CHAPTER 2

ANTECEDENTS

2.1 The importance of innovation in today's world.

Innovation as the word itself is generally understood and put into a global concept by using the dictionary definition *the introduction of something new* (The American Heritage Dictionary, 1994). This definition is correct but not complete at all because it does not include the final aims of innovating, therefore an enhanced version of the concept will help to understand twenty first century's business environment better. The next definition comes from a CBI innovation and trends survey:

"Innovation occurs when a new or changed product is introduced to the market, or when a new or changed process is used in commercial production. The innovation process is the combination of activities - such as design, research, market investigation, process development, organizational restructuring, employee development and so on - which are necessary to develop and support an innovative product or production process" [1].

The last innovation definition emerges from the actual context in industry and global economy and its correct understanding is crucial for the future of products, goods and technology development.

2.1.1 Innovation versus invention.

In a way these two concepts are related, however differences among them are present. To invent means to conceive or produce first, to originate. It can be seen as to make up something out of nothing, in other words, to create something completely new (that never existed before) which might be a device, a method, a process or a theory developed from study and experimentation that finally became practical.

“Innovation is a revolution”. To innovate goes more for a renewal of already existing devices or goods through the generation of new concepts that improve the core functions realized by the original ones and for giving users a better accomplishment of the performance objectives. Words like adaptation, modification, minimization, magnification, differentiation, implementation, improvement, rearrangement, interchange, substitute, reverse, change and so on apply for this innovation concept.

Another feature of innovation that distinguishes from invention is that the innovation process itself is conformed by the marketing-of-the-innovated-good step which is not necessary an end in the invention task. That is why innovation becomes an essential part on the growing of industry.

In the end, inventions and innovations are related tightly. First because both have creativity as a fundamental source for action. Second because most of inventions are being innovated day a day and innovation will continue being the conductive way for invents to exist, to renew theirselves and to persevere in the world.

2.1.2 Innovation timeline.

Inventions and innovations are countless, from the starting point of life up to now. Many inventors who were innovators theirselves have left to us a legacy of scientific knowledge and technology. Table 2.1 shows some examples of the inventions/innovations in the 20th century.

Table 2.1: Inventions and Innovations in the 20th century [2].

Year	Invention/Innovation	Inventor/Innovator
1900	Dirigible Dixie Cups	Ferdinand Zeppelin Hugh Moore
1901	Vacuum Cleaner Assembly Line	Hubert Booth Ransom Olds
1902	Teddy Bear	Morris Michtom
1903	Coat Hanger Crayons Radioactivity, study of Safety Glass	Albert J. Parkhouse Binney & Smith Marie Curie Edouard Benedictus
1904	Ice Cream Cone	Charles Menches
1905	Popsicle Theory of Relativity	Frank Epperson Albert Einstein
1906 1907 1908	Planters Peanuts Paper Towels Cellophane	Amedeo Obici Arthur Scott Jacques Brandenberger
1910	Lionel Trains	Joshua Lionel Cowen
1912	Life Savers Candy Shopping Bag	Clarence Crane Walter H. Deubner
1913	Auto Mass Production Erector Set	Henry Ford A.C. Gilbert
1914 1916 1917	Tinkertoy Lincoln Logs Christmas Lights	Charles Pajeau John Lloyd Wright Albert Sadacca
1920	Band-Aid Hair Dryer Traffic Light	Earle Dickson Inventor Unknown Garrett Morgan
1921	Wheaties	George Cormack
1925	Masking Tape	Dick Drew
1927	PEZ Candy Television	Eduard Haas III Philo T. Farnsworth
1928	Bubble Gum Yo-Yo	Walter E. Diemer Donald Duncan
1930	Toll House Cookies Cellophane Tape	Ruth Wakefield Dick Drew
1933	Monopoly	Charles B. Darrow
1935	Ballpoint Pen	Ladislas & Georg Biro
1938	Nylon Stockings	Dr. Wallace H. Carothers
1940	Turing Machine	Alan Mathison Turing
1942	Duct Tape Nuclear Reaction	Johnson & Johnson Company Enrico Fermi
1943	Bouncing Putty	James Wright
1944	Blood Bank	Charles Drew

1945	Computer ENIAC Microwave Oven Slinky Tupperware	John Mauchley and J. P. Eckert Percy LeBaron Spencer Richard James Earl Tupper
1946	Disposable Diapers	Marion Donovan
1947	Kitty Litter Instant Photography Transistor	Ed Lowe Edwin Land J. Bardeen, W. Brattain and W. Shockley
1948	SCRABBLE Velcro	Alfred Butts George de Mestral
1949	LEGO	Ole Kirk Christiansen
1950	Frisbee "PEANUTS" Silly Putty	Walter Frederick Morrison Charles Schulz Peter Hodgson
1951	Liquid Paper	Bette Nesmith Graham
1952	Computer Compiler Mr. Potato Head	Grace Hopper George Lerner
1954	Milk Carton	John Van Wormer
1955	TV Remote Control	Eugene Polley
1956	Scotchgard	Patsy Sherman and Sam Smith
1958	Integrated Circuit Hula Hoop United States Flag	Jack Kilby and Robert Noyce Richard P. Knerr Bob Heft
1959 1960	Barbie Doll Etch A Sketch	Ruth Handler Arthur Granjean
1965	SuperBall Veg-O-Matic	Norman Stringley Ron Popeil
1966	Hand-held Calculator	Jack Kilby, J. VanTassel and J. Merryman
1968	Computer Mouse Microprocessor	Douglas Engelbart Ted Hoff
1971 1972 1973	Kevlar Pong Video Game Internet	Stephanie Kwolek Nolan Bushnell Vinton Cerf
1974	Post-it Notes Rubik's Cube	Art Fry and Spencer Silver Erno Rubik
1976 1977 1981 1991 1997	Personal Computer PC Modem Veggie Patty World Wide Web Teletubbies	Steve Jobs and Steve Wozniak Dennis C. Hayes Paul Wenner Tim Berners-Lee Anne Wood and Andrew Davenport
2000 2001	JD Batball SegwayHT	Jacob Dunnack Dean Kamen

2.1.3 Innovation today: new trends.

Before presenting a specific modern innovation process and going into deep analysis of it (which will be made in chapter three), it is convenient to introduce a new term which itself calls for a renewal of the traditional innovation concepts and conditions: *innovation of innovation.*

First, talking in a social-oriented context, an analogy can be made between the change from modernity to reflexive modernity and the change from innovation to reflexive (innovated) innovation. Modernity is facing actual challenges like ecological crisis and social conflicts and there are two tendencies trying to overcome those challenges: post-modernity and reflexive modernity. Post-modernity proposes to forget completely the roots of modernity while reflexive modernity intends to reflect and reapply the goals of modernity questioning its political, social and cultural dimensions.

On the other hand, today's innovation processes suffer four types of uncertainties (Ito, Moritz, Ruth; 2003):

- A contradiction between increased planning and the danger that the intended goals cannot be attained because deterministic planning causes rigidity and reduces flexibility.
- The lack of complete information for assessing the appropriateness of the products and its effects.
- The question whether or not the product innovation will lead to socially, economically, and ecologically desirable products.
- The globalization tendency; on one side the existence of one product for the world, on the other, a regionally adjusted customer oriented product.

That is why innovation of innovation is looking to redefine the general understanding of innovation and the innovation process. It wants traditional innovation to be more reflexive on its goals and assumptions and to redefine them.

There are some assumptions about present innovation processes that have been reconsidered:

- Innovation is a process that cannot be planned at all because of the new complexities of products and tighter core requirements.
- Innovation needs the joint work of different disciplines, knowledge, experience and cultural backgrounds.
- Innovation needs to be adaptive to the type and quality of products.
- Innovation looks to overcome the need for regionally adjusted products. So the performance level of technical systems depends now on the contexts in which they will be employed.

Table 2.2 (Ito, Moritz, Ruth; 2003) summarizes the characteristics of the two types of innovation just mentioned (reflexive and traditional).

Analyzing the case of mechanical engineering industries and their innovation processes it is found that changes are occurring too. For instance innovation is no more sequential but rather it is becoming an integrated networking process on which different competent actors work to fulfill requirements simultaneously taking into account ecological, social, economical, technological and cultural goals. These actors will be experts with different social, ethnic and cultural backgrounds and will be part of an "innovation community" which in other words is "the functionally integrated and interdependent set of organizations (universities, institutes, professional associations, government bodies, etc) involved in commercializing a new technology" (Ito, Moritz, Ruth; 2003). To facilitate that innovation communities have a good performance; aspects like communication, cooperation, knowledge, skill and experience should be reinforced.

Table 2.2: Main features of reflexive and traditional innovation

Criteria	*Traditional Innovation*	*Reflexive Innovation*
Premise	Innovation is progress	Progress through negotiated innovation
Goals	Faster, more and larger	Social and ecological sustainable goods and processes
Goal attainment	Decisions forced by market pressure	Social discourse
Planning	Deterministic	Rejection of the planning myth; only probabilities
Products	Market demand	Sustainability
Processes	Sequential	Recursive
Competencies	Engineers contributing exclusively	Compound of various actors' specific contributions
Function of innovation in society	"Life elixir"	Allow a better life for more people
Nature of innovation	Uniform processes and products	Culturally adapted processes and products

Finally, there are two relevant concepts that should be reviewed since they will be helpful to understand latter relations and statements. They are *industrial culture* and *culture of manufacturing.*

The industrial culture approach goes from the social science towards the engineering while the culture of manufacturing goes the other way round. Both apply research to the programmable automation area.

The former approach analyses the design, transfer and use of CNC technology within an internationally comparative framework. It investigates the cultural differences in machine tool design, transfer and use using variables such as social, psychological, institutional and cultural (Ito, Moritz, Ruth; 2003).

The latter approach employs cultural, social and psychological factors for developing an appropriate understanding of the emerging diversity in manufacturing technology development (Ito, Moritz, Ruth; 2003).

The final goal of both is to synthesize the social science and the engineering field when designing technology by means of doing collaborative research. A global product diversification, the human centeredness of production systems (for example Human Oriented Manufacturing Systems, HOMS) and the need for human centered technology (for instance Human Centered Computer Integrated Manufacturing, HCCIM) will lead to a modernization of the innovation processes with different actors and individualized innovation courses.

Traditional innovation methods in manufacturing industries are being questioned because of the emerging need for culturally appropriate regionalized products and the increase of uncertainties at societal levels (Ito, Moritz, Ruth; 2003). The industry has influenced not only the technological sector but also the social and cultural ones. Therefore there is a new necessity of a culture approach into technology innovation which can only be achieved through a linkage of disciplines, cultures and communities; their systems and their processes.

2.2 Introduction to distributed work and related forms of work.

Not being this a formal definition, which will be given in a later chapter, distributed work deals mainly with the work in teams whose members are geographically dispersed but all having common objectives. When talking about distributed work it is implied that work at a distance will occur and this might change the way people was used to work in teams.

2.2.1 Distributed work from its beginnings.

Definitely, in order to understand and to integrate the existence of the distributed work on today's engineering field it is necessary to know its origins and to analyze the foundations that made feasible distributed work to be a new working style approach. Aspects such as a global economy, the international opening for commerce, the technological advancements, the necessity of managing products at distance, the increasing presence of multidisciplinary teams, the cultural evolution of nations and so on, have brought a necessity of exploring new paths of organizational processes and team work.

It is usually thought that distributed work (DW) emerged recently, however history shows that this working style already existed centuries ago in many places. Our ancestors invented methods of stabilizing information and agreements at distance. The management of cooperation at distance requires techniques, conventions and social norms, organizational structures, institutions and people's customs, inclusively. All this is part of a mechanism for achieving objectives and most of those mechanisms were strategies created in the past (Hinds, 2002).

One example of how ancient cultures managed work at distance was the use of "acceptance" rituals (like those made with the purpose of having new people to become part of a community). Those ceremonies were celebrated between two parties who, through gifts, symbolic actions and magic demonstrations; meant having accepted new rules and life modes from each other. Despite that participants came from completely distinct cultures, those rituals contained a common language which was understood and interpreted by both sides as acceptance or non-acceptance among them. This is also an example of how communication has been a fundamental tool for working at a distance.

However, our ancestors did not base on one type of available "technology" for working at distance. It can be mentioned that the invention and usage of scripture allowed to document statements from a group or community rules. Scripture allowed having a physic proof of agreements between groups which obviously is more liable than just a word-promise.

Money is another tool that helped intercultural work to evolution. From the beginnings communities obtained goods using an exchange system which was, for some time, a good method for commerce. Later on when metal appeared in scene a more concrete payment method was available and this ended with the arrival of coins (money).

All the aspects mentioned before are important but were not the only paths for making relationships at distance. The human factor and the socializing factor are also important for maintaining strong commercial and exchange relations. Curiously the biggest religious doctrines and constitutional governments have influenced work among nations too. Catholicism is a classic example of one of the first "global services enterprise" spreading new lifestyles to all world. In the case of government, when creating a constitution, this document is itself an example of standardized norms and acts adopted by a group of states.

There are much more things that have favored the remaining of distributed work throughout the time that could be mentioned, because of them distributed work is available in the present as an option for organization in the industry, institutions or work teams looking for the same goals. But the main objective of this thesis work is rather to take advantage of all this evolution, to study the present methods and to use this as the starting point for improving the current DW processes thus creating new tools for the future of engineering.

2.2.2 Working modes related to distributed work.

Having the main objective of this thesis on mind, I want to give a brief description of some already existing research lines that may favor the basic statements of internationally distributed work, meaning those areas of study and those tools that can be utilized for supporting distributed work and/or those implied by it.

Shared Mental Models and Coordination in distributed teams.

Coordination is the effective management of the dependencies among subtasks, resources (e.g., equipment, tools, etc) and people (Espinosa, 2002). Teams and individuals that work simultaneously on large-scale projects require a great coordination to get high quality products on time. This often involves collaboration from more that one location and makes coordination more difficult to accomplish.

Teams are able to manage more complex tasks than an individual, but also there are subtasks with many dependencies which create a difficulty for large team coordination however, according to Espinosa (2002) difficulties are managed in the following way:

- Teams coordinate explicitly using programming mechanisms (schedules, plans, procedures) or by communicating (orally, in writing, in drawing, formally, informally, in-groups).
- Teams also coordinate implicitly (without consciously trying to coordinate) through team cognition mechanisms, which are based on shared knowledge team members have about the task and about each other.

The shared knowledge helps team members:

- Understand what is going on with the task and anticipate what is going to happen.
- They can use this knowledge to plan their own actions.
- As they interact with each other and gain expertise with the joint task, they develop knowledge about the task (i.e. team cognition) and about the team.

The team cognition consists of three parts: shared mental models, transactive memory and team situation awareness. All these assert that knowledge similarity helps teams to coordinate and, although they have been more applicable to in-place teams; they look for reaching the distributed team trend. *Shared mental models* are organized knowledge that members share about the task, each other, goals, and/or strategies that help them to coordinate. *Transactive memory* is knowledge of who knows what in the team; helps teams coordinate because members know who to contact when they need information, and also because members develop expectations about who in the team will acquire which kinds of new information when it arrives to the team. *Team situation awareness* is up to the minute perception and comprehension of what is happening in the shared task environment, which enables the team to act in a synchronized fashion (Espinosa, 2002).

Virtual work teams.

It seems that the distributed team topic has been repeated through all the text. Actually, as taken into account in Espinosa's dissertation and in many other research papers, the study of distributed work teams is essential if we want to go deeper into the distributed innovation task and accomplish the objectives proposed in my thesis. On this part I remark some important aspects of a distributed team:

- To select and construct a work team is not an easy task and depends directly of the necessities of the product to be developed. Questions arise like: what fields (which type of professions) should be included and combined? What ethnic and culture backgrounds shall people have? What degree of expertise is required? How big the team will be (size, amount of people)? Which tasks will each of them be developing?
- Geographic distance among members influences and changes the way a work team organizes and it is actually what I want to research more on since the Dojyo project configuration is of this kind (internationally distributed). Geographic distance brings two parallel effects: the necessity of managing time difference and the necessary existence of a face-to-face communication with a defined frequency.

- The way team members communicate in a distributed fashion and its conflicts have to be overcome, then getting the technological means for doing so is encouraged.
- A team can always exist but generating a formal shape of a team is hardly achieved without the presence of leadership. In a distributed fashion, leadership takes a new approach and a decision between using a centralized or a decentralized (individual, distributed) leadership should be carefully thought (Haywood, 1998).
- Finally it is important to mention that managing human, social and cultural aspects of every member is not easy but must be done in order to work properly.

Knowledge work and knowledge work teams.

Knowledge work or the force of mental work is a very interesting development since it goes further than just working in distributed teams (Fisher, 1998). It treats distance collaboration from a “distributed mind” perspective which takes the definition of work far away from just being an activity of force. Organization, creativity, innovation, shared mental work, vertical multiple skills, distributed leadership and cyber organization are some of the treats of knowledge work.

Others.

Some other related areas to distributed work, each one being widely developed are the international education, the cultural differences in the professionalization of engineers, the patterns for international cooperation and more.

2.2.3 Concurrent engineering (CE) and global manufacturing (GM).

CE is defined as the integration of many disciplines into the overall life-cycle of a product to get advantage on competitiveness in terms of reduced costs, better quality and shorter production times. This is achieved through simultaneous activities and work in multidisciplinary teams.

In the traditional sequential engineering, decisions were taken practically at the end of the process and the product elaboration was sequentially done from one department to another. With parallel engineering, all departments start working together from the design step and the joint effort is made up to the final stage of the product, always inside of a common time-space frame. To change from one type of engineering approach to the other has not been easy; it has implied cultural changes, it generates some level of uncertainties at decision-take process and it brings a necessity of coordinating multidisciplinary and multi-enterprise teams in an adequate manner.

Two aspects concurrent engineering and distributed work share for succeeding is that they both need to have good means of communication and that they must be aware of the coordination factor being the only difference that concurrent engineering is basically defined on a same individual work place and distributed work is done at distance.

Here are some other definitions of concurrent engineering [3]:

- Concurrent Engineering is a philosophy in which all product life-cycle (PLC) activities are concurrently considered in the design phase. This is made by a multidisciplinary team of PLC experts, with the objective of identifying and preventing problems in the following phases of the PLC. This leads to an increasing of product's quality and a decreasing of product's developing time and cost.

- CE is a systematic approach for creating a product design that considers all elements of the product life cycle from conception through disposal. CE defines simultaneously the product, its manufacturing processes, and all other required life-cycle processes, such as logistic support. CE is not the arbitrary elimination of a phase of the existing, sequential, feed-forward engineering process, but rather the co-design of all desired downstream characteristics during upstream phases to produce a more robust design that is tolerant of manufacturing and use variation, at less cost than sequential design.
- CE is a systematic approach to integrated product development that emphasizes the response to customer expectations. It embodies team values of cooperation, trust, and sharing in such manner that decision making proceeds with large intervals of parallel working by all life-cycle perspectives early in the process, synchronized by comparatively brief exchanges to produce consensus.
- CE is a design engineering environment in which computer-aided design technology is used to assess and improve the quality of a product, not only during the active design phase but through its entire life-cycle.
- CE is a goal-directed effort where "ownership" is assigned mutually among the entire group on the "total job" to be completed, not just "pieces" of it, with the understanding that the team is empowered to make major design decisions along the way.

- CE is a systematic approach to the integrated, concurrent design of products and their related processes, including manufacture and support. This approach is intended to cause the developers, from the outset, to consider all elements of the product life-cycle from conception trough disposal, including quality, cost, schedule, and user requirements.

One example of the application of concurrent engineering in industries is on the manufacturing operations area. Some benefits are minimized tooling investment, simplified process, communized features, improved component quality, reduction in assembly plan complexity, improved vehicle dimensional integrity, minimized variations due to different suppliers, eliminating shipping costs and reduced piece cost. This is the case of an advanced stamping manufacturing engineering team at Daimler-Chrysler who optimized their product design and die process through the concurrent engineering work [4].

Now I want to present some paragraphs of the general terms of global manufacturing (GM). It is important for my thesis since the GM premises involve international work, relationships, technology exchange and cultural adaptation and although the global manufacturing approach is oriented towards the industry its basics concepts can be oriented to school engineering projects such as the Dojyo.

Globalization refers to growing economic interdependences among countries, as reflected in increasing cross-border flows of goods and services, capital, and know-how (Acosta, Leon, Villalobos; 2004). The increasing trend for globalization is a competitiveness response driven by the forces that are internal (the need to reduce costs, increase quality, and rapid need for technology and other resources) and external (large emerging markets, and global competition) to a company.

In the present, the technological interconnection between countries is possible because of a significant reduction in the communication, transportation and computer system costs. As a consequence world information is available to change the way of working in a company. For example, engineering project implementations can be much faster if the technical team has a good understanding of the local culture, or a product can gain more market share if the product design is tailored according to the country where it will be sold. One of the Dojyo’s task objectives is the possibility of putting the final product into the market therefore some of these global manufacturing concepts should be reviewed as advices.

A new concept named Global Enterprise Model (GEM) is proposed to facilitate the consideration of globalization factors in technological endeavors. It may help engineers to deal in an easier way with the global nature of a project. Acosta, Leon and Villalobos (2004) give interesting comments about the three interdependent layers of which a GEM is conformed: the global mindset layer, the operational layer and the societal layer.

Global mindset refers to the knowledge and skills concerning globalization possessed by the people at each level in a company’s organization. The knowledge about globalization can range from awareness to detail knowledge about the different cultures, international legal systems, and business environment. But knowledge alone is not sufficient to have an effective global mindset; the skills to integrate and exploit this knowledge for competitive advantage are a necessary component. For example a global design group will be aware of the importance of 'localization'. Localization is the process of adapting a product to meet the language, culture and other requirements of a specific target environment or market (Acosta, Leon, Villalobos; 2004). In the Dojyo case study one will be able to see how important is to prepare team members letting them to get knowledge on distributed work and providing them with the skills to develop a global product.

The operational layer refers to the value-adding activities, the necessary infrastructure, the systems and the environment associated with the different stages in the life-cycle of a product. For this layer, the most important dimensions considered by GEM that are applicable to my work are global organization, global resources and global operations. Global organization mainly deals with the exchange of technological advances among teams in different countries and the exchange of best-practices among production facilities located in different regions. Global resources are the use of foreign capitals and the centralization of the capitals into one organization. Finally an example of global operation is the design function of a company which can be adapted to a global environment by having design centers in different countries. Global production includes the supply chain, manufacturing, and distribution systems and infrastructure.

The third GEM layer is the societal one. It considers the national characteristics of the countries involved. It includes three dimensions often disregarded by the engineering community; namely, the nation's cultural, economic and political environments. In my opinion for the dojyo engineering team the most important one might be the cultural. Culture is the totality of socially transmitted behavior patterns, beliefs, values, customs, traditions and heritage. Culture is learned, not inherited. Cultural differences among nations make a substantial difference in the way managers and workers behave in organizational settings (Acosta, Leon, Villalobos; 2004).

One of the goals of GM is the capability of technology transfer from every region in the world reducing conflicts and enabling the internationalization of an enterprise. On a GM framework people show cultural differences but they work on a common task [5].

A GM organization is always looking for expansion to more regions even countries. When this happens new workers have their own way of thinking, their own expectative, their own culture, and sometimes their own language thus in order to perform a right industrial activity there must be adjustments on the traditional configuration of the group. GM not only describes how to transfer human resources from their original region to a new one but it includes also the technology, tools, designs, etc. that have to be adjusted to the new region [5].

2.2.4 Today's technology. Communication tools for distributed work.

Information and communication technology available today is large and has almost any usage. It opens a world of possibilities for overcoming problems a distributed team might find if they tried to work without any linking tool. Here, I briefly present what are the most recent communication tools for DW and a short explanation of each.

According to Charles Conrad (2002) there are five types of information technology: electronic data processing, management-information systems, decision support systems, office automation, and expert systems. He also mentions the telecommunications as critical to integrate teams. Historically, some of the most interesting types for my thesis are:

- *Electronic data processing*. This is the tabulation and analysis of large amounts of data into meaningful form.
- *Management information systems*. It is a system that gives information to managers for planning, controlling and evaluating the activities on a team.
- *Office automation systems*. “All the electronic systems concerned with the communication of information to and from persons both inside and outside the team” (Conrad, 2002).
- *Electronic mail*. Is the networking of computers in order to send, receive and store information (messages) in electronic format.
- *Electronic calendaring*. By using a networked computer members are able to keep calendars and share their availability with the others in the team.
- *Audioconferencing*. Is the use of electronic devices that allow members from different locations to meet via voice (e.g., telephonic equipment).
- *Videoconferencing*. Is similar to audioconferencing with the difference that video transmission equipment is needed. This allows geographically dispersed groups to communicate.
- *Computer conferencing*. “A conference enables members to enter comments about various topics in a sequence, indicating which prior comment they are responding to. Members can sign on at any time to participate and their comments are kept permanently to catch up easily” (Conrad, 2002).
- *Fax*. It allows the transmission of documents from one place to another.
- *Imaging*. One example of imaging is the things one may be able to do with the scanners: the digitalization of images.

- *Distributed computing*. Processing is done by many machines dispersed in a network, not anymore by central units.
- *Telecommunications.* They help people to communicate from different locations and to coordinate work effectively.
- *Groupware.* These are technologies that support a whole team on generating ideas and making decisions to coordinate projects.

Taking a look on the configuration of the Dojyo project and the team needs the most useful tools are the electronic data processing, electronic mail, electronic calendaring, computer conferencing, fax, imaging and telecommunication (audioconferencing and videoconferencing). The last two may be difficult to realize because they are expensive but these tools can be applied regionally (e.g., members in Munich can put it into practice, members inside Mexico can do the same, etc) or they can be integrated in computer conferencing which makes it feasible to apply them globally. These communication tools will be proposed on a methodology as help for distributed teams to acknowledge the technological options available today for working remotely.

2.3 The Dojyo project

In this section I will describe the Dojyo project in which I am active member. The information here is based on two reports written by Prof. Acosta and me and a presentation I prepared myself. What is stated is the development of the project from its beginning up to what has been done so far.

2.3.1 What is Dojyo?

Dojyo is generally a term used for describing traditional Japanese training or meditation halls or gymnasiums. It consists of two Japanese characters, the character DO meaning “the way”, also in a philosophical sense, and the JYO, signifying a “place.” The place where one can study, and potentially find, the way; this is the meaning of Dojyo.

In academic education the Dojyo principle is less used and discussed these days, but may offer a fascinating new way to meet the challenges of internationalization and globalization. The core idea, developed by Prof. Yoshimi Ito, President of the Japan Society of Mechanical Engineers, is to establish virtual learning dojyos, in which students from different countries and cultures conjoin via the internet to work on a specific task of common relevance and academic and educational interest. This project (e.g., travel costs, food, housing, materials, and software) was sponsored by the Japanese Ministry of Education, Monbusho.

Our group named TANE* has met two times during 2003; the first meeting was to clarify the conditions of cooperation, establish a team spirit, and develop a common vision of the Dojyo; the second one to jointly discuss, finally optimize and present the results of the Dojyo, to evaluate the Dojyo, and to discuss further procedures.

** Before continuing I would like to comment that as every team does we chose a nickname to create our own identity. We called our group TANE. TANE is a Japanese word meaning “seed” and it is also the acrostic for Tele Athletic New Experience*.

Our group is formed by students and professors from Germany, Japan, Mexico and the United States and we are all lead by Dr. Eckehard F. Moritz, member of the Sports Creative Engineering Tank, Technical University of Munich who is charge of the organization and final concept.

2.3.2 Selection of students

Students were selected through a questionnaire-based contest which mostly measured general aptitudes, creativity and engineering skills. Following are the questions designed for the purpose above:

1. *Which game(s) would you like to play among an internationally assembled group of students (e.g. at a summer school)? Why did you choose that game?*
2. *2. What sorts of motivation can you think of that motivates people to move (in some sort of "sportive" way)?*
3. *3. What can an assembly robot (KUKA-style, one big "arm" that may move into any direction and rotate around any axis) be used for, alternatively?*
4. *4. Please conceptualize (sketch) a new type of sports 'n fun device; either one called "dance wheel", or one called "roll 'n jump". Tell how it works, and why people like it.*
5. *Why would you like to be part of the Dojyo?*

I was chosen among seven participants at Universidad de las Américas, Puebla and Professor Carlos Acosta was directly invited as expositor and active member also.

2.3.3 Main objective of the Dojyo

The objective of the Dojyo Project is the intercultural learning and the gain of experience on simultaneous group work of a geographically distributed team. It is looking to overcome the challenges of internationalization and globalization in order to develop a new product worldwide accepted. The TANE team is shown in figure 2.1.

2.3.4 General frame of the Dojyo

As a new trend in the traditional project style, the Dojyo required a more complex frame for its establishment:

Figure 2.1: TANE members

1. Preparation: To get ready the original idea, to look and gain sponsorship, pre-planning and pre-organization and the selection of participants.
2. Realization: We attended two face-to-face workshops in Munich, Germany. The duration of these was approximately one week each.
3. Procedures: It was important to follow all what was already stated by the organizers but was also important what we planned for further after each workshop.

4. Development: That means the work we did in Munich and in our own locations.
5. Construction: As every team, we were assigned a task which reflects all the work done in Dojyo and the results of it. We built a prototype.
6. Dual project: Why I choose the Dojyo project as a study case for my thesis is because it is also based on the same fundamental topics: distributed work and innovation.

2.3.5 Our assigned task, the innovation process and the result

Our given task was to develop a computer supported mechanical device that offers the possibility of practicing a sport, playing and communicating with others via net, exercising the body, having fun and getting motivated. It can be seen from this definition that the main core functions are: fun, exercise and shared satisfaction.

Then it followed an innovation process (described in detail on chapter 3) that took TANE team to the final result. It consisted on the following steps: Discussion and analysis of the main topic; reviewing of project context; definition of core functions; definition of main perspectives and boundary conditions; a creative concept development workshop; the selection of a solution, optimization and first thoughts on details; further procedures, organization and distribution of contents.

The final outcome of all this can be defined as follows:

To realize a cooperative device that gives human being the sensation of flying by using movements and body exercises which allow him to play or manipulate scenery simulation software. Its name is Flyguy.

2.3.6 Activities during the first workshop

The initial face-to-face meeting took place during February in Munich, Germany. We mainly participated in conferences, visits and team building tasks. The first point included topics like perspectives for international engineering education, sports culture and technology, international systematic innovation and shared mental models and coordination in geographically distributed work teams.

As I mentioned, we also made short trips to visit mainly technological institutions and organizations with the purpose of becoming acquainted with new technology available and possibly applicable to our product. These were the Technical University of Munich (TUM) showed in figure 2.2, the Olympic Stadium and its sports facilities, and the robotics section of the DLR German Aerospace Center (figure 2.3).

Figure 2.2: TUM

Figure 2.3: DLR

Finally we were part of team-building activities that helped us to get the “Dojyo working spirit”. In the next picture (Figure 2.4) the team values of support and trust is presented.

Figure 2.4: Performance at Olympia Zentrum

2.3.7 The process back home

On February we came up with the final concept of the Flyguy and we established the future procedures to be done through the year on course. There were sub-teams created with the purpose of developing one or two specific aspects of the technical/non technical parts for the Flyguy: 1.Structure for support of person plus training (Chris, Adrian, Ingo, Kathleen, Martin, Moto. 2.Physical movement into electrical signals (Kathleen, Yusuke, Moto, Wendy) 3.Processing signals to change virtual environment (Wendy, Yusuke, Chris) 4.Gameplan (Daniel, Martin, Adrian) 5.Creating environment (Wendy, Yusuke, Chris) 6.Creating exchange network (Kanan, Daniel) 7.Management (Fozzy, Gunter, Ingo, Klaus, Carlos).

One of the main problems to solve in order to be able to work at distance was communication. Germany, United States, Mexico and Japan are completely dispersed countries in the globe; far one from each other. The University of Siegen, Germany has researched on computer supported cooperative work (CSCW) and they have developed one distance communication platform called BSCW (detailed on chapter 3). This network system allowed us to create our own common environment as a team.

Another tool we used to keep in touch was the email. This is not a synchronic way of communication but the main focus of having it was that all members were informed on time for the coming-soon activities for the week, for the month. Emails were the means by which we kept the pace day by day of what was happening or coming up in our project. We created something called TANEWS for getting the latest information and activities done by all the partners round the world. TANEWS was issued twice a month by every member in the team and was sent to all via email.

Time was another challenging task to overcome. Sometimes it was difficult to have all team members chatting online at the same day at the same time. But there were always some people working, organizing and leading so nobody got lost or missed important things.

From March to September we worked on many things and discussed a wide variety of topics. Just as some examples: some people researched on similar devices to Flyguy, others looked for companies that could help us with materials or devices for the prototype, others worked on the design of the prototype, others were suggesting the electronic parts and possible software to be tried, some worked on the concepts, etc. So many things we did with one purpose: to come up with a real Flyguy that could be tried later on and improved afterwards.

2.3.8 Activities during the second workshop

Our second face to face meeting took place in Germany during the first week of October. Once again, from the dawn to the dusk there were plenty of activities planned in order to achieve the desired results. Compared to the first workshop, this was more flexible on the time schedule and quite different from the first one because the new objectives were more specific and technical-oriented. This means that we were now to build up a real thing, a Flyguy prototype which was to be tried, tested and rethought for improvement and future work continuity. Despite of the difference among the two workshops, both of them rewarded us on the way that we gained so much experience, we advance our knowledge on the engineering fields and we developed in part our new device which was really interesting.

During these 5 workshop days, we faced different tasks and we visited interesting places to help our minds to get a better idea on what technological applications can be used in our Flyguy. One interesting experience was the visit to the Ars Electronica Center, Linz. . Here we found an apparatus similar to ours and we tried it out too (Figure 2.5). But this was not the only thing; looking at the different projects on the museum, we discovered that some of these have applications that could be put into the Flyguy: electronics, visual/graphics, computer animation, etc.

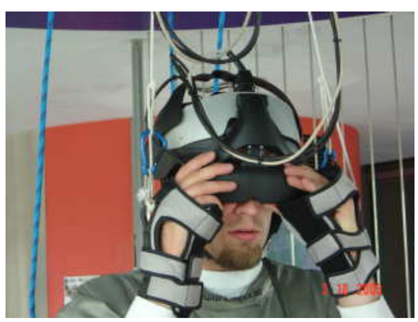

Figure 2.5: The Humphrey

The most important outcome from this second meeting was the prototype building (figure 2.6) and testing (figures 2.7). The detailed design, building and testing results are described in chapter five together with the whole dojyo as a case study.

Figure 2.6: Optimizing, design and building of the flyguy prototype

Figure 2.7: Testing the prototype core functions

As a last part I would like to go a little deeper on how the building prototype task came since I participated directly on it. As mentioned before, the prototype construction was one of the most important objectives of our second meeting. The procedure for making it possible was not an easy task and it presented a new and interesting challenge. From the first meeting, I decided to be part of the mechanical design sub-team of Dojyo and to work on the design of the frame for the Flyguy. After being back in Mexico, I started looking at different types of sports equipment for body support and found some good ideas, talked to the German members about it and sent pictures to them so they had a clear idea and chose the best fitting our needs. I also sketched some concepts for the frame and after some weeks of discussions and decisions I came up with the final solution, which was a practical one for the purposes of trial. Then we ordered the materials which were donated by Maytech, (a big extruded aluminum profile company). By this way of organizing it was possible that when we actually traveled to Germany for the second time everything was ready to run on.