.4.4 Globalization

Although the team did not get involved in any international activities or exchange of skills, it did have a globalization factor in being located in two different countries with part of the skills available in Mexico (awareness) and the other part in the US (3D browsing).

4.4.5 Collaboration

Collaboration constituted the major component of this project, in which the team was forced to collaborate to get things done. Now whether the team effectively collaborated or not, is not the issue at this moment; what is important is that it would have been difficult to

produce the final product without the collaboration efforts of the team members, and this is what makes the DiSEL 98 Team a virtual team.

By showing that the DiSEL 98 Team obeys the above five attributes, it proves to be a virtual team.

The second step is to show to what extent the team was successful. I will do that by showing how much did the team abide by the seven critical success factors discussed in Chapter 3.

4.4.6 Training On-the-Job Education and Development

It can be easily proved that the team was trained for this job. Lectures about software development in distributed environments were being given at the beginning of the project during Phase I. The team members were also requested to setup the connection with their counter parts by themselves; hence providing training on using the ICT framework adopted.

The only drawback that can be pinpointed in this area is that the lectures provided at the beginning of the semester were given in a slower pace that the project required and that caused some delays in Phase I. Another drawback can also be associated with the fact that the team members were not explicitly told about the value of collaboration in this project and that lead to the lack of collaboration in the initial stages of the project. That situation was adjusted later on when the requirements were oriented to achieve more collaboration.

4.4.7 Standard Organizational and Team Processes

This factor was not apparent through the activities of the DiSEL 98 team. No standard processes were adopted, mainly because the project was a one time project for the group and no standards had been established before that so the team members simply adopted ad-hoc methods to come up with plans and to write documents. Although there was an attempt by several members to abide by IEEE standards, some members chose other standards and there was no force in imposing a certain standard on the group.

As it was shown in Chapter 3, having standards speeds up the work, as well as, it provides a common framework for distributed members to be following the same approach.

4.4.8 Electronic Collaboration and Communication Technology

The technology that was used by the DiSEL 98 Team can be classified as medium level given the restrictions that were imposed. The team could have used better technology which would have enhanced the collaboration as well as the productivity. However, given the educational constraints the team strived to use the most efficient technology within that limit. Individual team members tried to use other collaboration tools that were not specified at the beginning of the project (ICQ) just to speed up collaboration and production.

Another drawback in this factor is that the team did not have a clear identified plan about the technology that was involved and which technology should be used in a certain type of meeting. Instead the team just tried the best connection possible during all meetings given the restrictions on bandwidth.

4.4.9 Organizational Culture

Given that the team members where all from different backgrounds, there was no organizational culture once the project started. However, as the project evolved the team started forming a certain organizational culture that was a characteristic of the DiSEL 98 Team. That culture was reinforced and improved when the team had the first face-to-face meeting in Mexico. Although it was specified in Chapter 3, that in order to help develop this culture, the team has to have at least one face-to-face meeting at the beginning of the project to enhance the collaboration, this type of meeting was restricted by the instructors and did have a significant impact on the efficiency of the collaboration that was required during the second phase of the project.

4.4.10 Leadership

It is true that by assigning a student as the project manager, the team was able to achieve vertical integration; however, that was at the cost of having a powerful leader especially at the beginning of the project. It also took more time for the other team members to start relying and trusting their project manager than it would have taken them to trust a manger

with more power. That was also one of the issues that caused some delays in the progress of the work.

4.4.11 Team-Leader and Team-Members Competencies

It cannot be stated that the team members of the DiSEL 98 Team were completely knowledgeable of the process involved, since this was an educational experience to all of them. However, it can be inferred that they have all learned some if not all of the competencies listed in Chapter 3, and are now able to tackle a virtual team with more knowledge than they had in this one.

4.5 Conclusion

After having defined and listed the major incidents in the life of the DiSEL 98 Team, and having classified this team as a virtual team, I can conclude that the team was able to achieve an average of seven out of ten in being a successful virtual team. It still has a lot to improve and to add to its structure, and an outlined approach to have the successful team will be provided in the last chapter of this thesis, Chapter 5.

CHAPTER FIVE

LESSONS LEARNED

Having gone through all the experience of managing a virtual team, and researching the several approaches that were proposed by other researchers, I shall provide in this chapter a detailed agenda for managing the DiSEL 99 Team. I also hope that the project manager of that team would learn from the mistakes that were done by the DiSEL 98 Team and correct for that by being aware of the problems before hand.

5.1 Problems to Watch Out For

Having gone through the experience of managing DiSEL 98, I have come across the following problems and difficulties which I expect might be repetitive in case of going through another similar project under similar conditions.

5.1.1 Lack of Orientation

The first problem that faced the DiSEL 98 Team was the lack of knowledge of what was required of the team at the start of the project. What the mission of the team was and how it was supposed to prioritize its work were not clearly defined. The team knew that it was supposed to develop a project under certain constraints of predefined requirements. Such

requirements included building on top of the pre-existing CAIRO, as well as some other fixed requirements based on what the team came up with proposed new technologies; such as when building a database system into CAIRO we were required to consider an SQL Server framework. These were clearly defined and understood at the beginning, however, these did not constitute the major and general mission of the project. Thus the team was disoriented in thinking that the major mission was to come up with this product that it defined by the requirements document. That, in fact, was only the tool to achieve the team's mission that was later on clarified to be enhancing our collaborative efforts to arrive at this product.

The advice to the DiSEL 99 Team would be to form a clear mission statement from day one, and on that, start building the requirements for the project. Knowing the general goal and objective behind the project would allow the team to place reasonable requirements that can be achieved given the virtual, educational, and time-limited settings.

5.1.2 Lack of Interaction between Team Members

At the beginning of the project, the leader will experience some lack of control as well as some difficulty in getting through with the other team members. This is mainly due to the fact that most team members at that stage are new to the new idea of virtual groups as well as new to the graduate university they are attending. In addition to that, you will find that most of them have not worked together before and have just been introduced to each other.

To make this phase short and easy to overcome, the team leader should suggest out-of-class meetings that also include the distributed counter part. These meetings should serve as the team orientation step discussed in Chapter 3 and should not be formally attended. Members are encouraged to express their ideas about the new group, what they think should be done and how they should go about doing it. Remember that at this stage nobody yet has his role outlined and all suggestions are ad hoc and just for team interaction.

5.1.3 Unknown Skill Level of Team Members

Another issue that reduces the interaction between team members at the beginning is the fact that nobody knows what the other person in the group is capable of doing or whether he or she has ever been involved in such a group.

This can be solved by putting information about each member in his or her web page specifying the type of projects that he or she has worked on, and what level of experience can be expected from each member.

5.1.4 Lack of Experience in Software Development

The lack of experience in the software development process might be a common factor for all the team members at the beginning. And the speed by which each member acquires this knowledge is different. It is important that before the actual planning of the project all team members are familiar with the process and what is required of each role. Each person should be able to know who to go to in case of a certain problem or conflict.

One way to speed up the learning of the process is to read in detail the assigned reading for the course material. At the first level it is important to read the process description and role descriptions then to read the work that was previously done on CAIRO, either through the theses available or through the reports produced.

5.1.5 Defining Project Resources

One crucial step before beginning the project is to know exactly what the technology defined for the project is. Which computers are there, and what software is in each. It is also important to know the structure of the course web page and who will be managing it so that improvements and additions can be easily incorporated once the project has started.

To organize this in a proper manner would be to make a list of all the machines for the course, including those in the other geographical areas. Include the software and directory structure of each computer and the name of the person(s) in charge of it.

5.2 How to Start

Having outlined the several problems that the DiSEL 98 Team has faced and how to bypass them for the DiSEL 99 Team, I will now lay out a start-up plan for the DiSEL 99 Team to follow. It is not important that the team follow this plan to the letter, but it is important that they get to know about it and understand why each step is important and required at some stage in the project cycle.

5.2.1 Define General Goals

During the fist meeting that the group will have, that would be most probably the first class hour in the Fall Term, the team members will get the chance to know each other and to have a brief description of what they are supposed to do. This description should stress on the general project mission and goals. The sponsors of the group, mainly the professors and teaching assistants should make it clear that the mission of the group is to understand the software development process in a distributed setting. This understanding is to be achieved by applying the process on a 9-month project that will involve the development of a software product that will be an upgrade of an existing version of a software that has already been built by the previous year team members. In doing so they are expected to prioritize their collaboration efforts across geographical boundaries with their counter team members and then develop the new product whose new requirements they are going to define. It is important that they know that they are the ones who are going to define the new requirements so as not to expect that definition from somebody else and spend time waiting for it.

Having briefly stated that brief description in the first lecture, the team will have more elaborate descriptions in the second couple of lectures where they are also introduced in more detail about the software development cycle.

A demo of the early version of CAIRO should be shown at the first lecture and in the next couple of lectures, each member must be able to run the demo alone and to experiment with

the existing product. This will help him or her to define the new requirements of the project later on.

5.2.2 Define General Project Requirements

Still no roles have been assigned but the group now knows the software well and knows the other team members in his location more than the distributed team members. At this stage group sessions should be held between the geographically distributed members to start placing some general guidelines for the requirements. No specific technical issues will be presented but the general orientation of the project should be defined. Examples include: should the new CAIRO have a database, should we build on the existing VRML environment and upgrade it, should we add extra features to the awareness detection, should we enhance social interaction and/or casual contact features in CAIRO, or any other new ideas which they can come up with.

It is important that these sessions be conducted after everyone has played with the existing version of CAIRO and that the ideas come from all geographic locations and not only form one place, even if one place might have a higher concentration of team members.

5.2.3 Create Members' Web Pages

The sessions held for defining the general requirements might be in-class or outside of class sessions. But in both cases they serve as a team get-together in which team members get to know more about each other. At this stage it is important for all team members to know each other well, this can be achieved by publishing a web page for each member with biographical information about each and with skills information and a picture if possible. The information in the web page will be updated frequently according to what the member will be doing in the project and according to his or her role. Information about the member's earlier projects and relative skills should also be included.

5.2.4 Create Team's Web Page

Having created personal web pages the team must now create a team web page. This web page will contain the team mission at this stage since it has been defined and it will contain links to all team members' pages. It will also contain information about meeting times and places, as well as a discussion forum where team members can exchange documents and other electronic information.

The web page must also assign email addresses for each member, most probably by using an email sever to do that. This proves to be handy later on, since it is difficult for most of MIT students to access their email accounts from outside of MIT, and this page can serve as a Hotmail or yahoo email provider for such students. Later on, the different roles can be assigned to different email groups, such as designers, programmers, and testers. And emails can be sent to the group and reach only those members in that group. This can be easily done in an email server such as MS Exchange[3].

5.2.5 Define Technology to Be Used

So we have started to rely on the technology to start the project, we already have web pages and email servers. Now it is time to define which computers will serve as servers, who will be system administrator, and who should have access to what computer and with what privileges. A system administrator must be assigned to manage this issue, he or she can be a team member or a teaching assistant. Access to the computers should be controlled so as not to have hard disk problems later on. User accounts and passwords must be assigned to each member and restrictions on the use of hard disk space must be allocated.

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[3] MS Exchange is a registered product by Microsoft Corp.

5.2.6 Assign Roles

At this stage the team members know each other well enough, and they have discussed the general requirements several times and most probably have come to a clearer point of where the project is going to be headed in the next eight or nine months. They have also at this stage understood the software development cycle and the roles involved, they have also got used to the professors and teaching assistants methods of conducting the classes. All that should be achieved in the first month of the project. At the end of that month, the team members have enough information to make a decision about which role(s) they are going to choose in the project. Each team member must list at least two roles which he or she would like to be involved in and the group sponsors will assign the major role of each member according to that.

5.2.7 Develop Plans

Once the roles have been assigned, the analyst group can start preparing the requirements document of the project and other plans such as document control, project management plans, quality assurance plans will start to be drafted. It is important not to speed up the porcesses of writing the plans, since the plans will serve as the foundation of what the group will be doing for the remaining part of the project. The plans also serve as a testing medium for the members to get to know how each other member functions and delivers in such an environment. They will also experience collaboration across geographical boundaries.

I would suggest that the team spend the first term in developing the plans and refining them. I would also suggest that they implement the development process, which involves quality checking and version controlling of the different versions on the process of producing the plans. By that they also get accustomed to the software development process and are able to have a better feeling of how that process is implemented in a virtual educational setting.

5.2.8 Start Development

Having produced all the plans and standards, the group can start the design phase of the project and the implementation later on. It is important to keep track of what was planned and the changes in the plans. Plans should also be updated frequently according to the changes made.

5.3 Enhancing Collaboration

What was outlined in the previous section will allow the group to start working and the project to progress. However, the major objective of this project is to rely on collaboration across geographical boundaries. This section will outline how collaboration in the virtual educational setting can be optimized.

5.3.1 Use of Technology

As it has been stated earlier, technology is the backbone of virtual teams. It is not the only thing that controls their work but without it, it is difficult to work productively. So the technology has to be clearly understood. The team with the help of its sponsors should decide on what video conferencing tool, chatting tools and web technology should they adapt.

The team should also specify what type of technology should be used in certain types of meetings and how often should that type of meeting be held and who should be present in it. The team should also define the types of email and the minimum response time for each type. All forms of communication that is to be conducted must be defined and associated with a technology and a certain level of priority.

5.3.2 Jointly-Defined Requirements

Defining the requirements should come from all the geographical locations. All team members must have an interest in pursuing the project. They should have approximately the

same level of priority of the project. This will prevent any team member from backing out on the project at a later stage when he or she encounters a project of higher priority.

The requirements should be defined keeping in mind that the objective of the project is to collaborate. Therefore they should not stress on a big product at the end but on a product that can be built through collaborative efforts.

5.3.3 Outside-Class Meetings

Outside class meetings are very important in forming the bond between the team members. These meetings are usually longer than the class meetings and the members feel more relaxed to discuss informal issues that might not be related to the project. The timing of those meetings should be scheduled so that all team members are present.

5.3.4 In-Class Workshops

The in-class workshops are of a shorter length and they are controlled to keep the focus of the group on the project at hand. The teaching assistant or professor organizing the workshop should facilitate the use of the technology so as not to waste time in the workshop on fixing the technology but to work on the project at hand.

5.3.5 Face-To-Face Meeting

A face-to-face meeting is very important for the bonding of the team members. However, due to the constraints placed by the educational setting, such meetings might not be feasible or allowed during the beginning of the project. But if there would be such a meeting later on the team members should know about it and start planning for it early. This will serve as a idea that would fill up some of their outside-of-class meetings, where they can exchange cultural information and descriptions of the places were each member is located.

5.4 Conclusion

After suggesting the outlined procedure for starting the project, I would like to remind the reader that this process has not be tested yet, it is just the outcome of my research and work with the DiSEL 98 Team. I do believe however, that this process can help increase the productivity of the team in addition to increasing their quality of knowledge about the software development process in distributed environments. And I hope that by following this procedure the project manager of the next DiSEL Team will be able to refine it and produce a better plan.

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APPENDIX

COLLABORATED DISTRIBUTED INITIATIVE SOFTWARE

SOFTWARE PROJECT MANAGEMENT PLAN

VERSION 2.3

MARCH 01, 1999

PROJECT MANAGEMENT DEPARTMENT

CHRISTIAN MANASSEH, PROJECT MANAGER

REVISION CHART

This is version 2.2 of the Software Project Management Plan issued on Feb 23, 1999.

Author: Christian Manasseh, Project Manager

Audited: Gregorio Cruz

Checked: Gregorio Cruz

Documented: Sanjeev Vadhavkar

Changes are based on the Action Item List produced on Feb. 9, 1999 after conducting a walkthrough of this document. An action item list is included in the appendix.

Changes are also based on comments given by Prof. Feniosky Peña-Mora on Version 2.1

TABLE OF CONTENTS

LIST OF FIGURES

List of Tables

1. INTRODUCTION

This project encompasses the development of the Collaborative Agent Interaction and synchROnization (CAIRO) software into a stable and reliable system that enhances collaboration between distributed environments. The targeted environments include design professionals in the software, aerospace, manufacturing, defense, and construction industries. The stress is on enhancing social interaction by introducing a VRML and human feelings awareness components.

1.1 Project Overview

The objective of this project is to deliver a functional version of the CAIRO that includes all the specified requirements in the Requirements Document [2], on time, and to the quality standards specified in the Quality Assurance Plans [1].

Major work activities will be targeted to deliver the software on time; hence, they will include all activities related to design, implementation, and testing of the software. Other activities will include: the management and monitoring of the design, implementation, and testing activities by providing quality and configuration management plans.

All project preparatory work, which can be summarized in completing the Requirements Document, the Quality Assurance and Configuration Management Plans, will be completed in the month of January 1999. The following two and a half months will be dedicated to designing, implementing and testing the product in three consecutive cycles.

The third generation CAIRO software will be developed as a collaboration effort between two geographically distributed environments. The team consists of 10 members at MIT and 4 members at CICESE. Meetings between all members of the CAIRO project team will be conducted using Microsoft NetMeeting[4] for meetings that involve presentation sharing, and using CAIRO v2.0 for regular meetings held between department members.

Required resources for this project will include access to the internet, a Programmer Development Environment (PDE) that will be specified by the programmers, Microsoft NetMeeting, access to audio and video equipment to conduct meetings, and a copy of all previous documentation related to earlier versions of CAIRO.

1.2 Project Deliverables

The major deliverable of the CAIRO project is the CAIRO software package that will include the following:

- A CD that contains the code for the CAIRO software and a word format of the manual
- A hardcopy of the User's Manual
- A CD that contains all online material related to the CAIRO project
- A hardcopy of the documentation CD

[4] Microsoft NetMeeting is a registered trademark of Microsoft Incorporation.

The deliverables will be handed over to the client at the end of the project, and copies of the above listed items will be given to all team members.

1.3 Evolution of the SPMP

An update of the SPMP will be provided whenever changes in the project schedule and/or scope occur. The new document will contain a summary page indicating where the changes occurred and a summary of the change. It will then be handed over to the Quality Assurance Department for checking. Based on the judgement of the Quality Assurance Engineer, an audit of the new document will be done. The updated version of the SPMP will then be the official governing version. Notice of the update will be given to the Document Specialist, who will keep track of all versions of the SPMP in the Project Documentation.

1.3 Reference Materials

The standards listed here should be consulted when applying this document. The latest revisions shall apply.

[1] CAIRO Project: Feb. 1999, Documentation Specifications

[2] CAIRO Project: Feb. 1999, Quality Assurance Plan

[3] CAIRO Project: Feb. 1999, Requirements Document

[4] CAIRO Project: Feb. 1999, Software Configuration Management Plan

[5] CAIRO Project: Feb. 1999, Software Testing and Debugging Plan

[6] Carnegie Mellon University Software Engineering Institute - Curriculum Module 9-2.0 1992, Unit Analysis and Testing

[7] Carnegie Mellon University Software Engineering Institute - Curriculum Module 19-1.2 1990, Software Requirements

[8] Carnegie Mellon University Software Engineering Institute - Curriculum Module 21-1.0 1989, Software Project Management

[9] ANSI/IEEE Std 1058.1-1987, Standard for Software Project Management Plans

[10] Yang, B. 1998, Managing a Distributed Software Engineering Team. M.Eng. Thesis. Massachusetts Institute of Technology.

1.5 Definitions and Acronyms

Activity. A major unit of work to be completed in achieving the objectives of a software project. An activity has precise starting and ending dates, incorporates a set of tasks to be completed, consumes resources, and results in work products. An activity may contain other activities in a hierarchical manner [9].

CAIRO. Collaborative Agent Interaction and synchROnization.

CICESE. Centro de Investigación Cientifica y de Educación Superior de Enseñada

MIT. Massachusetts Institute of Technology

Review. A meeting at which a work product or a set of work products is presented to the project personnel, managers, users, customers, or other interested parties for their comment or approval [9].

SPMP. Software project management plan.

Task. The smallest unit of work subject to management accountability. A task is a well-defined work assignment for one or more project members. The specification of work to be accomplished in completing a task is documented in a work package. Related tasks are usually grouped to form activities [9].

Work package. A specification for the work to be accomplished in completing an activity or task. A work package defines the work product(s), the staffing requirements, the expected duration, the resources to be used, the acceptance criteria for the work products, the name of the responsible individual, and any special considerations for the work [9].

2. PROJECT ORGANIZATION

This section of the SPMP shall specify the process model for the project, describe the project organizational structure, identify organizational boundaries and interfaces, and define individual responsibilities for the various project elements.

2.1 Process Model

Major project activities will be those related to design, implementation, and testing. They will be sequenced in three cycles, where each cycle results in a new version of CAIRO, which is then tested, with the test results documented for the next cycle. Deliverables at the end of each cycle include a working version of the program, an updated design document of the program, and a demo of the running software. To ensure quality and memory, each step in the cycle is monitored by an audit and documented.

The first cycle will start on February 2, 1999. Work in the first cycle will be in two separate tracks. Each track will have a design, implementation and testing phase. All tasks related to the Project Preparatory Activity will be accomplished from January 5, 1999 till February 9, 1999. Table 1. Shows the major activities and cycles with their respective duration.

Table 1. Summary of Major Activities

Activity Description	Start Date	End Date
Project Start	1/5/99	
Project Preparatory	1/5/99	2/9/99
Cycle 1	2/2/99	2/18/99
Cycle 2	2/20/99	3/4/99
Cycle 3	3/6/99	3/18/99
Manual Writing	3/21/99	4/13/99
Project Completion		4/15/99

The project will be following a spiral process model. The spiral model implies that the project evolution will be based on a starting model that will evolve as the cycles progress. New ideas and design updates will be implemented step by step in the several cycles. Figure 1 shows exactly how this will be implemented.

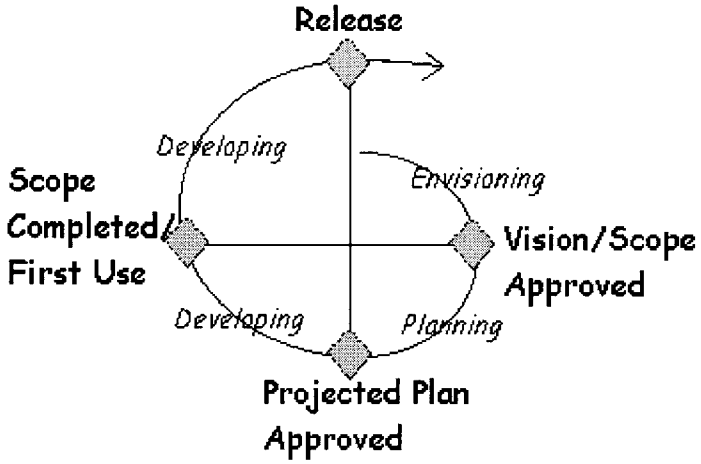

Figure 1. Process Model

2.2 Organizational Structure

The project personnel will be distributed into eight functional departments:

- Project Management
- Requirement Analysis
- 3D Interface Development Group
- User Interaction and Awareness Hardware Group
- Software Testing and Debugging
- Quality Assurance Engineering
- Document Control
- Software Configuration Management

The project will be completed by the combined efforts of 10 engineers at MIT and 4 members at CICESE. The project organization will also take into account that the major goal behind this project is educational, and the team involved has only one project to complete under this organizational structure. Based on that, each member will assume two roles: a major role and a minor role. Two members will share project Management: one from MIT and one from CICESE, to facilitate the management of the distributed team. Figure 2 will be the organizational structure of the CAIRO project.

2.3 Organizational Boundaries and Interfaces

To insure the quality and to keep track of the major activities, the product of every activity will be audited and checked by the Quality Assurance Engineering Department before allowing the product to go through to the next stage. Audits of the test results and the design document will be made after the release of every test report and design document. Configuration Management will keep track of all the new versions developed and keep track of the changes. The Configuration Management and Project Management Departments will share change management, and a board will be formed of the Project Manager, Configuration Manager, Quality Engineer, Designer, and Programmer to approve technical and client related changes. This board will include the following members from MIT: Christian, Sanjeev, Gregorio, and Kiran. The board will also include Rafael from CICESE.

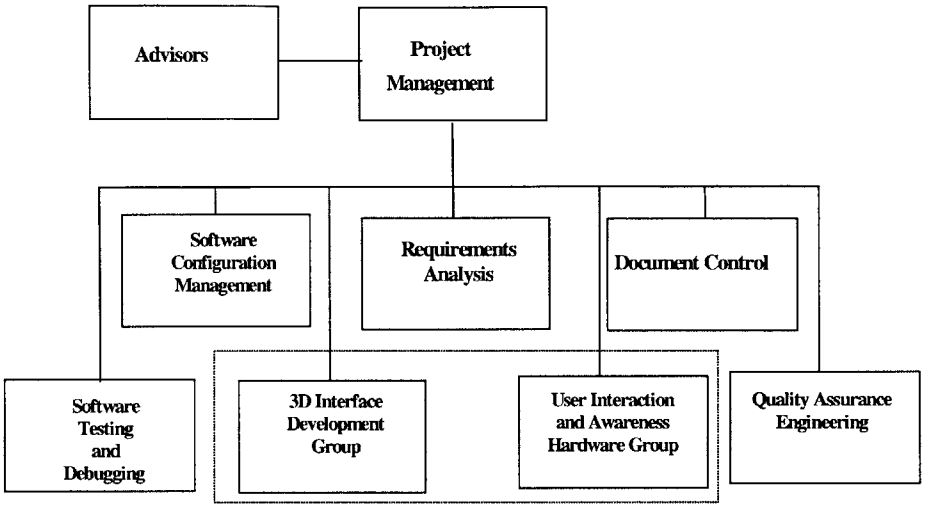

Figure 2. Project Organization Structure

2.4 Project Responsibilities

The role responsibilities and role allocations will be as follows:

Project Management. The software project manager has to plan and organize activities of his or her staff in such a way that there is confidence that the promised end product will be delivered on time, within the cost projected and with the quality expected. This is accomplished by assembling a staff that is qualified to do the tasks required, by directing and redirecting the staff as necessary, and by putting the controls in place that will provide the information necessary to direct the staff to its completed assignment. These controls are frequently referred to as risk management [7]. In addition to that, the project manager is also responsible for intangibles such as team morale, team harmony, and managing the expectation of the client [10].

Requirement Analysis. Requirement analysts act as catalysts in identifying requirements from the information gathered from many sources such as potential clients and market research engines, in structuring the information, and in communicating draft requirements to different audiences. Since there is a variety of participants involved in

the requirement definition process, requirements must be presented in alternative, but consistent, forms that are understandable to different audiences [7].

3D Interface Development Group. The role of the 3D Interface Development Group would be to design and implement a 3D environment to navigate through the chambers of CAIRO. The navigation effect as well as the 3D visualization adds to the social interaction feature that characterizes CAIRO and helps in achieving a better collaboration environment. The 3D interface encompasses both software design and programming. The role of the designer will address the following issues: satisfying the given functional specifications, meeting implicit or explicit requirements on performance and resource usage, satisfying implicit or explicit design criteria, and satisfying restriction on the design process itself such as time or available tools for design. The role of the programmer is to implement the design in an effective and concise code. The programmer shall also address issues of documenting the code and helping in writing the design document.

User Interaction and Awareness Hardware Group. The Awareness Group shall be responsible for representing the feeling of the user and his/her facial expressions, then transferring that into CAIRO as an add-on driver. This group will also deal with the hardware issues related to the machine that will perform the physiological detection process. The group will also have to do all necessary software design and implementation accordingly. The role of the designer will address the following issues: satisfying the given functional specifications, meeting implicit or explicit requirements on performance and resource usage, satisfying implicit or explicit design criteria, and satisfying restriction on the design process itself such as time or available tools for design. The role of the programmer is to implement the design in an effective and concise code. The programmer shall also address issues of documenting the code and helping in writing the design document.

Software Testing and Debugging. Program testing is the most practiced means of verifying that a program possesses the features required by its specification. Testing is a dynamic approach to verification in which software is executed with test data to assess the presence of required features. The inference involved in this assessment are

surprisingly complex. Testing employs analysis to determine software characteristics, which are then used to evaluate whether features are present or not. The tester will have to present a testing plan, include proposed test cases, which are to be conducted on every version of the product [6]. The test report will be updated to incorporate new test results and quality comments at each submittal.

Quality Assurance Engineering. The concept of Assurance of Software Quality is based on the principle of establishing good software engineering practices and monitoring adherence to those practices throughout the software development life cycle. This results to a large extent, in giving control of the software development process priority over control of the software product. It must be understood that quality cannot be the assigned function of any one person in the organization; rather, it must be the primary responsibility of every person involved in the software development process of a product. The role of the Quality Assurance Engineer, then, is to influence everyone to perform his or her function in a quality manner. The basis for this philosophy is that the consistent use of a quality process will result in a quality product. For this purpose, the Quality Assurance Engineer will check the product at every stage in the cycle. The Quality Assurance engineer is responsible for conducting Inspections, Walkthroughs, and Audits to assure the quality at each stage. The Quality Assurance Engineer will also submit a Quality Plan at the beginning of the project that has all desired specifications to be used for the development process.

Document Control. The Document Control Specialist will be in charge of creating and maintaining the project memory. In that function, he or she will also have the responsibility of maintaining the project web site and keeping track of all project documents and preparing the Documentation Report. The Document specialist will also play the lead role in putting together the Users Manual and setting forth the standards for report formats. A Documentation Plan will be submitted by the Document Specialist at the beginning of the project and will be checked by the Quality Assurance Engineers to be later on adopted by all team members.

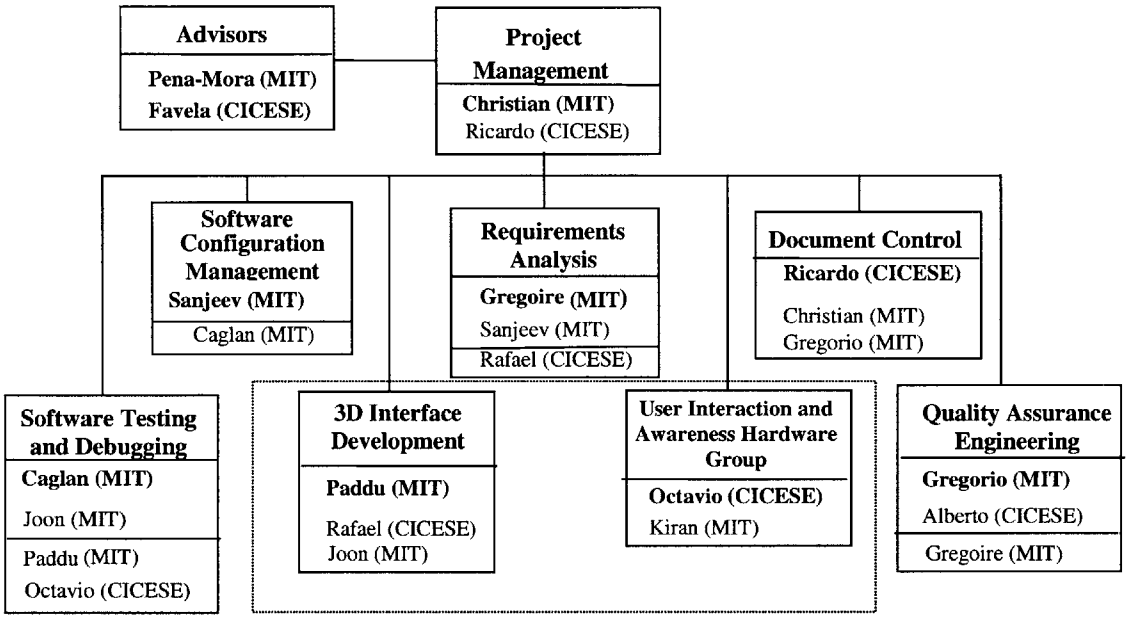

Figure 3. Project Organization

Software Configuration Management. Configuration management is an integral part of the software development process across all phases of the life cycle. It functions as a controlling discipline, enabling changes to be made to existing documentation and products in such a way as not to destroy integrity of the software. The Configuration Manager has to keep track of all version of the product at all times of the development process. For that purpose, he or she is required to submit an updated report with every new version specifying the implemented changes. The Configuration Manager shall also

submit a Configuration Plan at the beginning of the project specifying how the change will be managed.

The fourteen members of the CAIRO project will be distributed according to the organization shown in Figure 3. The minor role of each member requires him or her to be on call whenever his or her minor role group mates need any additional workforce.

3. MANAGERIAL PROCESS

This section of the SPMP shall specify management objectives and priorities; project assumptions, dependencies, and constraints; risk management techniques; and monitoring and controlling mechanisms to be used.

3.1 Management Objectives and Priorities

Work throughout this project will be presented in three different forms:

- Informal report
- Formal written report
- Group Presentation

Oral reports shall be the method by which feedback from the Quality Assurance Engineer will be given in regards to uncompleted documents. The informal report can be in the form of an email, note on the discussion web site, or simply a written comment.

Written reports will be the formal way of presenting one's work. The report will have to follow the format set forth by the Document Specialist and will have to be handed in on time or before the presentations by at least one night.

Group Presentation will be done to conduct inspections, walkthroughs, and major management announcements. All group members will attend the presentations.

Since there are not cost restraints on this project, time and quality will govern the progress of the project. Time is of major essence since we are restricted by the university schedules; for that reason only will it have more priority over quality. Otherwise, the major governing factor in the project life cycle will be the quality.

3.1 Assumptions, Dependencies, and constraints

The CAIRO project is being developed in an educational environment in which the group members are subjected to other major factors that control the progress of the project. Such factors include:

- Educational institution calendar
- Other courses project due dates and quizzes
- Educational Institution vacations and holidays

Other factors are related to the fact of having a distributed team and include:

- Time zone difference
- Availability of the other part of the team members
- Nature of the network connection
- Difference in language and accent spoken

3.2 Risk Management

The factors presented in section 3.2 increase the risk of not completing the project on time and quality. For that purpose a series of activities have been planned to minimize the risk in that area:

- Dedicating a whole semester (Phase I) for getting accustomed to the educational environment to which more than three quarters of the project personnel are new. Dedicating two months (Phase I) for learning the responsibilities of each one's role and the relation with other roles.

- Monitoring the progress of the project during Phase I to be able to provide a better schedule for Phase II. This was achieved by doing a walkthrough, writing a requirements document, testing the stable version of CAIRO, preparing a QA, CM, and PM plan, and debugging the program. In other words, all the roles had been exercised and tested before the beginning of Phase II.

- Getting accustomed to the existing product to decrease the learning effect in Phase II. The debugging and small additions to come up with the stable version of CAIRO helped the programmers get more acquainted to CAIRO.

The above issues address mainly the risk arising from dependencies on external factors. To manage the risk related to internal project factors, the schedule was planned to take into account a certain level of contingency that might result form late arrivals for the January month, as well as late starting in February. Management has also taken care to schedule for holidays and day switching (Monday schedule → on Tuesday) that might affect the schedule.

The allocation of two roles for each member in the project minimizes the risk of downtime due to loosing any members for a certain period during the project life cycle.

Other issues, which have to be addressed in later versions of the SPMP, should deal with the technological risks and level of influence that management has on the project individuals.

3.3 Monitoring and controlling Mechanisms

Reporting mechanisms shall be according to the specifications in section 3.1 and reports shall comply with the format given in the Documentation Specialist Plan.

For the purpose of keeping track of time, the management will distribute as part of its plan a time sheet similar to the one in Appendix for monitoring the activity of each Department. The "unit of measure" that will be filled out by the project members will be as follows:

- Line of code (LOC) for programmers
- UML Class for designer
- Functionality for testers

Time sheets will be submitted to management at the end of each cycle in the project schedule.

4. TECHNICAL PROCESS

This section of the SPMP shall specify the technical methods, tools, and techniques to be used on the project. In addition, the plan for software documentation shall be specified, and plans for project support functions such as quality assurance, configuration management, and verification and validation may be specified.

4.1 Methods, Tools, and Techniques

The tools used for accomplishing this project shall comprise of the computers available in the Design Studio of the Future at MIT and the Sala Electronica at CICESE. All team members are also allowed to use any other facility that might enhance the progress of the project or that would satisfy the requirements; such as, the Media Lab at CICESE.

The programming language to be used will be Java, and the standard compiler will be JDK 1.1.7. VRML language to be used is VRML 2.0. Any change in those technical requirements has to be approved by the Change Management Board specified in section 2.3 of this plan.

The design language shall be UML.

The team structure for each of the project departments shall comprise of a Team Leader that will be responsible for managing the flow of responsibility in his Department. Team Leader shall report in the form of an Informal Report or Formal Written Report to the Project Manager in case of any required changes to the technical tools.

4.2 Software Documentation

Software documentation shall be according to the latest version of the Documentation Plan issued by the Document Control Department [1].

4.3 Project Support Functions

Project support functions include:

- Software configuration management
- Quality assurance
- Testing and debugging

Software configuration management shall be according to the latest version Configuration Plan issued by the Software Configuration Management Department [4].

Quality assurance shall be according to the latest version of the Quality Assurance Plan [1] issued by the Quality Assurance Engineering Department.

Testing and debugging shall be according to the latest version of the Test Plan issued by the Software Testing and Debugging Department [5].

5. WORK PACKAGES AND SCHEDULE

This section of the SPMP shall specify the work packages, identify the dependency relationships among them, state the resource requirements, provide the allocation of resources to work packages and establish a project schedule.

5.1 Work Packages

The CAIRO project consists of 38 detailed work packages Table 2. organized into six major work packages:

- Project Preparation
- Cycle 1
- Cycle 2
- Cycle 3
- Manual Writing
- Project Finalization

The numbering scheme used for the description of activities shall be of the following format:

A.BB.CC

A is the major work package number

BB is the number of detailed work package

CC is the number of activity in the work package

Schedules presented in this document will be limited to the A.BB level, since activity distribution and handling will be part of the development group leader to plan and manage. Each group leader shall submit a draft of his schedule at the beginning of each cycle to the Project Manager to check against other groups.

5.2 Dependencies

Work package dependencies shall be as show in Table 2.

Table 2. Dependencies

ID	WBS	Task Name	Dependencies
1	1	Project Preparation	
2	1.1	Testing Plan	
3	1.2	QA Plan	
4	1.3	CM Plan	

ID	WBS	Task Name	Dependencies
5	1.4	SPMP Plan	2,3,4
6	1.5	Walkthrough of SPMP	5
7	2	Cycle 1	
8	2.1	Design Report v2.1	
9	2.2	Audit Design Report	8
10	2.3	Implementation of VRML Environment	8
11	2.4	Implementation of Decoding software	8
12	2.5	Demo CAIRO v2.1	10,11
13	2.6	CM Report v1.0	12
14	3	Cycle 2	
15	3.1	Test Report v1.0	12
16	3.2	Present Testing Report v1.0	15
17	3.3	Audit Test Report v1.0	15
18	3.4	Design Report v2.2	10,11
19	3.5	Audit Design Report v2.2	18
20	3.6	Implementation of VRML canvas	18
21	3.7	Implementation of Awareness UI	18
22	3.8	Demo CAIRO v2.2	20,21

23	3.9	CM Report v2.0	22
24	4	Cycle 3	
25	4.1	Audit SCM plan	23
26	4.2	Test Report v2.0	
27	4.3	Present Design Report v2.3	
28	4.4	Audit Test Report v2.0	26
29	4.5	Audit Design Report v2.3	27
30	4.6	Integrating Awareness into CAIRO	29
31	4.7	Demo CAIRO v2.3	30
32	4.7	CM Report v3.0	31
33	5	Inspection of final Design Report	31
34	5.1	Present Final Design Document	33
35	5.2	Present Final Testing Report	30
36	6	Manual Writing	
37	6.2	Manual v1.0	
38	6.4	Manual v1.1 Presentation	37

5.3 Budget

This section does not apply to this project

5.4 Schedule

See Appendix.

APPENDIX : Schedule (Base Line)

FEBRUARY

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
1	2 • Testing Plan • QA Plan • CM Plan	3	4 • SPMP v2.1	5	6	7
8	9 • Walkthrough of SPMP v2.1	10	11 • Design Report v2.1	12	13	14
15	16 • Audit Design Report v2.1	17	18 End of Cycle 1 • VRML environment • Decoder software • CM version control report	19	20 • Hand Test Report to inspectors	21
22	23 • Present Testing Report	24	25 • Audit Testing Report • Design Report v2.2	26	27	28

MARCH

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
1	2 • Audit Design Report v2.2	3	4 End of Cycle 2 • VRML Canvas • Awareness UI • CM version control report	5	6	7
8	9 • Audit SCM Plan	10	11 • Design Report v2.3 • Test Report	12	13	14
15	16 • Audit Test Report • Audit Design Report v2.3	17	18 End of Cycle 3	19	20	21
22	23	24	25	26	27	28
29	30 • Inspection of Final Design Document	31				

APRIL

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
			1 • Final design Document	2	3	4
5	6	7	8	9	10	11
12	13 • Present Final Test Report	14	15 • Manual + Demo	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

Appendix: Schedule (Updated)

FEBRUARY

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
1	2 • Testing Plan • QA Plan • CM Plan	3	4 • SPMP v2.1	5	6	7
8	9 • Walkthrough of SPMP v2.1	10	11 • Design Report v2.1	12	13	14
15	16 • Audit Design Report v2.1	17	18 End of Cycle 1 • VRML environment • Decoder software • CM version control report	19	20	21
22	23 • Hand Test Report to inspectors	24	25 • Audit Testing Report • Design Report v2.2 part I	26	27	28 • Design Report v2.2

MARCH

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
1	2 • Audit Design Report v2.2	3	4 End of Cycle 2 • VRML Canvas • Awareness UI • CM version control report	5	6	7
8	9 • Audit SCM Plan	10	11 • Design Report v2.3 • Test Report	12	13	14
15	16 • Audit Test Report • Audit Design Report v2.3	17	18 End of Cycle 3	19	20	21
22	23	24	25	26	27	28
29	30 • Inspection of Final Design Document	31				

APRIL

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
			1 • Final design Document	2	3	4
5	6	7	8	9	10	11
12	13 • Present Final Test Report	14	15 • Manual + Demo	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

APPENDIX: COLLABORATION CHART

Name	Collaboration	Delivery
Alberto		
Caglan		
Christian		
Gregoire		
Gregorio		
Jaime		
Joon		
Kiran		
Octavio		
Padu		
Ricardo		
Rafael		
Sanjeev		

Scores will be given from 1 to 3, 1 being good.