ELEMENTS OF A COLLABORATIVE SYSTEMS MODEL WITHIN THE AEROSPACE INDUSTRY

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PREFACE

Personal Perspective

One of the most significant events in my early career was that of participating in a grassroots movement to establish an early childhood education organization with a Montessori curriculum. It was envisioned and designed to benefit children of diverse backgrounds who had various economic means. With the successful establishment of our goal, I was deceived by the ease of that success. It seemed that one must only do the necessary work to develop an idea and its purpose and then add persistence along with commitment to reach the intended outcomes. Thus, I perceived through my early experience that it was the dedicated work of everyone toward the goal or outcome that was a key element in successful collaborations.

As my career progressed, I found that, whether the context was social action or organizational change, collaboration, as I had initially experienced it, was a daunting endeavor at best for most participants. The process of working together was further complicated with the advent of new themes and structures for working together such as TQM, teams, and teambuilding. Leveraging this early, successful experience with curiosity and additional investigation, I approached this dissertation research study concerning collaboration. Knowledge from the areas of social and group dynamics, systems theory, Neurolinguistic Programming, and management principles added to my understanding of collaboration. As my graduate studies surrounded aviation and aerospace environments, I discovered a discipline rich with unprecedented innovation through collaboration.

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CHAPTER I

INTRODUCTION

"We are caught in an inescapable network of mutuality, tied in a single garment of destiny. Whatever affects one directly, affects all indirectly."

–Martin Luther King

Introduction

The science of aviation began with a collaborative effort between Orville and Wilbur Wright at the beginning of the 20^{th} century (Schrage, 1990). Development of a 20^{th} century perspective has allowed the aviation field to expand and refine itself in a more progressive context than the fields of education and business. Extensive and concentrated efforts have been directed into technological and operational innovation in aviation and space contexts due to the focused attention caused by two major world wars, the exploration of other planets, and visits to the moon.

Collaboration can be found in every field in one form or another (Schrage, 1995, 2000). A variety of definitions for collaboration can also be found depending upon the author and the context (Chrislip & Larsen, 1994; Donnellson, 1996; Gray, 1989; Hargrove, 1998; Katzenbach & Smith, 1993; Saltiel, Saroi & Brockett, 1998; Schrage, 1995; Senge, Kleiner, Roberts, Ross & Smith, 1994; Welch & Sheridan, 1995; Wood &

Gray, 1991). The word "collaboration" has been described as a "complex phenomenon" by Gray and Wood, (1991) and Schrage, (1995). It was Gray and Wood (1991) who attempted to describe the guidelines of this complex phenomenon in order to move toward a theory of collaboration. The various definitions included ideas of collaboration that ranged from negotiated order theory to that of "thinking and working together." When described as a complex phenomenon, we begin to discover the multidimensionality and dynamic properties of collaboration.

The use of collaboration and collaborative systems in education and business contexts has been described in the literature only in the last 20 years. Aviation began with a collaborative effort and has had many successful examples of its use throughout its development, yet the research of collaborative systems in aviation has been limited to nonexistent. The paradigm has shifted from that of the "I" of an individualist to the "we" of the collaboration. With more at stake than ever before, business, science, technology, government, education, and aviation are increasing their collaborative efforts (Hargrove, 1998; Schrage, 1990, 1995).

This qualitative study presents the similarities and differences between definitions and proposed collaborative elements found in the literature. It also illuminates the difficulty faced when a dynamic, complex, interdependent, multifaceted system is dissected for analysis. When other researchers attempted to develop a theory of collaboration, the challenge of putting the dissected pieces together magnified collaborations' contextually varied elements and meanings across disciplines. There have been successful collaborations occurring in aerospace industry contexts that may provide a framework for a useful taxonomy (Dimancesscu, 1993; Lockheed Martin Corp., 1997-2000; Pritchett, 1998; Shirley, 1997, 1998). These frameworks clarified elements and provided new perspectives. The literature revealed limited research pertaining to the elements of successful collaborations within aerospace domains.

This study was designed to be an initial endeavor for gathering data from aspects of collaborative groups in aerospace environments based on a model created from a review of the literature. There has been limited research to elucidate the components of collaborative systems in these specific environments and circumstances. The literature includes stories and descriptions of the landmark innovations of aviation advancement in areas involving human factors (Wiener & Nagel, 1988), CRM (Crew Resource Management) (Wiener, 1993), the development of the Boeing 777 (Dimancesscu, 1992; Schrage 2000), Apollo missions to the moon and back (Lovell & Kluger, 1994), and the Pathfinder project to Mars (Hargrove, 1998; Pritchett & Muirhead, 1998; Shirley, 1997, 1998), yet there was little information that described or illustrated the elements and processes of the collaborative systems.

Statement of the Problem

The problem is the limited systematic review or research within successful aerospace industry collaborative systems in the literature. Currently, the literature contains only cursory overviews of past successful aerospace industries' collaborative efforts (Dimancesscu, 1992; Pritchett & Muirhead, 1998; Schrage, 1995; Shirley, 1998). There has not been any definition of components that are key to successful aerospace collaborative systems. Furthermore, an extensive body of knowledge concerning the complex phenomenon called collaboration does not yet exist (Wood & Gray, 1991).

Purpose of the Study

The purpose of this study was to determine the components of current successful aerospace collaborative efforts.

Research Questions

1. What are elements of an aerospace industry collaborative model?
2. What elements were identified as relevant by those within aerospace collaborative systems?

Assumptions

The following were assumed for the purpose of this study:

1. The aerospace industry, which by its nature is exceedingly complex, provided important and tangible examples of successful collaborative systems.
2. Individuals surveyed understood the questions and provided true and accurate responses.
3. The perspective of the researcher provided a similar personal bias received from the individuals responding.
4. The word "collaboration" and the word "group" may have different meanings depending upon the individual respondent.

Scope and Limitations of the Study

The scope of this study was limited to two internal group or team collaborations in specific aerospace environments. The two groups represented in this study were one aviation specific group and one space specific group. The Oklahoma Air National Guard represented the aviation group, and the NASA Johnson Space Center represented the aerospace group. The specific collaborations selected were based upon access and availability to the researcher. The responsible representatives within the organizations chose intraorganizational collaborations to be surveyed. The survey was an initial endeavor to gather preliminary, foundation data and to explore components of collaboration within the aerospace environment. The nature of qualitative research has been described as emergent and researcher biased (Creswell, 1994). To alleviate a portion of this conjecture, a database has been used to assist in aggregating response results.

Definitions

The following definitions are used for clarity in this study:

Aviation – The art of flying; aircraft design and manufacture (Oxford American Dictionary, 1986).

Aerospace – Is derived from aeronautics and space (http://roland.grc.nasa.gov/~dglover/dictionary/intro.html).

Collaboration – To work in partnership for the purpose of interacting.

Collaborative Systems – A group or team that, through their interactions, work together toward an outcome that no one individual in the system could have completed alone; full range of interactional activity of members.

Crew Resource Management [CRM] – Originally coined Cockpit Resource Management by John Lauber (Wiener, Kanki, & Helmreich, 1993).

Cybernetics – Science of maintaining order in a system (Campbell, 1982).

Dialogue – A conversation.

Discussion – To examine by means of argument.

Interact – To have an effect upon one another.

Neurolinguistic Programming [NLP] – Developed by Richard Bandler and John Grinder (Bandler & Grinder, 1975); a framework for understanding how people process information, learn and generate changed behavior.

Quasi-Collaborative Systems – Generally distinguished by unilateral interaction of group or team members and leader; a large group; separate tasks.

Relevant – Having significant and demonstrable bearing on the matter at hand.

Systems – (Miller, 1978) A set of interacting units with relationships among them. The word "set" implies that the units have some common properties. These common properties are essential if the units are to interact or have relationships. The state of each unit is constrained by, conditioned by, or dependent on the state of other units. The units are coupled. Moreover, there is at least one measure of the sum of its units which is larger than the sum of that measure of its units (p. 16).

- Closed – Emphasizing stability, loyalty, boundaries, and controls.

- Open – Emphasizing flexibility, collaboration, consensus, and communication.
- Random – Emphasizing variety, individuality, high achievement, excitement, unpredictability, and fun.

Successful – Having a favorable outcome.

CHAPTER II

REVIEW OF THE LITERATURE

Introduction

"We are what we think. All that we are arises with our thoughts. With our thoughts, we make our world." – Buddha

What is collaboration? It is "to work in partnership" according to Oxford American Dictionary (Erlich, Flexner, Carruth, & Hawkins, 1980). Beginning with this fundamental definition, this study reviewed the work of various authors who have written about collaboration in the context of aviation, aerospace, business, and education fields. The search revealed four difficulties with the literature. The first difficulty was concerned with the limited number of authors that had written about this specific subject. The second dealt with the differences in definitions among the authors and contexts. The third difficulty was the various definitions describing a collaborative system such as team, group, partnerships, alliances, skunk works, and so forth. The fourth centered on finding real world explanations describing the systems, processes, elements, or structures involved with generating collaborative results. The limited amount of substantive information led the researcher to outline possible elements of collaboration and to search for the combination of those elements. This was necessary in order to provide a basis for developing a questionnaire to gather data from examples of current collaborative systems in aerospace environments.

The differences in definitions from specific to more general denoted the sense that knowledge of this entity was limited and may be context referenced. Also these differences suggested the possibility of a complex social system (Ackoff, 1994) inherent within the collaboration. Therefore, the guiding definition for this study was a group or team that, through their interactions, work together toward an outcome that no one individual in the system could have completed separately. This research does not address "how" the process works, but rather what constitutes a collaborative system and what elements affect the success of collaboration in aerospace environments as revealed through the survey. This should provide a useful taxonomy that can be used to describe collaboration in aerospace environments.

The misused and misunderstood nature of "collaboration" has brought about the difficulty for having a clear and concise definition of the system, processes, elements, and structures. The variations in definitions gleaned throughout the literature review can be viewed in Appendix A. They are listed chronologically and with author(s) reference. This revealed the evolving nature of the change in definitions from Gray's (1989) adversarial, negotiated order theory viewpoint to Hargrove's (1998) viewpoint of congenial cooperation supported with a "recipe" for its process.

Metaphorically speaking, the various descriptions concerning collaborations are similar to the parable of the blind men who were given the task of describing an elephant. While one focused on a leg, another focused on the trunk, while another focused on a tusk, and yet another focused on the tail, and as they described what an elephant must look like (Wang, 1995) [see Appendix A]. Much like this parable, the literature concerning collaboration tends to understand or describe only a portion of what embodies collaboration or a collaborative system. This has led to the confusion of the process, the entity, and its overlapping elements.

Delving into the literature revealed limited information concerning the definitive word "collaboration" or "collaborative system." It also seems to be a word with fairly recent popularity. Although conceptual closeness is shared by such words as partnership, alliance, coordination (Whetten, 1981), cooperation (Johnson & Johnson, 1989), cross function and aspects of concurrent engineering (Dimancesscu, 1992), it was not until backtracking through the literature and looking for collective elements of collaboration that collaborative systems were revealed. In searching through aviation history one could go back to Orville and Wilbur (Schrage, 1990), continue on to the development of aircraft automation, the development of the "Cambridge Cockpit" for improving pilot performance (Edwards, 1988), and through the literature to the Lockheed "skunk works" (Lockheed Martin Corporation, 1997-2000) to view successful collaborative systems.

In most American industries Taylorism with his "scientific management" had a strangle hold on management and organizational behavior. His principle of micro-efficiency eliminated the natural responsiveness of a system to be more than the sum of its parts (Miller, 1978; Sheridan, 1988; Westphalen, 1998). Taylor's management difficulties were further exacerbated by Alfred Sloan's solution of "command and control" developed in the auto industry. Then in the late 1960s, auto manufacturers, some of the largest organizations in the United States, began to see smaller profit margins and to question why it was happening. The smaller, more efficient automobile from Japan was usurping the American market-share.

What was happening? The Japanese were learning and were paying close attention to those Americans sent to help them recover economically following World War II. They were adding their own ideas to make further improvements to the new processes. They flattened organizational walls in order to talk to one another across departments and developed cross function operations specifically for the purpose of better and faster designing. They improved products along with operationalizing consumer desires and necessities (Dimancesscu, 1992). Thus, the process of collaborating necessitated a system or environment that enabled and supported it. Linear inefficiency and waste led to organizational restructuring of key departments. This restructuring recognized and developed other new systems in support of the phenomena called collaboration.

The new systems to enable this phenomena were referenced as collaborative principles in the beginning when Trist (1977) first discussed and wrote that new organizational designs needed to be built upon these principles. The new "social architecture" (Perlmutter, 1965) was needed as the competitive model and technocratic bureaucracy were no longer proving functional. Ackoff (1974) called it "idealized designing" as this new model was envisioned through removing the past constraints within organizations and requiring participation by all along with continuous interactive, adaptive planning. This accelerated change necessitated flexibility or "requisite variety" (Ashby, 1954; Bateson, 1972) as well as innovation. The paradigm of competition was being pushed to the side for collaborative principles being the "emergent social process" (Trist,

1977) that would help cope with complexity and uncertainty as organizations moved from the industrial order to that of the information age.

The Beginning of an Understanding of Collaboration

There have been many generalizations attempting to define and develop a theory from the findings within the collaborative framework. The Journal of Applied Behavior Science dedicated two volumes of its publication to address various theoretical and empirical perspectives in 1991. Of the nine research-based articles, seven definitions were used in an attempt to synthesize each definition's significant aspects. Considering and elaborating on frequently occurring aspects within each definition, Wood and Gray (1991) developed a new generalized definition needing two additional pages for explanation. This explanation was followed by a summary elucidating the exclusion of other collective forms. They also summarized their endeavor, as defining an evolving phenomenon—the challenge undertaken in describing a phenomenon is the propensity to simplify the elements or parts while leaving unnoticed crucial underlying interactions.

The possibility of developing a theory concerning collaboration was not demonstrated through the review of literature (Erchul, 1992). When considering the practical value for a theory of collaboration, a solution was readily available in the ancillary literature. This allowed for an established theoretical framework. The theoretical framework began with a systems approach (Sheridan, 1988) which led to Information Systems Theory (IST), a general communication theory which explained how information becomes optimized in open, closed, or mixed communication systems intrinsically producing order, structure, and control (Cragan & Shields, 1998). This framework made a suitable foundation for the complex nature of collaborative systems.

In Gray's (1989) seminal work, she viewed collaborative systems through interorganizational partnering. This view considered the problem domain, confrontation, overcoming the impasses, and the use of negotiated order theory. She laid out a method for solving shared problems and resolving conflicts in order for organizations to obtain mutually satisfying and enforceable agreements. This method included the "broader sociological sense" of the term negotiation as "conversational interactions" between parties. That is parties negotiate and renegotiate their relationships emphasizing the cognitive interaction aspects of the process.

From the viewpoint of conflict resolution or problem solving, Gray (1989) addressed fundamental issues of any collaboration. Her collaborative formula addressed specific, structured steps as she asserted that negotiated order theory, focusing on emergent dynamics, is likely to best describe the interactions between organizational relationships or collaborations. She emphasized the importance of developing ideas for joint problem solving while searching for common ground, understanding, and workable options. Resolutions should generate an integration of interests and decision making for the parties involved while the environment promoted trust, respect, reasoning, consensus, and positive relationships. Gray (1985) was influenced through the clearly observed distinctions made by her colleague, McCann (1983) as he viewed the development of interorganizational domains from problem-setting, direction-setting, to structuring. He stated this is a naturally occurring process yet it can be interrupted, enhanced, or stopped at any time.

The three-phase model explained by Gray (1989), describing interorganizational partnerships, also included steps necessary for every (interorganizational) collaborative effort. The initial phase, often the most difficult, was problem setting. This gave the issue an identity and a forum for the discussion. It was at the level of this first phase that the definition of the problem is paramount. Commitment for collaborating may be strengthened by a third party facilitator or convener who persuaded the stakeholders to assemble. Next, came the identification of the stakeholders who held a legitimate stake in the process. Another important step in the initial phase was the identification of available resources. The resources to sustain the collaboration were an important key to all participants. These formation steps set the stage for stability. If they were shortchanged at the onset they would later hamper the collaboration's success.

Direction setting was the second phase of this process. This phase began the goal of mutual understanding. Stakeholders articulated the values that brought them to the table and believed that favorable outcomes would be the end result. This phase established ground rules for interactions and agendas, while it organized individual or subgroup work. The problem was supported by agreement of the facts, rather than emotion, that also supported possible options and resolution.

The last phase of the process was implementation. These issues dealt with those individuals that were not a part of the collaboration and established support and structure for those members that would implement the resolution or new program. The implementation phase attended to cultural and organizational differences plus staffing changes to assure adequate implementation or compliance. This perspective reflected the structured legal and conflict negotiation context within which it was conceived. Inherently similar, this model is more specific and detailed than Gray's (1985) earlier model built upon McCann's (1980) natural progression of interorganizational domains of problem-setting, direction setting, and structuring.

With Lieberman's (1986) study of collaboration in schools, she warned that the collaboration process is neither casual nor effortless. She states further:

> There are many problems and tensions. Those who have been involved in collaborative work know that while the idea of collaboration is very attractive, the reality is far more difficult and complex . . . we better understand its pitfalls, misconceptions, and conflicts. (p. 8)

Shirley Hord (1986) gave ten features of interorganizational collaborations as a way of developing workable relationships. This began an initial view of the complexity involved with collaborations. The ten features started with needs and interests. The next features included time, energy, communication, resources, and organizational factors. The features finished with control, perceptions, leadership, and personal traits. She stated that collaboration takes a vast amount of time, as participants must work together in many mutual activities. Collaboration is also energy intensive and requires frequent interaction and sharing. Collaboration requires a flexible environment and, for those needing stability and specificity, collaboration is a difficult process. Collaborative leadership that acts as a role model and the ability to view multiple perspectives is important. Other guideposts include those of patience, persistence and the willingness to share information and knowledge.

Hord has also outlined guidelines for those wanting advice for working within collaborations. She states that, in order to begin collaborating, an organizational structure needs to be set in place along with the allotment of time necessary for collaborating. Also, an important point to consider is that working with other people consumes more energy than working alone. Farr-Pettersen (1995) echoed that "collaboration was a time-intensive process" from the scheduling of necessary meetings to the multiple roles that professionals must balance. It was not a quick fix. There is also the necessity to remain flexible and open to all possible resolutions.

Collaborative work is enhanced by skillful people working together even though in these arrangements conflict may be inevitable. The product resulting from the conflict is the new learning and understanding Hord described as something similar to the rounding of the sharp edges of a newly cut stone. Collaborations must also deal with ambiguity as a part of their nature; therefore, flexibility needs to be the password. Initially, activities propel the collaboration forward with the larger goals becoming evident as the work is completed together. It is the shared experiences over time that are the keys to building trust, respect, and commitment. There is an important sense of pride built into a co-creation of the successful collaboration (Hord, 1986).

It is when a novice group is newly assembled to work together that the uncertainty begins, and this uncertainty is compounded by the complexity of interactions within the possible relationships (Dilts, 1998). This can be illustrated through the exponential increase of the number of possible relationships in a group comprised of seven members. Within that group of seven, there will be almost 1000 potential relationships influencing that small group's interactions. There are six people involved when any two people interact. Examples of these relationships are "1) who you think you are, 2) who you think the other person is, 3) who you think the other person thinks you are, 4) who the other person thinks he or she is, 5) who the other person thinks you are, and 6) who the other person thinks you think he or she is " (Bebee & Masterson, 1997, p. 37). This complexity and the level of processing of relationship interactions generally occur outside of our conscious perception (Dilts, Grinder, Bandler & DeLozier, 1980). If one was to view this interaction on a chart or graphic, there would be lines connecting each possible arrangement of interactions creating a web of lines crossing so many times as to be indistinguishable. Compare this graphic to one of a large community based group, for example, that is meeting to "collaborate" on a grant. The interactions in this example are generally from a group member to the leader or co-leaders. Even though this assembly is called a "collaboration" and it fulfills the definition of a collaborative system, the lack of interactional activity between all participants involved places it within a range of quasi-collaborations, those lacking complete interactional activity. The flow of interactional activity will qualify the difference between quasi-collaborative systems and collaborative systems in this research paper.

There were various elements that constituted an integral core for collaborative efforts. Hargrove (1998) began by taking advantage of extraordinary combinations of people. This extraordinary combination of people identified with possibilities rather than impossibilities and recognized that the diversity of other people's perspective melded with their skills and talents amplifying the potential for discovery of a shared creation. Secondly, these collaborations relied on bringing people together and enabling them to work on shared and understood goals. The purpose of these goals was larger and more lasting than what any of the individuals alone could have accomplished. Thirdly, as each one of us has come to view our world differently, a collaborative system allowed interactive dialogue to begin the process of building a shared understanding. This also included various perspectives of the problem, beginning from its root cause, to the solution. This system tested possible problem resolution actions with its varying consequences for optimal results. Finally, the shared understanding culminated in the shared discovery and creation. He called this a "recipe" for collaboration. Hargrove also had a category called "Building Blocks" of collaboration along with the required steps that made a "Collaborative Person." He included "Five Phases of Collaborative Conversation" plus sections concerning coaching for collaborations, practical applications, and tools for creative collaborations. The nature of Hargrove's detailed analysis of collaborative systems lends support to the idea of their multifaceted and complex quality. Much of this information was similar to the earlier writings of Michael Schrage (1990, 1995) on the subject of collaboration.

Michael Schrage (1995) discussed collaboration in terms such as "creative relationships," "intelligent innovations," and the "process of value creation." He described:

> collaboration as purposive relationship. At the very heart of collaboration is a desire or need to:
>
> - solve a problem,
> - create, or
> - discover something within a set of constraints.
>
> These constraints include:
>
> - expertise—one person alone doesn't know enough to deal with the situation;
> - time—collaboration is a real-time effort in an airplane cockpit or an operating theater, a more leisurely process in the arts and sciences;
> - money—budgets matter in both business and top flight scientific research;
> - competition—in science or business, others may threaten to beat a collaborative team to publication or to the marketplace;

> - conventional wisdom—the prejudices of the day (for example, the impressionists had to launch their own gallery to exhibit their work to challenge the French Academy).
>
> Given the constraints, collaboration is anything but an assembly-line process. It can't be routine and predictable. People collaborate precisely because they don't know how to—or can't—deal effectively with the challenges that face them as individuals. There's uncertainty because they genuinely don't know how they will get from here to there. In that respect, collaboration becomes a necessary technique to master the unknown. (pp. 29-30)

One of the pivotal elements that support collaborations according to Schrage is the concept of "shared space," an indispensable tool. He emphasized that there must be shared space in order to create the necessary shared understandings and to add dimension to interactions. This shared space is the medium that bridges spoken and visual language to create shared meanings. They can be worked in synchronously or asynchronously. This environment is easy to play in, accessible to all involved, alleviates distance through whatever means readily available. Generally, it is the known tools of the meeting place, a videoconference and whiteboard, email, fax machine, or the phone.

Another aspect that was similarly as important as shared space to successful collaborators was the development of a common language supporting shared meanings and understandings for relating specific information. They created specific terminology assisted with graphics, models, and patterns that assisted the group members in understanding and developing common communication that suited these new endeavors (Schrage, 1995).

When Gray and Wood (1991) wrote about the complexities of collaboration they discussed common elements in the definitions of collaboration in the review of the literature. They included stakeholders of a problem domain that had autonomy and participated in an interactive process. These stakeholders had shared rules, norms, and structures and intended to act or decide on the stated problem. Also, Gray and Wood found that it was not necessary to obtain an outcome for a collaboration. The end result could actually be unspecified and open to further analysis. This research article continued Gray's (1989) attempt to develop a theory of collaboration. They have been unable to accomplish this aspect of their research.

Collaborative interventions for social, educational and economic challenges remain the means to deal with the complexity of our current world. When considering theoretical arguments to support inter-organizational collaborations, Ashby's (1954) concept of requisite variety can also be considered. An organization working together with external collaborations that exercised the widest range of variability and flexibility would thus be in command of the controlling element. Flexibility was found to be the element that initiated time critical identification and response to threats or opportunities providing stability in complex, chaotic times.

Organizations are now partnering extensively in order to maximize resources for market share and innovation. Andrew Grove (1996), head of Intel, urged that partners and customers should be part of the collaborative debates. He further stated that this diversity of interests, biases, and expertise continues to allow a business the successful option of serving its customers and continuing with a competitive edge. The significance here is not the additional time or cost which it will necessitate but rather the sharpened focus and clarity this brings to strategic and powerful inflection points (rate of change) according to Grove (1996) that shifts the rules or paradigm (Kuhn, 1962) and has a powerful effect. If these strategic points are unnoticed or unheeded at the onset, the eventual cost to an organization could be billions as evidenced in the auto industry during the 1970s and 1980s (Dimancesscu, 1992). Yet when successful alignments are made resulting in a new framework, the unknown is made understandable, and effective actions, a distinct new order, emerges from the previous chaos.

In the Fifth Discipline Fieldbook, David Kantor (1994) related a story of a "team" collaboration that guided a company. He discussed distinctive characteristics of the group that included dialogue and unspoken messages from body language down to eye movements and breathing. He included the purpose or the goals and desires that motivated the participants along with the underlying supposition (Bandler & Grinder, 1975; Dilts, Grinder, Bandler & Delozier, 1980) of the system for tacit authority and boundaries. Lastly, he related as important the image we assumed for ourselves which influenced each person's behavior (Dilts, et al., 1980; McMaster & Grinder, 1993) and the situation. This did not describe a static system. These characteristic distinctions are interrelated and responded with feedback from the various elements. From this viewpoint, it was the sequenced interactions that had the pivotal element rendering the group either effective or dysfunctional. In Pert's (2000) work, she discussed that one of the roles of endorphins is to promote bonding, connecting, and other aspects that sustain relationships. She suggests that basically we are hardwired in our brain to relate to each other, a natural predisposition that we all possess.

Yet, the model described by Katzenbach and Smith (1993) remained as an elegant and clear example of necessary components for collaboration within a team. The focus began with skills, commitment and accountability. Within that framework the six elements described were 1) small enough numbers for optimal operation; 2) adequate corresponding skills to cover functional and technical concerns, problem solving/decision making skills combined with interpersonal abilities; 3) meaningful as well as important purpose; 4) specific and measurable goals; 5) clear and interactive approach; and 6) individual plus team accountability.

These clear and concise functioning categories seemed to glue themselves together with the axiom from participants that "being a part of something larger than oneself" remained an important distinction. According to Katzenbach and Smith (1993), group members had a better-developed sense of humor, which obviously dealt with the pressures and intensity of the performance together; they experienced change and growth more readily. They had more fun, resulting in an increase in performance; perhaps this was the key that made breakthroughs and innovation a possibility.

Larson and LaFasto (1989) concluded that successful teams shared eight characteristics. First, a clear and elevating goal; second, a structure supporting and leading to results; third, competent members; fourth, united in commitment; fifth, a collaborative environment; sixth, undergirded with principles of excellence; seventh, external support and recognition; eighth, principled leadership.

Along with the best aspects of a group working together, there were the opposing aspects of frustration, misunderstandings, arguing, and the edge of unmanageability (Forsythe, 1983). On this edge of chaos, was where new structures began to evolve and new levels of understanding developed. A new environment was needed to support groups working together that transcended antiquated disciplinary and departmental boundaries.

Education has become increasingly aware of the benefits of collaboration. It is integral to educational reform, a component to facilitate change (Welch, 1998). Education views collaboration in three ways; one is change and reform; the other is the necessity for educators to supplement the core knowledge requirements with "how to collaborate;" and lastly as a mode of learning.

This knowledge of how to collaborate was needed as a way to begin erasing the isolation educators found in the past that had held back clear reform and progress. Fullan (1993) wrote that even though collaboration was a current topic in education it was also the most misunderstood concept in educational reform. Yet, assumptions have been made pertaining to educators' knowledge of collaboration, what it means, and how it is accomplished. The reality of the concept has been lost in the rhetoric of the copious articles written. An illustration of this (Garmston, 1997) addressed the "three easy steps" to teaching collaboration to educators. To begin with there were the necessary fundamentals of collaboration which he referenced as a "craft." The nine fundamentals necessary to practice were communication skills, inquiry, problem solving, making decisions, resolving differences, self assertion, integration, metacognition, and self control. Continuing, Garmston iterated step one as the need to know what collaboration is and what it is not. Step two required one to be "familiar with the collaborative terrain." This included content and process knowledge, a thinking environment, mastery of the nine fundamentals, and co-cognition. Step three, which can be learned but not taught, he stated, was the development of the mental or metacognitive skills of collaboration.

Teachers have come from a long history of working in a somewhat isolated environment as an individual in control of the class. That model is no longer effective for teachers nor does it satisfy most of their students. Teachers became aware of collaboration aspects to promote reform and further educational progress. They began establishing collaborative skills through the current core professional standards. Training was also required for teachers and administrative staff in order to insure collaborative skills were known and used by currently practicing teachers and professionals (CEC, 1995). Welch (1998) outlined definitions, foundations, and skills necessary. Both the benefits and barriers drew heavily from organizational theory.

The collaborative learning model can be viewed through an explanation of group development and cohesiveness (Bruffee, 1993; Forsyth, 1983; Michaelson, Black & Fink, 1996; Silverman & Casazza, 2000). In a collaborative learning environment the format is much the same as in any collaborative system. It is necessary for a student as one participant of this collaboration to contribute as much as any other collaborator, even the instructor who is considered an equal participant (Silverman & Casazza, 2000). This is an important distinction as compared to the format of cooperative learning where the instructor is still responsible for delivering the learning. Michaelson, Black, and Fink (1996) have developed a model for building effective learning groups. They stated that their experience showed that being in close proximity ensures the initial stage of group development. Secondly, members need tasks that stimulate high levels of interaction such as making decisions based on complex data sets. Yet the most important component for group cohesiveness is providing external performance comparisons with other groups or outside influences that are perceived as a threat to group goals. Last, but not least, is the significant rewarding for group work and performance. This model gives insight into components that play an integral part in any successful group or team performance not only learning.

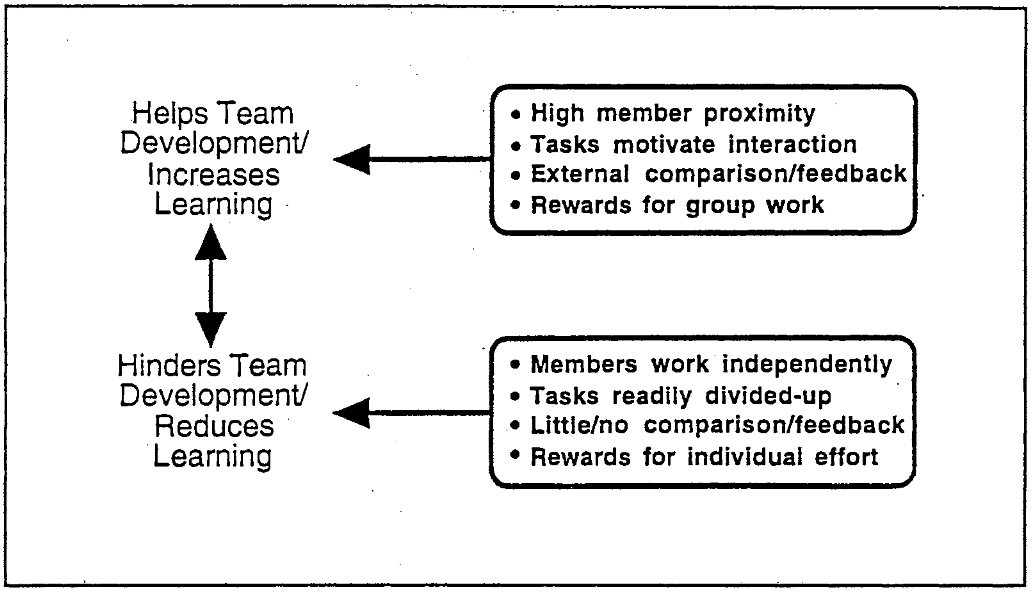

Figure 1. Impact of Task Characteristics on Team Development. Adapted from Michaelson, et al., 1996.

The first enclosed box of four characteristics could be representative of collaboration while the second set of characteristics is more indicative of cooperation and coordination or quasi-collaboration. Collaborative learning developers discovered how partnerships changed over time in the learning environment, the role patterns that emerged, and how those changes influenced the learning process (Saltiel, Sgroi & Brockett, 1999).

Schrage (1990) described the act of collaboration as a shared creation and discovery. One example that he used was the tragic flight of United 232 in 1989. There was no procedure for a plane that became unable to maneuver due to loss of all hydraulic systems so they began to make it up as they went. When problems arose, an off-duty pilot flying as a passenger volunteered to assist the plane's crew. One of the crucial decisions the crew credited for its ability to accomplish the impossible was the initial agreement of collective consent before anything was tried. Aviation experts considered their efforts that saved 185 lives out of 296 a miracle. Aviation, space, and the medical field intrinsically deal with life or death consequences within exacting time constraints that, generally, do not need consideration in other collaborative environments.

During the work on the Pathfinder Rover Project, Shirley's (2000) successful team was compiled of a mix of skilled experts with varied educational backgrounds and consultants when necessary. The Rover team included both cultural and gender diversity; varying age ranges added dimension both in experience and freshness. Other components that enhanced the success of the group were good interpersonal skills, active listening, idea presentation, and trust as they learned to understand each other's "language." She made sure there was an ample mixture of humor, rewards, and socializing. One of the most important structural components of this team was the role of "leaderless" leader in which Shirley placed herself (Janis, 1972). This allowed an open systems operation for the group. These were the beginnings of some of the components that developed the collaborative effort to deliver a small rover landing on Mars successfully, during the July 4, 1997 NASA mission.

The formula that helped build a successful team was used to collaborate with suppliers. These collaborations furthered the development of improved parts designs along with cost-cutting operations. Throughout the process, vendors, national labs, and other NASA centers were added to the team, thus controlling costs in a limited budget. Everyone focused on performance plus results. The team members were disciplined as they broke the rules to think outside the box. They worked toward providing necessary deliverables while heading in the direction of innovation and moving toward the deadline. They improvised, took calculated risks, creatively "pushed the edge of the envelope" while all the way using precision, raising standards, and refining the odds for success (Pritchett & Muirhead, 1998).

Isaacs discussed a theory of dialogue (Senge, Kleiner, Roberts, Ross & Smith, 1994) detailing how breakdowns in group effectiveness were closely related to how individuals viewed the world (Bandler & Grinder, 1975; McMaster & Grinder, 1993). Shirley (1997) discussed the process she used on the Rover project to build shared understandings and learn each other's "language" in her team to avert this breakdown in collaborative systems.

Aviation and space development is renowned for use of simulations to learn from, to improve by, and as a key component of success (Westphalen, 1999). Continued simulated practice problems paid off in contingency plans that were eventually used when the Rover landed on Mars. Given the small operational window for successful task completion it remained necessary to be prepared and knowledgeable for any contingency while having the ability to thwart any challenge.

The aerospace industry seemingly had an advantage in collaboration all along. With a systems orientation, quantitative use of technology on all levels, equipment development, and opportunities from one of the last frontiers, space exploration, this industry refined processes and procedures developing collaborative abilities on a grand scale. They accommodated the changing times with changed thinking exemplified by terms such as *better, faster, cheaper,* which was NASA's motto for the 1990s under Daniel Goldin (Pritchett & Muirhead, 1998).

The Mars Pathfinder Project was an example of successful collaborative systems in operation. Processes were innovated to allow for the interactions necessary thus creating and developing desirable outcomes. According to Shirley, Rover Director, flexibility was the key component in the process of directing a diverse group of scientists and engineers (Hargrove, 1998). She described the implementation of the process used as concurrent engineering (Shirley, 1997). Concurrent engineering coincided with fast cycle time and was also known as integrated product development. Multifunctional teams were utilized to facilitate this process. The concurrent engineering process was quite simple. It began with everyone involved from the beginning to the end simultaneously; the needs and constraints of all parties were made known and understood in order to be considered throughout the process.

Rapid prototyping, a systematic approach to integrated design and related processes (Dimancesscu, 1992), made consequences and issues surface for quicker resolutions through total participation. Rather than moving linearly, there are clusters of processes in concurrent engineering that operated simultaneously toward the goal and around the project constraints. The Mars Pathfinder was the initial project to substantiate the *better, faster, cheaper* motto (Shirley, 1997). It was supported by the flat organizational structure incorporated by Shirley for the Rover development.

Donna Shirley wanted the Rover to

> . . . belong to everybody. Everybody would feel invested in it. She drew a circular organizational chart, rather than a hierarchical one, with people doing work on the inside, doing the work together, and the managers on the outside acting like the cell wall of bacteria, so that you make the nutrients come in—like money—and keep out the disease, the bad stuff, like excessive interference from upper management. (Hargrove, 1998, pp. 42-43)

Another innovative term "co-location" which was used on the Pathfinder project and was borrowed from previously successful aerospace industry projects such as the development of the Boeing 777 jet aircraft. The Boeing 777 project changed organizational structure in many ways as it concluded that it was necessary for the environment to support the development of collaborative systems (Dimancesscu, 1992). This principle was used by the Pathfinder team when they were located in a residence hall, which gave them continual access to one another and made interaction even more feasible for innovating and developing within the concentrated time parameters (Shirley, 1998).

For those in the aircraft manufacturing arena, collaboration has been ongoing due to the complex needs of this aviation environment specialty (Karlenzig, 1998). A large commercial aircraft has approximately 6 million parts contained within it. There is a "Big Problem" that might not be readily visible to someone unassociated with aviation manufacturing and service companies. It was thought that this problem would not have a solution for decades longer. Yet, aerospace manufacturing and maintenance have collaborated with an electronic publishing company to begin the resolution of this complex problem. It is the production of aircraft component documentation. For instance, a

75,000-page aircraft engine product and maintenance manual must contain each industry's product and procedural data along with the evolving policy and procedural information. Although the solution is ongoing, great strides have been accomplished through the collaborative efforts of this colossal industry-wide problem.

The aerospace industry cannot be discussed without the acknowledgement of its technology intense operations. This fusion of technology can be found from the designs of new airplanes to space shuttles, from precision training simulation, through to daily management and the publication of product and maintenance information and manuals. New technologies were developed for every space exploration project as well as aviation development and also played a crucial role in the success of the Mars Pathfinder project (Shirley, 1998).

Technology has been an enabler to collaborative systems from partnerships to teams, groups, and organizations. Technology has supported the processes and interactions of everyone involved, the environments, and the capture of evermore-complex informational data of the various projects. The supporting role of technology (rather than the innovation of it) was the pivotal element in the profound transformation of the design process, management roles as well as the entire corporate culture of Boeing's breakthrough 777 jet. Spurred by the development of CATIA software, a 3-dimensional computer model, as the main design tool and 2200 new computers connected via the world's largest network of IBM mainframes, designers worked for the first time without a wooden model. The support of technology also shifted the previous organizational walls that contained Engineering and Operations as separate entities and melded them into functional Design Build Teams (DBT). The once linear process gave way to concurrent engineering, collaborating towards the successful outcome, elimination of reworks, and enormous savings in time and money. This process ferreted out potential problems as it facilitated communication for problem solving in a less threatening confrontation. The environment was not without conflict and turmoil. Leading the reason for conflict and turmoil was the massive organizational changes made in a relatively short time period within the corporate culture and former working process. This endeavor changed the face of aircraft manufacturing forever (Dimancesscu, 1992).

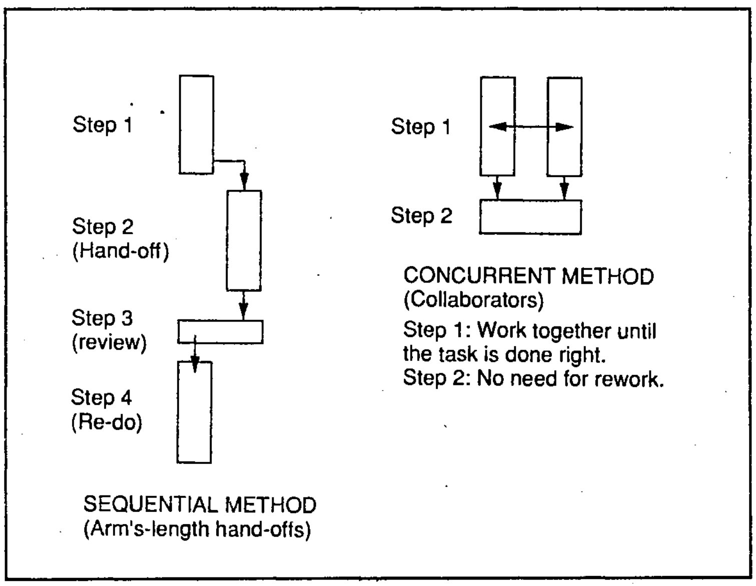

Figure 2. A Sequential Versus a Concurrent Process.
Adapted from Dimancesscu, 1992.

Organizations had to change or die in order to be viable in the marketplace. The concepts of collaborative systems were beginning to develop along with the advent of organizational restructuring towards functional team units. This advent combined with the necessity to understand consumer needs became a powerful incentive for reorganization (Dimancesscu, 1992). The old guard established by Taylor and his scientific management principles had to give way to more fluid and organic decentralized structures (Schrage, 1995).

Changes such as innovation became more paramount with the marketplace competition and of course "what the customer wants." The life cycle of a product was shorter lived. Development time for new products, therefore, became an exercise in rethinking old strategies in order to be "first in the marketplace." The rules changed the structures and the dynamics then had to change. Increasing organizational complexity and competition became part of the new business environment and the necessity for collective brainpower, commitment, and energy had to be utilized. Entrepreneurial partnerships, joint-venture business collaborations, and community problem solving cascaded into the forefront of everyday news.

The advent of easier to use, more powerful, and more accessible technology was a key factor that led to the functionality of the form. From telephones, copy and fax machines to video conferencing, the common denominator of all of these tools remains communication. This common denominator, communication, was contained not only in verbal interactions but also in the images that were drawn when the idea or concept could not be put into the "right" words. So the components or "tools" according to Schrage (1995) were the whiteboards, napkins, sketches and holographic computer models that had assisted us in our thinking and our understanding—the picture, graphic, or model became worth a thousand words. Yet there was one other tool supporting the interaction that was so important the interaction would be stifled without it. That support tool was the shared space and time necessary for collaborating.

And More Collaborations

Education has been reluctant to create the kind of meaningful change that would fundamentally shift the way education was conceived and delivered. Every aspect of education has emphasized the need for total and comprehensive change (Chrislip & Larson, 1994). As stated by Cotton (1991), the focus on reform only from the level of academics did not raise the level of student achievement. School-community collaboration must have effective and expanded support services for urgent and multiple needs of urban students and families. Teachers were unable to address the many needs of the students, which impeded academic achievements. These ranged from dysfunctional families, drugs, non- English speaking students, and homelessness. This need gave rise to school collaborations with health and social service agencies, colleges and universities, parents and community members, business and industries, as well as with neighborhood organizations. Oklahoma had set up several models: Possibilities, a school for homeless children; Oklahoma County Coalition of Citizens and Professionals for Youth, to ensure delivery of various and necessary services in truancy; and the Oklahoma Early Intervention Plan for Children with Special Needs.

The National Aviation and Space Administration (NASA) had collaborated with educational systems and institutions dedicated to improving science literacy. One of many successful collaborations had been the Minority University-Space Interdisciplinary Network (MU-SPIN). This collaboration evolved through four stages. The first stage began with the initial conceptualization, developing the infrastructure of hardware, software, and training people to apply these new skills. Throughout the collaboration stages success was experienced by continued interaction with NASA, Goddard Space Flight Center, the National Science Foundation, and the Association of Computer and Information Science/Engineering Departments at Minority Institutions. When the MU-SPIN Network Resources and Training Site was established, its collaborations began to take off which allowed the Network to train an increasing number of students and faculty while building additional partnerships on the cutting edge of science and technology research (Harrington & Thomas, 1999).

Shirley (1997) discussed the use of creative communication and the "free flow of information" as the key to creative collaborations based on her work at the Jet Propulsion Laboratory. She continued that communication should be conveyed in as many ways as possible such as with overheads, slides, visual imagery, demonstrations, and information through all of the senses. These addressed the varied ways individuals experienced the information as they processed it into an individual knowledge database. Without these considerations, obstacles in the interactions became apparent and did not foster a common understanding.

The aspect of cockpit crews acting as individuals rather than as a team due to the intense technological environment was a concern of aviation experts. Higher performance levels of cockpit and ground crews were correlated with higher communication quality (Schrage, 1995; Wiener, 1993;).

The X-33, one of the largest collaborations yet envisioned, is happening now within the aerospace community. This newest design for space travel ". . . required a revolutionary approach to collaboration . . ." stated Storojev and Barth (1998, p. 54). This project will enable the next-generation plane/spacecraft, Reusable Launch Vehicles (RLV) to be ten times faster than the space shuttle, ten times less expensive, and replace the shuttle in ten years. Thus the "three tens" along with the three year parameter from drawing pad to launch pad equals the X-33. From the shortsighted, "*better, faster, cheaper*" has evolved this more viable model. It is a business venture, a public/private partnership; it is required to be a commercial success; partners are also investors and interested in the opportunities for the space market. The paradigm has shifted—public/private collaboration rather than competition. The new frontier forced the development of state-of-the-art management tools for collaboration and communication. It also forced the social structures of the partners to reorganize in order to facilitate both working and sharing information across the boundaries of corporate networks.

The Lockheed Martin (1997-2000) organization illustrated the expansive project and national involvement of its partners under the headings of NASA, Aviation Industry, the US Air Force, and other major subcontractors. This project called VentureStar™ incorporates roughly 26 different organizations with about 2000 people working on the project from all over the United States to accomplish its goals.

Program management, design work, systems integration, and X-33 (the prototype for the VentureStar™) vehicle assembly are all happening at Lockheed Martin's "Skunk Works." For over 50 years the Skunk Works has been working collaboratively to create breakthroughs in technologies as well as aircraft. In order to go beyond the current possibilities in flight, they have developed a simple formula for innovative success. This simple formula is to identify talent in the aviation field, bring that talent together, and add the optimal equipment, tools, and resources—the right tool for the job. The final step, a supportive environment that is built to sustain the most select solution to the challenge which is then completed within the deadline. This successful collaborative formula has worked from the P-80 Shooting Star, the first production jet, to the F-22 Advanced Tactical Fighter and now the X-33, predecessor to the full size VentureStar™ (Lockheed Martin, 1997-2000).

In order to assure the success of this large a collaboration, these partners took direct, decisive, and immediate action towards change and optimization of what most business books would like the reader or audience to believe takes years to accomplish. For instance, Rocketdyne went from a hierarchical organization to cross-functional teams or product integrated teams. In order to facilitate this change, they designated program integrators as a part of the teams. These facilitators managed communication between the teams and division specialties. Rocketdyne also took the next important step of moving the teams to a single floor as they removed all of the partitions on the floor. They found this accelerated the rapid integration of the team and communication increased. The environment to support collaboration remains a key element to insure success (Storojev & Barth, 1998).

David Urie, the initial project manager at Lockheed's Skunk Works for the X-33, admitted that the degree of collaboration necessary for this detailed and sizeable project was a daunting prospect. One of the key factors that significantly enhanced cooperation was Lockheed's mandate that each partner organization maintain an on-site presence. This allowed decision-making on site as face-to-face communications and meetings remain the most important element for sharing project knowledge. Technology nevertheless keeps all in contact with virtual meetings, video conferencing, LAN/WAN networks, and whiteboard applications. Wide-area networks and later a web site allowed for the major acceleration in the refinement of the body design through the exchange of CAD files at two major wind tunnel facilities. Design reviews were completed daily via the electronic media as were other vital information saving much time, travel, and money (Storojev & Barth, 1998).

Collaborative systems are at the heart of successful organizations. Dividing up problems and delegating them is a failure of leadership and a failure of seizing opportunities leading to an intellectually bankrupt process (Schrage, 1995, 2000). The aerospace industry is seizing the opportunities by using collaborations in more situations, which are also reflecting organizational changes. This is seen from the flatter team-oriented organizational structure of GE Aircraft Engines (Shand, 2000) to the new Global Trading Exchange for aerospace and the defense industry that has included Boeing, Lockheed Martin, BAE Systems, Raytheon plus Commerce One, an e-commerce leader, along with Microsoft (Lockheed Martin, 2000).

Theoretical Framework

Erchul (1992) stated no operational definition or theoretical foundation for collaboration existed even though Gray and Wood (1991) had attempted to develop coherence of definitions and develop a theory for collaboration.

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It allows for the successful as well as non-productive collaborative system. IST is a general communication theory. Therefore, it can explain how information can be optimized within open, closed, or any mix of communication systems for the purpose of creating order, structure, or control out of the tendency toward chaos (Cragan & Shields, 1998). Communication theory was developed during the Second World War in order to solve three distinct communication problems. It involved the communication that human systems had with machine systems, inter-human communication, and inter-machine communication. Starting from systems theory, Norbert Wiener and Claude Shannon created a cybernetic feedback theory accounting for the complexity within a system (Watzlawick, Beavin, & Jackson, 1967) and then developed the mathematical equations that supported communication theory (Sheridan, 1988). The basic concepts of IST included syntactic (identification), semantic (meaning), and pragmatic (relational connection) information. Assuming a basic component of collaborative group interaction is the information contained within the complexity of communication (Forsyth, 1983), IST, with its underlying support from systems theory, remains a strong framework for the collaboration.

Summary

In the review of literature, collaboration was found to be more of a complex phenomenon than a distinct entity. An overarching definition was unavailable, and various differing terms described the collaborative system. Relatively few authors have written about this phenomenon. Those that have written about it have written in limited detail giving only a small vignette from a larger picture.

One of the first activities necessary for effective collaborations was the restructuring of organizational configurations in order to have an environment that supported the collaborative system. Most authors commented that collaboration was difficult and complex, needing the use of flexibility to reach goals or outcomes. Other important considerations were the time and energy necessary for the collaborative process. There were also concerns that the collaborative effort needed to be supported and sometimes even protected by its leadership or management; command and control will not support any collaborative endeavor. Rather, it is maintaining the focus of purpose that creates the flexibility and responsiveness necessary. An open systems perspective supported these successful aerospace industry collaborations. Also, these operational changes had a trickle down effect on partnering and supplying organizations that interacted with the initial collaboration.

By limiting the review of literature to the aerospace industry along with supporting areas of education and business, there was enough overlapping information to include all aspects of the aerospace environment. An important principle was discovered. It was that the collaboration process, together with collaborative systems and environment, allows multiple individuals to work together to solve a common problem or develop innovation that could not be solved by one person or one organization. Collaboration is a complex activity; it is multi-factoral with each factor having multiple levels impacted by context variables. Collaboration is by its nature time consuming and difficult. This research does not address "how" the process works but rather provides information concerning the collaborative system's key elements found within the aerospace industry.

Table I illustrates the commonalities among the collaborative systems model and authors' models discussed in the review of literature.

TABLE I

COMMONALITIES AMONG COLLABORATIVE SYSTEMS MODEL AND VARIOUS AUTHORS' MODELS

Key Elements from Research	Collaborative Systems Model	Hord '86	Gray '89	Larson & LaFasto'89	Katzenbach & Smith '93	Schrage '90, '95	Shirley '98, '00	Hargrove '98
Purpose or mission for group or team	X		X	X	X	X	X	X
Commitment/Dedication to the challenge	X	X	X	X	X	X	X	X
Group/Team meetings and discussions	X	X	X		X		X	X
Constraints	X					X	X	
Tools and resources for project and simulations	X					X	X	
Significant contributors	X					X	X	X
Decision-making format	X				X		X	
Review of project	X						X	
Participants education and employment longevity	X						X	
Cross functionality of team or group	X	X		X	X	X	X	X
Training plus teambuilding	X						X	
Other successful team elements								
Communication	X	X				X	X	X
Teamwork (common approach)	X		X		X			
Individual and group accountability	X				X		X	
Conflict, learning, and performance	X	X	X		X		X	X
Intraorganizational coordination	X	X			X	X	X	

CHAPTER III

DESIGN OF THE STUDY

Research Design

"The important thing is not to stop questioning. Curiosity has its own reason for existing. One cannot help but be in awe when he contemplates the mysteries of eternity, of life, of marvelous structure of reality. It is enough if one tries merely to comprehend a little of this mystery every day. Never lose a holy curiosity." – Albert Einstein

The purpose of this study was to determine the components of current successful aerospace collaborative efforts. The problem indicated for this study was the limited systematic review or research within successful aerospace industry collaborative systems in the literature. Currently, the literature contains only cursory overviews of past successful aerospace industries' collaborative efforts (Dimancesscu, 1992; Pritchett & Muirhead, 1998; Schrage, 1995; Shirley, 1998). There has not been any definition of components that are key to successful aerospace collaborative systems. Furthermore, an extensive body of knowledge concerning the phenomenon of collaboration does not yet exist (Wood & Gray, 1991).

Research Questions

1. What are elements of an aerospace industry collaborative model?
2. What elements were identified as relevant by those within aerospace collaborative systems?

Research questions were formulated knowing that the nature of qualitative research was that of an emerging design that allowed continual review and reformulation of the research questions (Creswell, 1994).

This study involved a series of steps beginning with a thorough review of the literature concerning collaborative teams or groups in the aerospace industry. The review of literature was extended to include the overlapping disciplines of organization and education, as they are aspects within aerospace environments while providing information concerning collaborative practices. The collaborative system was defined as a group or team that, through their interactions, work together toward an outcome that no one individual in the system could have completed alone.

The design of the study was defined by the limited amount of information contained in the review of literature concerning aerospace industry collaborative systems. It was decided that a qualitative study was necessary in order to take a firsthand look at the various elements within the real-life context (Creswell, 1994; Isaac & Michael, 1982; Key, 1997). It was also decided to gather information through a survey to avert as much researcher bias and other research biases such as the Halo or Hawthorne Effects, "Self-fulfilling prophecy," and so forth as suggested by Cronbach in Isaac and Michael (1982).

This research study did not gather information that would pertain to the various elements of organizational environment, leadership, the dynamics of group interactions, or the complexities of intra or inter-personal relationships of the respondents.

The IRB (Institutional Review Board) approved the study April 11, 2000 (IRB # ED-00-244). The approval form is contained in Appendix B.

Selection of Sample

Aerospace environments were contacted that support group or team efforts in order to accomplish their outcomes. Informational interviews with organization representatives were used to clarify project background. Two groups were designated as the research sample. The individuals of these groups were involved in successful collaborative systems within aerospace contexts. Appropriate sample size was not a consideration, due to the nature of qualitative study's inability to support varying inferences across disciplines or differing group practices (Creswell, 1994; Isaac & Michael, 1982; Key, 1997). The selected respondent teams or groups are from the government sectors of the aerospace industry. The sample selection was chosen to yield a rich source of data for analysis and synthesis.

There were 44 participants from two different groups surveyed for this study. Nineteen were from the Oklahoma Air National Guard based in Oklahoma City (aviation group) and 25 were from the NASA Johnson Space Center (aerospace group) in Houston. Both of these groups worked in collaborative environments within their organizations. The Oklahoma Air National Guard group was comprised of all pilots. They were involved with planning missions necessary to their operations. The surveys were completed in reference to their general team and group interactions.

The surveys were distributed to 25 members of the Space Shuttle flight STS-99/SRTM (Shuttle Radar Topography Mission) Mission Team. This was a mission to map the Earth's landmasses as previously never done. SRTM included a very small cold-gas thruster system to assist in counteracting gravity gradient forces on the 200-ft long radar mast that was deployed out the port side of the Space Shuttle's cargo bay. This thruster system failed early in the mapping operations. As a result, the Space Shuttle began to use more of its own propellant in order to maintain the apparatus in the correct mapping attitude. If not corrected, the mission was faced with having to shorten its mapping by at least one day resulting in the loss of science. The problem presented to the team was what things could be done to save Space Shuttle propellant in order to buy back the lost day. The survey NASA completed was in reference to a well-defined and focused goal on a real-time exercise over a relatively short time period (see memo Appendix C).

In the aerospace group, 6 of the 24 were management positions of the Mission Control Center Flight Control Team. These included Flight Directors, Flight Manager, and a Mission Evaluation Room Manager. Management surveys were differentiated by a green mark in the upper right hand corner of the survey. The remaining 18 surveys went to Flight Controllers in Mission Control from the three teams that supported the mission.

Survey Development

A questionnaire was developed after reviewing the literature and obtaining validation from Shirley's (1997, 1998, 2000) experiences especially with the Rover team.

Various collaborative elements were derived from the literature and were cross-referenced with those used within the Rover team (Pritchett & Muirhead, 1998; Shirley, 1998, 2000) to develop questions concerning successful collaborative efforts. A model for collaboration was synthesized and distinctions made within this model resulted in the development of the survey questions. This process was used to find a convergence of information for validation, authenticity, and trustworthiness of the elements (Creswell, 1994; Key, 1997) within the survey questions for this study.

The questionnaire was comprised of both closed, restricted response and open-ended, unrestricted response questions. A semantic differential attitude scale describing meetings was developed through the review of the literature and information from Shirley's (2000) experience managing the Rover team. Beebe and Masterson (1997) stated that well-run meetings balance both structure and interaction. Five components and their polarities were used in the semantic differential to measure meeting effectiveness.

The convergent nature of the questions took advantage of respondents' limited time and focused on specific qualities of collaborations while allowing for random comments on all questions. Also, structured questions with restricted responses were used for standardized results and ease of analysis (Isaac & Michael, 1982). This was balanced with the opportunity for respondents to give greater depth of answers through unrestricted and open questions. Instructions included with the survey were concise in order to minimize bias. The questions were grouped into two sections commensurate with respondents logical information processing abilities and recoding (Miller, 1956; Miller, Galanter, & Pribam, 1980). This survey used questions designed specifically for aerospace collaborators.

Data Collection Methods

The methods of gathering data consisted of surveys distributed to individual group or team members collaborating on work projects. The survey instrument contained closed, restricted response and open-ended, unrestricted response questions along with a semantic differential attitude scale. Distribution of the survey was completed by the organization's representative in order to protect the confidential status of the respondent. Care was taken to include the participant cover letter with the survey (Appendix C).

A representative of the selected aerospace organization distributed the survey. To protect the respondents' anonymity distribution details were unknown to the researcher and self-addressed stamped envelopes were used to mail surveys back to the researcher. The resultant cumulative analysis and synthesis of survey data were shared with the selected organizations.

Data Analysis Techniques

Data interpretation incorporated matrices and database analysis to illuminate specific patterns of interest, and repetition of word use within comment sections. These patterns are the basis of this research study and defined collaborative elements through the questionnaire technique (Watzlawick, Beavin, & Jackson, 1967). Each survey respondent was allowed two "no response" areas. If more occurred, the survey was considered "invalid." One survey was considered invalid.

The questions of the survey defined components or elements from the successful aerospace collaborative systems in response to research question one. Content analysis of the comments given in Section I, Question 11 denoted relevant correlation with defined components of the survey. Relevance or demonstrable significance of this content analysis was determined from the perspective of the respondents. A term or similar concept that was mentioned five times or more from each group was considered relevant. Relevance was determined for closed-ended questions as indicated by an average of 95% or greater of respondents.

CHAPTER IV

FINDINGS

Introduction

"Words form the thread on which we string our experiences."

–Aldous Huxley

The purpose of this study was to determine the components of current successful aerospace collaborative efforts. The problem indicated for this study was the limited systematic review or research within successful aerospace industry collaborative systems in the literature. Currently, the literature contains only cursory overviews of past successful aerospace industries' collaborative components (Dimancesscu, 1992; Pritchett & Muirhead, 1998; Schrage, 1995; Shirley, 1998). There has not been any definition of components that are key to successful aerospace collaborative systems. Furthermore, an extensive body of knowledge concerning the phenomenon of collaboration does not yet exist (Wood & Gray, 1991).

Survey Findings

These findings culminated from the results of surveys given to 24 subjects affiliated with NASA's Johnson Space Center and 19 subjects affiliated with the Oklahoma Air National Guard concerning completed collaborative projects.

In Section I of the survey the following questions were responded to:

Question One: *Are There Significant Contributors to Your Project That Are Not Formal Members of Your Group/Team?*

- The aerospace group responded with 63% yes; 33% no; 1 respondent not answering the question. A written response indicated, "Not part of flight control team, but part of Mission Evaluation Room."
- The aviation group responded with 84% yes; 11% no; 1 respondent not answering the question.

Question Two: *Does Your Group Have a Specific Decision-making Format? Ex: Consensus, Decision Tree.*

- The aerospace group responded with 79% yes and 21% no. Two written responses indicated "Pre-established 'Flight Rule' decisions. Decision hierarchy: back room→front room→flight director; based primarily on professional experience and team training."
- The aviation group responded with 74% yes and 26 % no.

<u>Question Three</u>: *Is Technology Used to Keep the Group/Team Connected?*

- The aerospace group responded with 96% used email and 11% used video conferencing. Other forms of technology that were mentioned included "LAN, Internet, Digital Voice Circuits, phones, downlink shuttle telemetry, and PC database of 'Flight Notes.'"
- The aviation group responded with 89% used email and 5% used video conferencing. One respondent indicated that technology did not keep the group/team connected and two respondents did not answer the question.

<u>Question Four</u>: *Is Technology Used for Simulation?*

- The aerospace group responded with 79% used model making; 46% used spreadsheets, and 75% used possible scenarios. Other ways that the aerospace group used technology for simulation were "failure as well as nominal operations, joint integration simulation, malfunction elimination, state-of-the-art workstations, and planning consumable usage temperature prediction."
- The aviation group responded with 5% used model making, 63% used spreadsheets, and 26% used possible scenarios. Other ways that the aviation group used technology for simulation were "listing accumulated data, presentations, and Access databases."

<u>Question Five</u>: *What Is the Optimum Time for a Project to Last?*

- The aerospace group responded on two levels; one was a "launch to landing" parameter with a range of 5 to 16 days and the other was a total project time which included "pre-flight work" and "preliminary planning" which ranged from 1 to 4 years. The average for the launch to landing time averaged from 8 days to 13 days as optimal time for it to last. These days include 3 shifts 9 hours each with an hour overlap for briefing and continuity. The preliminary planning averaged from 1 to 1.7 years as an optimum time on a project.

- The aviation group responded within a range of "72 hours (3 days) to 6 months (180 days)." An average of all respondents gave a range of between 37 and 58 days for a project to last. This included project planning, implementation, and completion.

Question Six: *Are There Other Departments in Your Organization That Your Group/Team Needs to Work And/or Coordinate With?*

- The aerospace group responded with 100% yes. A written response included, "A shuttle mission is very complex and typically requires significant inter-discipline coordination."
- The aviation group responded with 95% yes with one respondent not answering the question.

Question Seven: *Do You Have a Review Board of Outside Experts or Peers That Review Projects and Offer Their Evaluative Perspectives?*

- The aerospace group responded with 79% yes; 17% no; with 1 respondent not answering the question. Five written responses included, "They can offer opinions, but we don't have to accept their input; From a program and mission perspective, the answer is definitely yes. For our particular discipline, we are fairly self-sufficient, the answer is essentially no; Each console shift is nine hours; teams overlap to support round-the-clock; Varies by task; Not always, but for very complex missions we do. STS-99 was such a mission."

- The aviation group responded with 53% yes; 42% no; 1 respondent not answering the question. One written response indicated, "Peers."

Question Eight: *How Often Are Group/Team Meetings?*

- The aerospace group responded with 38% daily; 50% weekly; 12% monthly; 1 respondent not answering the question. A written response indicated, "Usually start out monthly and then switch to weekly as get closer to the flight."
- The aviation group responded with 16% daily; 79% weekly; 4% monthly. Three written responses indicated, "Sporadically; Biweekly; Depends on project/deployment."

Question Nine: *How Would You Describe Group/Team Meetings?* Rate your meetings somewhere along the five point scale below that best describes your experience by placing an "X" in the appropriate section.

The respondents' ratings can be seen in Figure 3. A written aerospace response indicated, "Typically spirited."

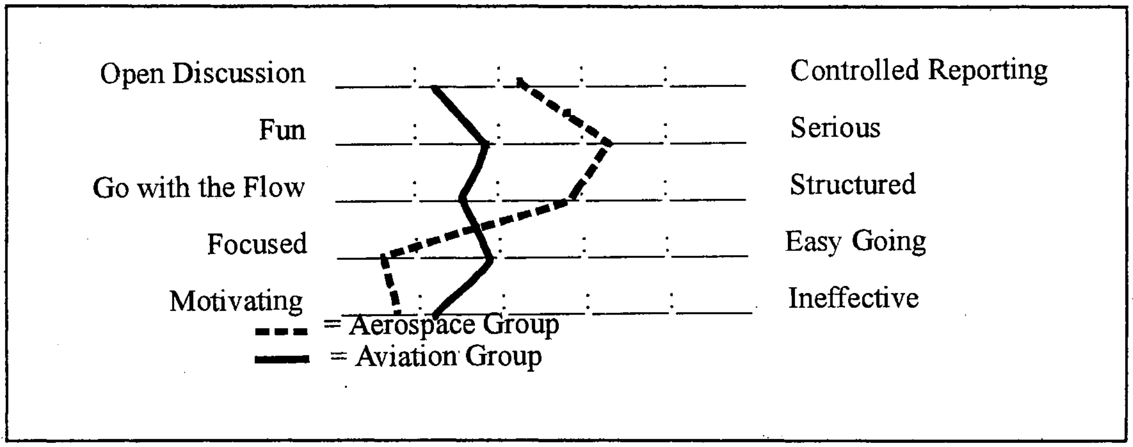

Figure 3. Semantic Differential.

Question Ten: *Would You Consider "Learning" a Byproduct of Your Group/Team Discussions and Activities?*

- The aerospace group responded with 88% yes; 8% no; 1 respondent not understanding the question.
- The aviation group responded with 95% yes; 5% no.

Question Eleven: *What Elements Make Your Group/Team Successful?* Written responses for the aerospace group indicated the following comments from the survey. Those comments with asterisks (*) indicate a response from management personnel:

- *Dedicated individuals, self motivated, achieving.
- Pre-mission simulations and meeting; strong leader that can keep team focused on task, one who can take input and make decisions; communication.

- *Attention to detail, cutting-edge knowledge, dedication to the mission.
- *Common goal; extremely talented engineers using good tools; excellent leadership and responsiveness of project management.
- Open communication; strong desire to get the "right" answer; maintaining a focus on achieving a specific goal.
- Dedication, experience, talent.
- *Very clear goals and finite time to complete the goal.
- Pre-mission planning and simulation.
- You work as a team and not for the individual; lots of excellent training and preparation; careful hiring and retention of individuals who enjoy/work well in this environment is crucial.
- Individual accountability/responsibility; highly motivated/enthusiastic personnel; good tools/hardware.
- Focus, attention to detail and plenty of practice (i.e. Training and mission preparation).
- *Effective communication, respect, quality training program, formal reviews.
- Communication—clear, concise, organized, well thought through: preparation beforehand—reading procedures, plans rules; training and rehearsals.
- "Can Do" attitude i.e. you do whatever you have to for 1. Safety, 2. Mission objectives.

- Having a definitive leader, empowering each of the leads to make recommendations and decisions about their systems.
- Common goal—mission success; intelligent, experienced co-workers; basically team players; a realization that we are a unique group with one of the more interesting jobs in the world.
- Being prepared, staying on top of responsibilities, good communication between group members.
- Everyone's commitment and dedication to the project or mission. Training working together to solve problems and to anticipate problems and work on possible solutions or strategies in advance. We try to anticipate problems and work out solutions or options prior to these are documented in flight rules. Adaptability; Aware space flight is a big system and a small change in one system can cause changes in another. "Tiger Team" to work a problem. Certain members of the team worked extra hours to find a solution to our prop problem.
- Safety, error free, on-time, team spirit, desire to be successful.
- *People that like what they are doing; processes and structure that work based on past experiences; general population with college education.
- Mission cognizance, proper training (generic systems and flight specific), proactive disposition.
- Extremely success oriented attitudes "Failure is not an option," flexibility, focus on the goal.
- Good communication.

- Dedication, goal oriented personnel, specific goals in mind, exhaustive training.

Written responses for the aviation group indicated the following comments from the survey. Four respondents did not write any comments:

- Expertise.
- Coordinated and focused meetings that utilize time effectively.
- Lots of different backgrounds and perspectives.
- Teamwork and good communication.
- Open minded to other peoples input.
- Differing years of experience. Younger people tend to lend more creativity..
- Cohesive bound.
- Open discussion.
- Chain of command; regulatory discipline.
- Takes it serious.
- Openness, easy, motivating.
- Group/Team management.
- Each member of the team is directed to ensuring that their areas of responsibility are fully completed by their suspense date. The members work together.
- Experience (technical).
- Small team with open discussions.

In Section II of the survey the following questions were responded to:

Question One: *Please Indicate the Subject Area of Your Undergraduate Degree.*

- The aerospace group responded with 92% in the overall category of engineering; 8% in math/physics.
- The aviation group responded with 21% aviation; 21% business; 16% engineering; 11% sciences with one respondent each in math, political science, education, and general studies. There were two respondents that did not answer the question.

Question Two: *Please Indicate the Subject Area of Your Masters Degree.* No doctorate degrees indicated.

- The aerospace group responded with 21% in engineering; 13% in science; 4% in business; 6 respondents indicating "N/A"; 3 not answering the question.
- The aviation group responded with 4% in aviation and 4% in human relations.

Question Three: *Years at Present Employment.*

- The aerospace group responded with a range from 6 to 34 years with an average of 17.9 years employment.
- The aviation group responded with a range from 3 to 20 years with an average of 12 years employment.

Question Four: *Does Your Group/Team Have a Stated Purpose or Mission for Your Project?*

- The aerospace group responded with 100% yes.
- The aviation group responded with 95% yes; 5% no.

Question Five: *Are You Accountable Individually for a Component or as a Group for the Project?*

- The aerospace group responded with 50% individually; 12% group; 38% both.
- The aviation group responded with 32% individually; 47% group; 16% both. One respondent did not answer the question.

Question Six: *Do the Members of Your Group/Team Have a Diversity of Skills or Cross-functionality to Complete Your Project/Task?*

- The aerospace group responded with 88% yes; 8% no; 1 respondent that did not answer the question.
- The aviation group responded with 95% yes; 5% no.

Question Seven: *Has Your Group Participated in Team Building or Group Development Activities?*

- The aerospace group responded with 83% yes; 17% no.
- The aviation group responded with 53% yes; 42% no; 1 respondent that did not answer the question.

Question Eight: *Does Everyone in Your Group/Team Participate in Discussions or Activities?*

- The aerospace group responded with 75% yes; 25% no.
- The aviation group responded with 89% yes; 11% no.

Question Nine: *Does Your Group/Team Work with Completion Deadlines?*

- The aerospace group responded with 100% yes.
- The aviation group responded with 95% yes; 1 respondent indicated, "Sometimes."

Within budget constraints?

- The aerospace group responded with 58% yes; 25% no; N/A; 1 respondent that did not answer the question.
- The aviation group responded with 84% yes; 11% no; 1 respondent that did not answer the question.

Question Ten: *When Starting a New Project How Does the Group/Team Make Sure Everyone Understands the Parameters of the Project/Task?*

- Both groups indicated multiple methods with discussion and documentation being the preferred methods.
- The aerospace group responded with 92% for discussion; 83% for documentation; 17% for graphs; 29% charts; under the "other" category 2 respondents indicated simulation tests; 1 respondent each indicated "briefing; team training; and lots of meetings."

- The aviation group responded with 84% discussion; 74% documentation; 32% graphs; 26% charts; under the "other" category 1 respondent each indicated "written regulations and You Name It!"

Question Eleven: *Has There Been Conflict Between or among Group/Team Members That Needed to Be Negotiated?*

- The aerospace group responded with 79% yes; 21% no.
- The aviation group responded with 84% yes; 16% no.

Discussion of Findings

Discussions of the findings of this study were summarized as they related to each of the broad research questions. These findings were referenced with the literature where applicable.

Research Question One

What Are Elements of an Aerospace Industry Collaborative Model?

Element One – Stated Purpose or Mission. There was an almost overwhelming affirmative response from both groups for having purpose or mission statements for their group. This was mentioned in the literature and considered one of the most important elements for success (Katzenbach & Smith, 1993; Land & Jarman, 1992; Schrage, 1995; Senge, Kleiner, Roberts, Ross & Smith, 1994; Shirley, 1998).

Element Two – Commitment/Dedication to the Challenge. An element discussed by Katzenbach and Smith (1993) as essential to performance. It was also considered an important element for success as reflected by the survey results of this study. This may be inherent within the aerospace cultures (Sheridan, 1988; Shirley, 1997, 1998).

Element Three – Group/Team Meetings and Discussions. The necessity for meetings, daily or weekly, kept members connected and suggested that this forum of getting together is still preferred and one that worked well. Meetings became daily as the project timetable was accelerated toward the implementation stage (Shirley, 1998, 2000; Storojev & Barth, 1998). Meetings were highly motivating for both respondent groups (Figure 3, p. 53). Shirley (2000) stated that the weekly meetings for her Pathfinder Rover group invigorated and generated energy while also forming the identity of the team. Shirley (1997, 1998) also stated that introverts, though infrequently participating in discussions, added to the team's performance as the ideas they expressed tended to be well thought through. The aerospace groups indicated a significant number of group members that participated in discussions. Meetings are generally where the important discussions take place versus unstructured dialogues. This is also a very important element, shared space, where the developmental conflict generates learning enhancing performance—a cybernetic feedback loop.

Element Four – Conflict, Learning, and Performance. Both groups indicated a significant amount of conflict that had to be negotiated. Hord (1986) stated that conflict was a part of learning and, as this learning increased, integration of higher performance was inherent in the collaborative process (Donnellson, 1996; Katzenbach & Smith, 1993;

Senge, 1990). Developmental conflict is also a distinction between a true collaboration and a quasi-collaboration whose process is more closely aligned with cooperation and coordination.

Element Five – Constraints. Both groups responded overwhelmingly affirmative for working within time constraints and deadlines, while some also experienced budget constraints depending upon the group or the phase of the project as indicated by written comments from the questionnaires. Duration of a project was dependent upon the specific project and generally separated into phases or stages such as planning, customer and crew, launch to landing as indicated by written comments on the questionnaires. Schrage (1990, 1995) and Shirley (1997, 1998, 2000) acknowledged that groups or teams generally worked within constraints. Constraints were variable dependent and held the contrasting aspect of flexibility or requisite variety for working with, around, or accepting the challenge of the constraint to enhance results.

Element Six – Tools and Resources for Project and Simulation. The tools of the two groups surveyed in this study were those generally known in technology such as email, video conferencing, LAN systems, computerized models, spreadsheets, databases, state-of-the-art-workstations and those for specific application such as downlink shuttle telemetry, digital voice circuits, and joint integrating simulation. The aerospace group reported the highest incidents of simulations.

Element Seven – Significant Contributor Findings. It was found that in both the aerospace and the aviation respondent tabulation there were significant contributors to the project that were not formal members of the team or group (Shirley, 1998).

Element Eight – Specific Decision-Making Format. There were approximately three-quarters of each group of respondents that stated they had a specific decision-making format for their group or team (Katzenbach & Smith, 1993; Shirley, 1997, 1998). Multiple problem-solving and decision-making formats were inherent within both environments. Engineering was the dominant undergraduate education, which provides structured problem-solving methodologies.

Element Nine – Review Board. The necessity for review boards was higher in the aerospace group concerning evaluation of the project than in the aviation group. Yet, there was enough response even in the aviation group (53%) to consider the benefits of review boards for successful collaborative systems having a relatively longer duration time (Schrage, 2000; Shirley, 1998).

Element Ten – Education and Years at Employment. The undergraduate background of the aerospace group was exclusively in engineering and physics which included every respondent. Over one third of the respondents held graduate degrees in engineering or a related field. The undergraduate background of the aviation group was more diverse in subject specialties with a lesser percentage of graduate degrees. Employment longevity with the aerospace group had a 17.9-year average of employment at the same organization with approximately one third fewer years of employment for the aviation group with a 12-year average. Both figures would be considered an extended period of employment at the same organization. The combination of education and continuous employment showed a relationship that affected the duration and complexity of collaborative projects within each group. Wheatley (1992) stated there is a consistency and predictability perhaps even similarity found in individuals of an organization at all levels in spite of the varying range of roles.

Element Eleven – Cross-Functionality. There was also an overwhelming affirmative response in the two respondent groups that there was a diversity of skills to complete projects (Dimancesscu, 1992; Hargrove, 1998; Katzenbach & Smith, 1993; Schrage, 1995; Shirley, 1997, 1998). The education, training, and employment information gathered in this study indirectly supports this response.

Element Twelve – Training plus Team Building Activities. Team building is best done over time according to Shirley (1997) with one of the best bonding activities being a social event after a presentation or product delivery. With an average of 12 and 17.9 years employment with the same organization taken from the survey results, the respondents had time to build trust, respect, and motivation in various ways for high performance team interaction (Wheatley, 1992). Also, a significant number of the aerospace group had reported team building (Donnellson, 1996; Katzenbach & Smith, 1993) training with approximately half of the aviation group reporting the same type of training. Respondents stated continued training delivered within their organization as one of the most important elements for success.

Element Thirteen – Other Successful Elements Elicited. "Teamwork" and "communication" were the most favored elements for the aviation group of respondents (Katzenbach & Smith, 1993, Schrage, 1995). "Training" was the most mentioned term in the aerospace group with "communication" the second most significant which was tied with "commitment." According to Katzenbach and Smith (1993) commitment differentiated the high performance teams they studied. Various communication aspects were considered important by most authors (Hargrove, 1998; Hord, 1986; Salvage, 1990, 1995; Senge, Kleiner, Roberts, Ross, & Smith, 1994; Shirley, 1997, 1998, 2000). The many and varied elements included by the respondents indicated the complex, multifaceted along with the multileveled nature of the collaborative effort (Anderson, 1996; Forsyth, 1983; Gray, 1989; Hargrove, 1998; Hord, 1986; Shirley, 1997; Trist, 1977).

Element Fourteen – Group Accountability. Katzenbach and Smith (1993) along with Donnellson (1996) stated that this is a challenge for teams working together as individual performance has been historically the only source of the evaluation. The aerospace group's accountability is equally divided between individual and group. The aviation group indicated that they were more accountable for the group/team performance than the individual. Individual accountability within groups and teams remains important as reflected in the numerous times mentioned by the respondents.

Element Fifteen – Intraorganization Coordination. There was unanimous response from both groups of respondents that had to coordinate with other departments within their organization due to the mission complexity and significant inter-discipline interaction (Hord, 1986; Katzenback & Smith, 1993; Scrage, 1990, 1995; Shirley, 1998, 2000).

The findings of this study yielded to the description of an "emergent social process" (Gray, 1989; Trist, 1977) developing complex multilevel interactions within the collaborative system. What has been gleaned by this survey has been in a specific field bringing with it a unique culture and practices not described by this survey yet alluded to through the disciplines that support it (Anderson, 1996; Creswell, 1994; Key, 1997; Sheridan, 1988).

The summarization of the findings of elements for the aerospace collaborative model indicated from this research study is as follows:

- Purpose or mission for group or team
- Commitment/Dedication to the challenge
- Group/Team meetings and discussions
- Constraints
- Tools and resources for project and simulations
- Significant contributors
- Decision-making format
- Review of project
- Participants education and employment longevity
- Cross functionality of team or group
- Training plus teambuilding
- Other successful team elements
- Individual and group accountability
- Conflict, learning, and performance
- Intraorganization coordination

The elements of this model formed components of a collaborative system that support and allow multiple individuals to work together for innovating or solving a common problem that could not be accomplished individually. When viewed from a systems perspective there is no beginning or ending, no "a" or "b," but rather a continuity of the system with feedback from each element of the aerospace collaborative model offering a higher degree of complexity (Ackoff, 1974; Bateson, 1972; Cragan & Shields, 1998; Dilts, 1983; Senge, 1990; Sheridan, 1998; Watzlawick, Beavin, & Jackson, 1967).

Research Question Two

What Elements Were Identified as Relevant by Those Within Aerospace Collaborative Systems?

All elements of the model were validated by a minimum of 64% agreement with respondent results. Relevant elements by those within the collaborative systems surveyed were those elements that were considered from the open-ended question (Section I, question 11), written comments, and the three questions (Section I, question 6; Section II, questions 4 and 9) that were answered similarly by a 97.5% average of the respondents from both groups. The first relevant element identified was having a stated purpose or mission for the project completed by the collaboration (Gray, 1989; Hargrove, 1998; Katzenbach & Smith, 1993; Larson & LaFasto, 1989; Schrage, 1990, 1995; Senge, Kleiner, Roberts, Ross, & Smith, 1994; Shirley, 1998, 2000) also a highly relevant element among various authors. Shirley (1998) built a motto for her Rover team that worked in the same capacity along with developing a "capability plan." The second relevant element was working within completion deadlines, which was mentioned by Schrage (1990, 1995) and Shirley (1997, 1998, 2000). The third element was coordinating with other departments within the organization (Hord, 1986; Katzenbach & Smith, 1993; Schrage, 1990, 1995; Shirley, 1998, 2000) due to the complexity of the collaboration.

The most frequently mentioned terms from each group were indicated from the written comments on the survey. Incidence of the patterns from the open-ended question was noted and used to validate relevant elements of the model (Watzlawick, Beavin, & Jackson, 1967). Considering the two most mentioned areas from each group of respondents, the survey yielded "training" (aerospace group), "communication" (both aerospace and aviation group), "commitment" (aerospace group), and "teamwork (aviation group) respectively. The literature mentioned training in respect to promoting teams in organizations and to assisting their development through team building training (Donnellson, 1996). Although the kind of training mentioned on the survey was not always qualified, it was training pertinent to the work accomplished. "Communication," "commitment," "teamwork" were also mentioned in the literature yet not ranked in this specific order or considered by any one author (Hargrove, 1998; Hord, 1986; Gray, 1989; Katzenbach & Smith, 1993; Larsen & LaFasto, 1989; Schrage, 1990, 1995; Shirley, 1998).

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

"We can throw stones, complain about them, stumble on them, climb over them, or build with them."– William Arthur Ward

The purpose of this study was to determine the components of current successful aerospace collaborative efforts. The problem indicated for this study was the limited systematic review or research within successful aerospace collaborative systems in the literature. Currently, the literature contains only cursory overviews of past successful aerospace industries' collaborative components (Dimancesscu, 1992; Pritchett & Muirhead, 1998; Schrage, 1995; Shirley, 1998). There has not been any definition of components that are key to successful aerospace collaborative systems. Furthermore, an extensive body of knowledge concerning the phenomenon of collaboration does not yet exist (Wood & Gray, 1991).

This study had two broad research questions that addressed the purpose of the research. The first question was to determine what are elements of an aerospace industry collaborative model. Then, the second question was to find what elements were identified as relevant for those within aerospace collaborative systems. These questions were answered through the data provided by a questionnaire survey developed from the review of the literature and discussions with Donna Shirley (1997, 1998, 2000) concerning her successful collaborative effort, the Mars Pathfinder Rover Project.

This research study did not gather information that would pertain to the various elements of organizational environment, leadership, the dynamics of group interactions, or the complexities of intra or inter-personal relationships of the respondents.

Summary of Findings

For research question #1 this study found elements of successful aerospace collaborative systems that provided a model. The elements of this model added to descriptions of collaborative systems found in the literature while definitively describing the aerospace collaborative systems that were studied. The elements were 1) purpose or mission for the group or team; 2) commitment or dedication to the challenge; 3) group or team meetings and discussions; 4) constraints of deadlines and budgets; 5) tools and resources for project and simulations; 6) significant contributors to the collaboration; 7) decision-making formats; 8) reviews of project; 9) participants education and employment longevity; 10) cross functionality of team or group members; 11) training on the job plus teambuilding; 12) other key elements identified relevant by the respondents but not explicitly included in the model such as communication and teamwork; 13) individual and group accountability; 14) conflict, learning, and performance; along with 15) intraorganizational coordination. These fifteen elements of the model were found in the collaborative systems studied and supported multiple individuals working together for innovating or solving a common problem that could not be accomplished individually.

For research question #2 the elements that were nearly unanimously identified as relevant for those within aerospace collaborative systems from the closed-ended questions of the survey included having a stated purpose or mission for the project; working within completion deadlines; and coordinating with other departments within the organization. Furthermore, relevant terms correlating to the model as indicated by the high incidence of appearance in the respondents' comments to the open-ended question of the survey were training, communication, commitment, and teamwork.

Conclusions

These conclusions are from the results of the survey given to 24 subjects affiliated with NASA's Johnson Space Center and 19 subjects affiliated with the Oklahoma Air National Guard concerning completed collaborative projects. They are offered as related to the findings on each broad research question.

Research Question One

What Are Elements of an Aerospace Industry Collaborative Model?

Elements were found in aerospace industry environments that became a model for collaborative systems. Most of these elements were also found in the ancillary literature, such as that concerning organizations and education from the works of Hord, Gray, Larson and LaFasto, Katzenbach and Smith, Schrage, and Hargrove. Although a consensus was not found of collaborative elements across the disciplines in the literature review, there were similarities. An underlying foundation from the aerospace environment may be the pervasive influence of a systems perspective imbued throughout the disciplines of this field, which Sheridan (1988) described:

> The system perspective has proven useful in a number of ways. It is more than a way of drawing diagrams or of doing mathematics. Most of all it is an intellectual discipline—a way of thinking comprehensively about problems. (p. 37)

The resultant elements of this study did not follow the descriptions in the ancillary literature pertaining to organizations and education, although there were similar elements distributed throughout different authors' works. This difficulty was previously described in Chapter II as being more analogous to the Parable of the Elephant and the Blind Men. It is difficult to view a small vignette of a project and bring forth all of the information that culminated in the larger whole. Various author descriptions and the differing factors involved in their perspectives could not be distilled into a single congruent descriptive summary. Without a significantly similar definition, this difficulty will continue. The phrase of "working together" will not suffice as a connecting bridge.

Comparing the relationship of the elements of the aerospace collaborative model with those of the various authors in the literature, it is found that the aerospace model is a more comprehensive configuration of elements and has added to the definition of collaboration found in the literature. This will further understanding among researchers of collaborative systems providing common elements and definitions that have up till now been missing in the literature (Gray & Woods, 1991). Shirley's (1998) description is the closest to the model containing most of the elements. Katzenbach and Smith's descriptions followed next, with more than half of the elements, closely followed by Schrage's and Hargrove's descriptions. The remaining authors contained less than half of the elements and these authors were also earlier writers on the subject of collaboration, which may explain their fewer numbers of similar elements and suggesting the emergent nature of collaboration from Trist's (1977) and Gray's (1986, 1989) early writings.

No clear distinctions between the elements were found either in the literature review or survey results. Often elements were defined in reference to each other and described together rather than distinct and separately. This suggests a multilevel overlapping of the multiple elements within the collaborative system. The configuration of the unified system is importance in evaluating that system. Viewing these component parts has alluded to the complexity through their interactions, overlapping occurrences among those parts, and the continual lessening of clear distinctions throughout the literature (Forsyth, 1983; Miller, 1978; Watzlawick, Beavins, & Jackson, 1967). Yet, specifying these necessary component parts allowed development of a foundation model for validation in this initial study within specific aerospace environments. Koestler (1964) describes such a situation as the following:

> . . . a social body is not an aggregation of elementary parts or elementary processes; it is an integrated hierarchy of semiautonomous sub-wholes, consisting of sub-sub-wholes, and so on. Thus the functional units on every level of the hierarchy are double-faced as it were: They act as whole when facing downwards, as parts when facing upwards. (p. 287)

These elements can also be described as an emergent cybernetic social system as Trist (1977) initiated in his writing on collaboration, which were the earliest found. This could also be described as having inputs made to the system from the organization, environment, and contributors which were then melded with interactions from contributors or throughputs (human to human, machine to machine, and human to machine) of the collaborative system resulting in the outputs whether product, performance, or both (Wiener & Nagel, 1988). The emergent cybernetic social system follows the fractal principles illustrated by Wheatley (1992) through the example of the intricacy of a fern leaf from its basic stick shape. It is the creation of complexity from simplicity. From basic elements, new combinations can be made at differing levels resulting in a very complex entity.

Research Question Two

What Elements Are Identified as Relevant to Those Within Aerospace Collaborative Systems?

All of the elements of the model were validated by survey results indicating greater than 64% agreement with the model. Relevant elements by those within the collaborative systems surveyed were those that were nearly unanimous. There were three questions that were answered affirmatively by 97.5% of all respondents. The first question was having a stated purpose or mission for the project (Gray, 1989; Hargrove, 1998; Katzenbach & Smith, 1993; Larson & LaFasto,1989; Schrage, 1990, 1995; Senge, Kleiner, Roberts, Ross & Smith, 1994; Shirley, 1998, 2000), which was mentioned in the literature by every author except Hord (1986). Hord had some of the earliest writings considering collaborations for educators. Having a purpose sets the direction for the individuals involved while easing ambiguity (Beebe & Masterson, 1997; Cragan &

Shields, 1998; Dilts, Grinder, Bandler & DeLozier, 1980; Land & Jarman, 1992) and maintaining focus (Wheatley, 1992).

The second element considered relevant by those within the aerospace collaborations surveyed was working within completion deadlines (Schrage, 1990, 1995; Shirley, 1997, 1998, 2000). There was only a slight mention of this in the literature while most author's did not consider this element in their writing. The third relevant element was that of coordinating with other departments within the organization due to the complexity of the project (Hord, 1986; Katzenbach & Smith, 1993; Schrage, 1990, 1995; Shirley, 1998, 2000). More than half of the authors listed this within their elements.

Tabulation of the written comments yielded "training" among the highest word incidence of all respondents' comments. This result articulated the importance of providing job specific training for employees. Shirley (1998), was the only author suggesting this element in the literature. Donnellson (1996) mentioned it in reference to team building training yet the survey results implied that the training supported characteristics consistent with the job performance. Recurrent training keeps employees up-to-date, feeling prepared, and knowledgeable. Yet in organizations with tight budgets, this is the first activity downsized or eliminated.

Tabulation indicated the next highest incidence was "communication and commitment," which were tied. Communication was mentioned by over half of the authors with those who wrote from the 1990s forward almost unanimous in their inclusion of this element. Schrage (1990, 1995) discussed that "language matters" and that words are parts to a shared understanding. Shirley's (1997, 1998) example of a similar nature illustrated the necessity for diverse groups such as engineers, scientists, and administrators to share a language with common meaning to be able to interface their expertise along with their needs. Language added complexity to these relationship structures (Bandler & Grinder, 1975; Beebe & Masterson, 1997) and revealed perspectives of the multiple levels inside these collaborative elements. Communication has two aspects, content and relationships. The comments did not distinguish between them (Watzlawick, Beavin, Jackson, 1967).

Commitment was the element that ALL of the authors found necessary. Commitment, which has been described as an unmanageable force, but a very important element of teams by Hord (1986), Larsen and LaFasto, (1989) is especially indicative of high performance teams as suggested by Katzenbach and Smith (1993). There may be some intrinsic value within the aerospace environment that promotes this sense of commitment and dedication enhancing the boundaries of performance. This may be illustrated, for example, by one of the quotes from a survey respondent "failure is not an option" and also in the writings of Lovell and Kluger (1994).

"Teamwork" was the third highest ranked element by the respondents from survey comments. This element was mentioned by less than half of the authors in the literature. This concept illustrates the difficulty of elucidating all elements within all levels of interactions as well as suggests this element may be more inclusive on an organizational level (Gray 1989; Hargove, 1998; Katzenbach & Smith, 1993).

Consider a comment from Shirley (2000) who stated, in reference to the successful operation of the Mars Rover, that it was not that she did anything different from the literature but that she put "all the information together totally, completely, and systematically." The survey respondents demonstrated this concept via their additional written comments to closed-ended, restricted response survey questions.

The survey results revealed the multiple factor aspect but also indicated further consideration that had to include multiple levels of interactions of these factors. An emergent cybernetic social system such as the collaborative systems model developed in this study may be best described through the use of computational agents that model interactional dynamics between participants with multiple iterations as a way of elucidating key elements, levels of interactions, and characteristics within true collaborations. A model is a map to help clarify and understand the territory, yet it is not that specific territory or the various facets of that territory (Bandler & Grinder, 1975; Bateson, 1972; Korbyzski, 1933). That is best described within the experience—when one is there.

Further research is necessary to provide additional information of these initial findings.

Recommendations

From the results of this study, the following recommendations for future research are offered:

1. To access an aerospace collaborative system within its organizational environment at the beginning of the project. The environment and management are considered a major support for collaboration.
2. Survey other aerospace collaborative efforts to refine the model defined in this study.

3. Clarify meaning of the model's relevant elements, for example, communication's dual aspects of content and relationship need further consideration.
4. Determine the problem solving and decision-making tools and processes used within these collaborative environments.
5. Evaluate the pervasive influence of the systems perspective within the aerospace industry culture.
6. Expand data gathering techniques through individual and group interviews.
7. Review extant aerospace data for detailed information, reviews, and performance of successful collaborations.
8. Evaluate processes used to develop a stated purpose or mission for the project.
9. Evaluate what diverse skills group or team members have that assures the cross functionality of the collaboration.
10. Include additional questions concerning elements identified as relevant by respondents of survey.
11. Amend question #4, Section I to two parts for further clarification.
12. Adjust large groups into sub-groups of collaborative systems with the guidelines of the model where it is necessary to solve problems or create something new.

In order to build upon this initial, foundation study, further research would capitalize on the ongoing aspects of the collaborative systems that have proven successful from their past endeavors. Gathering more information through the initial survey concerning collaborative systems from the aerospace industry would certainly be a welcome addition to the literature while furthering the understanding of this phenomenon. It would also assist in refining the model put forth in this study.

There were elements that were described as relevant to those within the collaborative system. All of the relevant elements (training, communication, commitment, and teamwork) need further clarification as they were tabulated from single terms appearing in the open-ended question comments. With the addition of other data gathering techniques, the elements of this model could be clarified and expanded upon easily as the initial, foundation model has been defined.

With the advent of knowledge management practices and software, reviewing the extant data of a collaborative system may yield valuable information concerning various elements of the aerospace industry collaborations. Authors such as Karlenzig (1998) along with Storojev and Barth (1998) have reported the advantages that technology offers in this area. They have discussed the advantage of this tool in relationship to supporting the necessary processes of an ongoing project with key personnel moving on to other opportunities. With the advent of knowledge management, all pertinent information is captured assuring continuity of the task and the project.

A single element for further research that could be important in many contexts, as well as the aerospace industry, would be the problem solving and decision-making tools and processes. Does an engineering education, which is imbued with solving problems, have additional information, tools, or resources to accomplish a major aspect of any collaboration or is it the influence of a systems perspective that reduces single application short-sightedness, which was so clearly elucidated by Sheridan (1988) and many others (Anderson, 1996; Forsyth, 1983; Miller, 1978; Senge; 1990; Senge, Kleiner, Roberts, Ross & Smith, 1994; Shirley, 1997, 1998).

In this same vein the processes used within the aerospace environment to develop a stated purpose or mission would add to the literature in the context of collaborative systems. There was almost unanimous agreement among authors reviewed in this study concerning its importance.

In reference to the last recommendation of using the collaborative model to adjust large groups into smaller collaborative systems, this task would be one of the most interesting and perhaps most exciting. It is very difficult for large groups to develop the interactional pattern with all members that facilitates the discussions, learning, and ultimately, performance of a collaborative system. This would avert the coordination of cooperation through compromise and facilitate the constructive, developmental conflict that potentiates within true collaborative systems and produces greater results.

Final Remarks

We have a special talent according to Korbyzski (1933) to share ideas, knowledge, and insights. Our ability to promote this special talent would result in exponentially increasing all knowledge, further resulting in the acceleration of our development and human potential. Collaborative systems have the means to accomplish this end.

Aerospace industries have impacted our daily living with the by-products of their innovative development. Their contributions in the area of collaborations would certainly enrich the literature and erase the confusion brought about by simple one-size-fits-all "recipes" as a formula for collaborative systems.

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APPENDIXES

APPENDIX A

DEFINITIONS

Definitions

The following diverse definitions are of collaborations or teams that share a collective meaning of "working together."

I. Gray (1989)—...as process of joint decision making among key stakeholders of a problem domain about the future of that domain. Five key aspects of this definition...

1. The stakeholders are interdependent.
2. Solutions emerge by dealing constructively with differences.
3. Joint ownership of decisions is involved.
4. Stakeholders assume collective responsibility for the future direction of the domain.
5. Collaboration is an emergent process (p. 227).

II. Gray & Wood (1991)—Collaboration occurs when a group of autonomous stakeholders of a problem domain engage in an interactive process, using shared rules, norms, and structures, to act or decide on issues related to that domain (p. 146).

III. Katzenbach & Smith (1993)—A team is a small number of people with complementary skills who are committed to a common purpose, performance goals, and approach for which they hold themselves mutually accountable (p. 45).

IV. Chrislip & Larson (1994)—That concept as we use it, goes beyond communication, cooperation, and coordination. As its Latin roots—*com* and *laborare*—indicate, it means "to work together." It is a mutually beneficial relationship between two or more parties who work toward common goals by sharing responsibility, authority, and accountability for achieving results. Collaboration is more than simply sharing knowledge and information (communication) and more than a relationship that helps each party achieve its own goals (cooperation and coordination). The purpose of collaboration is to create a shared vision and joint strategies to address concerns that go beyond the purview of any particular party (p. 5).

V. Senge, Kleiner, Roberts, Ross & Smith (1994)—...as any group of people who need each other to accomplish a result (p. 354).

VI. Schrage (1995)—is the process of *shared creation*: two or more individuals with complementary skills interacting to create a shared understanding that none had previously possessed or could have come to on their own. Collaboration creates a shared meaning about a process, a product, or an event. In this sense, there is nothing routine about it. Something is there that wasn't before. Collaboration can occur by mail, over the phone lines, and in person. But the true medium of collaboration is other people. Real innovation comes from this social matrix (p. 33).

VII. Welch & Sheridan (1995)—Collaboration as a dynamic framework for efforts which endorses interdependence and parity during interactive exchange of resources between at least two partners who work together in a decision making process that is influenced by cultural and systemic factors to achieve common goals (p. 11).

VIII. Donnellson (1996)—a group of people who are necessary to accomplish a task that requires the continuous integration of the expertise distributed among them (p. 10).

IX. Saltiel, I.M., Saroi, A. & Brockett, R.G. (1998)—As the concept is used in this work, collaborative partnerships have at their core an intense relationship centered on mutual goals....the goal may not have been achieved without the relationship (p. 6).

X. Hargrove, R. (1998)—implies doing something together,.....desire or need to create or discover something new, while thinking and working with others, that distinquishes the action.

The Parable of the Blind Men and the Elephant
the original version from the Buddhist canon

A number of disciples went to the Buddha and said, "Sir, there are living here in Savatthi many wandering hermits and scholars who indulge in constant dispute, some saying that the world is infinite and eternal and others that it is finite and not eternal, some saying that the soul dies with the body and others that it lives on forever, and so forth. What, Sir, would you say concerning them?"

The Buddha answered, "Once upon a time there was a certain raja who called to his servant and said, 'Come, good fellow, go and gather together in one place all the men of Savatthi who were born blind . . . and show them an elephant.' 'Very good, sire,' replied the servant, and he did as he was told. He said to the blind men assembled there, 'Here is an elephant,' and to one man he presented the head of the elephant, to another its ears, to another a tusk, to another the trunk, the foot, back, tail, and tuft of the tail, saying to each one that that was the elephant.

"When the blind men had felt the elephant, the raja went to each of them and said to each, 'Well, blind man, have you seen the elephant? Tell me, what sort of thing is an elephant?' "Thereupon the men who were presented with the head answered, 'Sire, an elephant is like a pot.' And the men who had observed the ear replied, 'An elephant is like a winnowing basket.' Those who had been presented with a tusk said it was a ploughshare. Those who knew only the trunk said it was a plough; others said the body was a grainery; the foot, a pillar; the back, a mortar; the tail, a pestle, the tuft of the tail, a brush. "Then they began to quarrel, shouting, 'Yes it is!' 'No, it is not!' 'An elephant is not that!' 'Yes, it's like that!' and so on, till they came to blows over the matter.

"Brethren, the raja was delighted with the scene. "Just so are these preachers and scholars holding various views blind and unseeing.... In their ignorance they are by nature quarrelsome, wrangling, and disputatious, each maintaining reality is thus and thus."

> Then the Exalted One rendered this meaning by uttering this verse of uplift:
>
> *O how they cling and wrangle, some who claim*
>
> *For preacher and monk the honored name!*
>
> *For, quarreling, each to his view they cling.*
>
> *Such folk see only one side of a thing.*

APPENDIX B

INSTITUTIONAL REVIEW BOARD

APPROVAL FORM

OKLAHOMA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD

Date:	April 11, 2000	IRB #:	ED-00-244
Proposal Title:	"TOWARD A TAXONOMY OF COLLABORATIVE SYSTEMS IN AVIATION AND SPACE ENVIRONMENTS"		
Principal Investigator(s):	Ray Hamilton Bailee Westphalen		
Reviewed and Processed as:	Exempt		

Approval Status Recommended by Reviewer(s): Approved

Signature:

Carol Olson

Carol Olson, Director of University Research Compliance

April 11, 2000
Date

Approvals are valid for one calendar year, after which time a request for continuation must be submitted. Any modification to the research project approved by the IRB must be submitted for approval with the advisor's signature. The IRB office MUST be notified in writing when a project is complete. Approved projects are subject to monitoring by the IRB. Expedited and exempt projects may be reviewed by the full Institutional Review Board.

APPENDIX C

SURVEY INSTRUMENTS

Thank you for taking your time to complete the following survey. The terms *group or team* are used interchangeably, you may circle the one that pertains to you. Please add any **additional comments** you feel are necessary for any question.

1. Are there significant contributors to your project that are not formal members of your group/team?
   Yes ☐ No ☐

2. Does your group have a specific decision-making format? Ex: consensus, decision tree...
   Yes ☐ No ☐

3. Is technology used to keep the group/team connected?
   Email ☐ Other________________________________
   Video conferencing ☐ ________________________________

4. Is technology used for simulation?
   Model making ☐ Possible Scenarios ☐
   Spreadsheets ☐ Other________________________________

5. What is the optimum time for a project to last?________________________________

6. Are there other departments in your organization that your group/team needs to work and/or coordinate with?
   Yes ☐ No ☐

7. Do you have a review board of outside experts or peers that review projects and offer their evaluative perspectives?
   Yes ☐ No ☐

8. How often are group/team meetings? Daily ☐ Weekly ☐ Monthly ☐

9. How would you describe group/team meetings? Rate your meetings somewhere along the five point scale below that best describes your experience by placing an "X" in the appropriate section.

Open Discussion	____:____:____:____:____	Controlled Reporting
Fun	____:____:____:____:____	Serious
Go with the Flow	____:____:____:____:____	Structured
Focused	____:____:____:____:____	Easy Going
Motivating	____:____:____:____:____	Ineffective

10. Would you consider "learning" a byproduct of your group/team discussions and activities?
    Yes ☐ No ☐

11. What elements make your group/team successful?________________________________

____

____

Section II.

1. Please indicate the subject area of your undergraduate degree.

Engineering ❑ Sciences ❑ Other________________

Math ❑ Business ❑ ________________

Physics ❑ Aviation ❑

2. Please indicate the subject area of your ❑ masters/ ❑ doctorate degree.

Engineering ❑ Sciences ❑ Other________________

Math ❑ Business ❑ ________________

Physics ❑ Aviation ❑

3. Years at present employment __________.

4. Does your group/team have a stated purpose or mission for your project?

Yes ❑ No ❑

5. Are you accountable individually for a component or as a group for the project?

Individually ❑ Group ❑

6. Do the members of your group/team have a diversity of skills or cross-functionality to complete your project/task?

Yes ❑ No ❑

7. Has your group participated in team building or group development activities?

Yes ❑ No ❑

8. Does everyone in your group/team participate in discussions or activities?

Yes ❑ No ❑

9. Does your group/team work with completion deadlines?

Yes ❑ No ❑

Within budget constraints?

Yes ❑ No ❑

10. When starting a new project how does the group/team make sure everyone **understands** the parameters of the project/task?

Discussion ❑ Charts ❑

Documentation ❑ Other________________________

Graphs ❑

11. Has there been conflict between or among group/team members that needed to be negotiated?

Yes ❑ No ❑

*Additional Survey Comments*____
____
____

PARTICIPATION LETTER

To Survey Respondent—

This letter is to request your participation in my research study. The attached survey will provide me with needed data for my dissertation on collaborative practices within the aviation and space industries. Currently, I am a doctoral candidate at Oklahoma State University, College of Education, Aviation and Space.

Your participation as a respondent to this survey is voluntary. Your completion and return of this survey is your consent for the researcher to use the data provided in the publication of a dissertation. No respondent will be able to be identified and information given on the survey will remain anonymous.

I appreciate the time and thought involved in responding to the questions, which are relevant to my research. If you have any questions concerning this survey or research study please contact me. Thank you for your response.

Bailee Westphalen
2200 Markwell Place
Oklahoma City, OK 73127
405.495.7522
BaileeCS@mindspring.com

APPENDIX D

CORRESPONDENCE

Flight Director Office
Mail Code DA8
Johnson Space Center
Houston, TX. 77058

FAX (713) 483-3304

INFORMAL MEMO

Date: 05/01/00

To: Survey Participant
From: Milt Heflin
Subject: Collaborative Practices Within the Aviation and Space Industries

I have volunteered to assist a doctoral candidate at Oklahoma State University collect information on collaborative practices within the aviation and space industries. As part of the study, I thought it would be interesting to collect some data for the survey from the team that solved many problems in real-time associated with the STS-99/SRTM mission.

I selected you from the STS-99 manning lists. The attached survey is very straightforward with only 22 questions. It should take very few minutes to complete. The student has included self-addressed-stamped-envelopes for easy return. Deadline to return the survey is May 10th.

In the survey treat "project" as "mission" (as in STS-99), and focus your answers as they related to your experiences for STS-99 real-time mission support.

Where it asks to select either "group or team", please select "team".

Again, the survey is very short and should not take much of your time. Mailing no later than by Wednesday, May 10th will be greatly appreciated.

Thanks for participating....and, again congratulations on pulling victory from the jaws of defeat during STS-99!

Milt

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VITA

Bailee R. Westphalen

Candidate for the Degree of

Doctor of Education

Thesis: ELEMENTS OF A COLLABORATIVE SYSTEMS MODEL WITHIN THE AEROSPACE INDUSTRY

Major Field: Applied Educational Studies

Biographical:

Personal Data: Born in Miles City, Montana.

Education: Graduated from North High School, Omaha, Nebraska in June, 1964; received Associates of General Studies degree from the University of Nebraska at Omaha, Nebraska, December, 1976; received Bachelor of Psychology degree from Oklahoma City University, Oklahoma City, Oklahoma, December, 1995; received Masters of Science degree in Natural and Applied Sciences from the Oklahoma State University, Stillwater, Oklahoma, May, 1998. Completed the requirements for the Doctor of Education degree with a major in Applied Educational Studies at Oklahoma State University in July, 2000.

Professional Experience: Director, Montessori School of Omaha, 1969-1971; Social Services Outreach Coordinator, Nebraska Department of Human Services, 1972-1976; Owner, Changing Paradigms, consulting Montessori and Early Childhood Development Centers, 1977-1979; Small Business Consulting, 1980-1990; Inter-Actions, RTC, President, Training and Business Consulting: Metro Area Vo-Tech and Oklahoma Housing and Urban Development, 1991-1996; Sprint PCS Telecommunications, Inc., Creek Nation Indian Tribe, Community Action Agency of Oklahoma City, Oklahoma State Vocational-Technical Schools, University of Oklahoma Center of Management, State of Oklahoma, 1996 to present; Instructor, Adjunct Faculty Metro Tech and the University of Phoenix 1997 to present.

Professional Memberships: American Society of Training and Development, Society of Neurolinguistic Program, Society of General Semantics, Association for Experiential Education.