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**THE INTERNATIONAL ORGANIZATIONAL NETWORK
AS CORE CAPABILITY:
GLOBAL PRODUCT DEVELOPMENT IN
FUJITSU LIMITED**

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**MITJP 93-07**

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## 1.0 Introduction and Framework

Of the large amount of work in recent years that has examined new product development, surprisingly little has moved beyond consideration of the project as the principal focal unit. Two issues, the effects of organizational structure (e.g., divisional, functional, or geographic design), and internationalization have typically not been considered. Instead, projects are implicitly examined in an organizational vacuum, or with the organization as neutral, or non-influential, except as the passive recipient of externally sourced technology. Additionally, for many authors, new product development implicitly takes place within the confines of a single (home) country, whereas the products studied may in fact be developed across borders, may depend on international networks for technology and knowledge transfer, or otherwise be the result of the development of an international organizational product development capability.

These two omissions are surprising, especially since many of the products considered, such as automobiles or computers, are in industries which are both dominated by large multinational companies (MNCs), and in which organizational capability is as, or even more, important than technological know-how at a particular point in time. From this perspective, technology and product development can be seen in part as an *outcome* of organizational structure and process, rather than factors being of little or no importance.

The omission of the international dimension is probably due to a combination of three factors. First, there has been a general parochialism (maybe even ethnocentrism) in much academic management work at the organizational level in the US (Boyacigiller and Adler, 1991), a bias which has to a degree diffused to other levels of analysis, such as the project. Second, there has been an underlying assumption, in influential writings on corporate and competitive strategy, that an MNC's strategy should be to build home base strengths for subsequent exploitation abroad (e.g., Porter, 1986; 1990), which has, therefore, emphasized the particular strengths and features of an MNC's home base. The home base, from this external perspective, focuses on the local environment, an environment in which the internal organization of the firm is largely 'black-boxed.' Third, global product development - the combination of different global technology resources into a single technology or product - is a recent phenomenon, even for products with a long history of internationalization of sales, such as automobiles.

In a brief review of the history of studies of the new product development process, Katz and Allen (1985) and Allen and Hauptman (1987), for example, have focused on development and research activities within R&D functions, and examined issues in the interorganizational matrix of R&D departments. A "second generation" of new product development research, represented by Clark, Chew, and Fujimoto (1987), and Iansiti (1992), extends the first generation research to include other functional activities, such as marketing and production, and integrates these activities into the new product development process. Some of these researchers have focused on particular linkages among these functions, such as the work of Von Hippel (1986) on lead users. A "third generation" of product development work, led by the work of Fujimoto, Clark, and Aoshima (1992), Nobeoka and Cusumano (1992), Wheelwright and Clark (1992), Aoshima (1993), and Meyer and Utterback (1993), has moved beyond the single project as the unit of analysis, to consider issues in inter-project technological transfer and learning. In addition to considering some instances of advanced technological development and cross-functional integration, this literature calls for the recognition of the importance of longer-run, inter-project relationships. However, this literature still tends both to focus on the new product project, or multiple projects, as a more-or-less self-contained unit of analysis, limiting organizational considerations to those of project staffing or structure (Leonard-Barton, 1992), and is largely silent on the international dimension.

Those studies that have addressed the link between the project and the organization, have typically considered the organization as a dependent variable shaped by "external" technological innovation or new product development shocks. This work considers the degree of 'fit' of the organization to technological change (e.g. Abernathy and Clark, 1985; Tushman and Anderson, 1986; Henderson and Clark, 1990; Anderson and Tushman, 1990), especially the impact of technological discontinuities.

In contrast, other literature, such as that concerned with a more resource-based view of the firm, starts from the premise that resource bundles and capabilities underlying production are heterogeneous across firms (Peteraf, 1993), and introduces the notion that firms can develop unique organizational advantages, variously referred to by nomenclature such as invisible assets (Itami, 1987), or core competencies (Prahalad and Hamel, 1990). For Prahalad and Hamel (1990: 82), for example, core competencies are "the collective learning of *the organization*, especially how to coordinate diverse production skills and integrate multiple streams of technologies" [my emphasis]. This is almost identical in meaning to the concept of core capabilities used by Leonard-Barton (1992).

Building on this notion of heterogeneity, global product development may be considered as the combining of particular resources from different locations or countries, resources that may be embedded in different institutional contexts and organizational principles of work (Kogut, 1991). In high technology product development, for example, the combined resources of two or more locations are frequently required for the successful completion of a particular project. It is also rare that a product or technology developed in the home country can be simply exported to an overseas market, even if effective product development has been possible in a purely domestic environment.

When global development is required, although communication between subsidiaries with different organizing principles of work imposes additional demands, the assimilation and combination of different national methods of product development can lead to distinct MNC capabilities. If difficulties of communication can be overcome, the result is an international organizational network which, itself, represents a distinctive core capability and source of competitive advantage. How an organization combines the resources creates sustainable competitive advantage beyond the value of the individual different resources.

This paper focuses on some of the organizational principles in R&D, and summarizes three examples of international product development within one company's international network, that of Fujitsu Limited. It shows how Fujitsu Limited has been successfully developing a core capability in its international organizational network. The three cases focused on are those of:

(i) the FETEX-150 central office switch, developed jointly by Fujitsu Network Switching of America, Inc. of Raleigh, North Carolina, with the Switching Systems Division of Fujitsu Limited, located in Kawasaki, and Fujitsu Laboratories, Ltd., also in Kawasaki;

(ii) the FLM 150 and FLM 6 multiplexers, developed jointly between Fujitsu Network Transmission Systems, Inc. of Richardson, Texas, and the Transmission Systems Division of Fujitsu Limited in Kawasaki; and,

(iii) a 2½" hard disk drive, and an embedded controller for a 5¼" disk drive, developed by Intellistor, Inc., a Fujitsu subsidiary company located at Longmont, Colorado, and the corresponding divisions of Fujitsu Limited in Kawasaki.

In contrast to the studies of new product development which have focused on products based on more-or-less stable technologies, the technological trajectories of these products is highly volatile. This complexity is compounded by such factors as standards, and the need for

compatibility with existing equipment and vendors' requirements. While Fujitsu Limited is a recognized leader in advanced technology development, this paper argues that Fujitsu has an even more potent weapon with to which to fight its competitive wars: it has been developing a core capability in its international organizational network, which is turning out to be just as valuable an ingredient in its future success.

In addition, contrary to the rhetoric of some writers of technology transfer who focus at the national level, the examples suggest the possibility that technology transfer between Japan and the US may be more complex than the aggregate data used in macro assessments sometimes suggests. In international product development, there is usually a two-way flow of technology between organizations in different countries at each stage of development.

Global product development is shown, through these cases, to have a number of potential advantages compared to national product development. The key strategic advantage is the creation of product and technological capabilities that are not easily replicable by competitors. New routines for combining technologies become established, such as between software development in the US and hardware development in Japan. At each stage of the product development process, such as working with third-party vendors and performance testing, international organizations adapt and develop common interorganizational standards. The capacity to absorb (Cohen and Levinthal, 1990) different component technologies requires each part of the MNC's interorganizational network to develop a minimum threshold capability in the others' technologies. This acts as a vehicle for technological diffusion transnationally, provides a number of platforms from which MNCs can launch new products, and enables MNCs to meet local user requirements. In advanced high technology products, meeting local user requirements involves much more than local product market adaptation. Different standards, compatibility requirements in open systems, local supplier requirements, and functionalities are major drivers of the development of a global product development capability. The strategic capability also derives from the combination of the most talented labor in each of the product areas, such as hardware in Japan and software in the US.

Distinct organizational structures and processes evolve around the new capabilities. At a concrete level, these involve new communication processes and methods of interorganizational coordination (e.g., personnel transfers), common CAD/CAM systems, the development of distinct task partitioning, and the establishment of common organizational structures.

This paper illustrates these issues at the level of the MNC, and summarizes aspects of the evolution of three Japanese R&D facilities in the US. It concludes with a call for a more systematic examination of the organizational aspects of new product development, and for the explicit incorporation of an international dimension to such analysis.

## 2.0 Fujitsu Limited

### 2.1 Company Description and Activities

Fujitsu was established in Japan in 1935, although its origins go back to 1875 and Furukawa Co., Ltd. It remains, today, part of the Furukawa Group of companies, which comprise 44 companies in total and include The Dai-Ichi Kangyo Bank, Ltd., Asahi Mutual Life Insurance and Fuji Electric Company, Ltd. It first entered the US by setting up an office in New York in 1967, which was followed by the establishment of Fujitsu California Inc. in 1968.

Having grown out of the Communication Division of Fuji Electric Co., Ltd., it moved into the manufacture of radio communication equipment in 1953 and developed Japan's first commercial computer, the FACOM 100, in 1954. Fujitsu began the volume production of

transistors in 1960 and its main R&D subsidiary, Fujitsu Research Laboratories was set up in 1968. Its first analog electronic central switching system was delivered in 1971 and it invested in Amdahl Corporation, currently a $2.2 billion a year Silicon Valley maker of IBM-compatible mainframes, as early as 1972 (its stake in Amdahl is currently 44%). By 1980, Fujitsu was ranked number one in information processing sales and, in that year, it introduced its first word processor. The 1980's saw continued growth and the establishment of the Fujitsu presence in the US that remains today.

Fujitsu's businesses revolve around interlinked technologies in three main areas, technologies that fuel the product ranges that Fujitsu is developing and marketing at any point in time. Firstly, in telecommunications, Fujitsu manufactures switching systems, telephones, submarine transmission systems, fiber optic transmission systems, radio transmission systems and satellite transmission systems. Secondly, in computers and information processing systems, Fujitsu is a producer of supercomputers, general purpose computers, office processors, workstations, personal computers, Japanese word processors, peripherals and terminals. Finally, in electronic devices, Fujitsu's products include compound semiconductor devices, integrated circuits, microcomputers, keyboards, connectors and relays.

<center>INSERT FIGURE 1 ABOUT HERE</center>

Of Fujitsu's 1992 sales of ¥3,441,947 (see Figure 1), 73% was in computers and information systems, 13% was in communication systems, 10% was in electronic devices and 4% was from other operations. The main operating divisions operate separately, converging over specific products. Likewise, Fujitsu has made a number of acquisitions in the US and Europe in recent years. In addition to Amdahl, in the US, Fujitsu has made other acquisitions, such as Santa Clara based Poqet Computer Corporation, that makes pocket sized computers, and Intellistor, the Longmont (CO) based maker of computer memory devices that is described below.

In 1992, Fujitsu relied its home country market for 70% of sales, although this had gradually reduced from 78% in 1988. While a breakdown for the US was not given, Fujitsu has a strong presence in Europe, including its 80% ownership in ICL, Britain's largest computer maker.

While expenditure on R&D, as a percentage of sales, has risen slightly, from 9.3% of total sales in the year to 3/31/1988 to 11.2% most recently, more significant has been the fact that the increase in R&D expenditure has been set against a backdrop of rapidly rising sales over the same period, so that Fujitsu's R&D expenditure actually grew by 106% over the four year period to 3/31/1992, equivalent to a compound rate of some 20% per annum. In the latest year, to 3/31/1993, Fujitsu expenditure on R&D fell by 2% from the previous year.

## 2.2 Fujitsu in the US

Fujitsu's US operations are divided into two parts: those that come under the control of the Fujitsu America, Inc. holding company umbrella and those that report directly to Tokyo, either to the respective divisions or to the Fujitsu Laboratories Ltd. main corporate R&D subsidiary. Whilst most of these companies have been set up by the Japanese parent, some come into the Fujitsu US portfolio through outright acquisition (e.g. Intellistor, Inc.) and Fujitsu also has some sizable ownership stakes in what are still independently managed companies (e.g. Amdahl Corporation, Poqet Computer Corporation). Despite its 44% stake in Amdahl (down from a previous 49%), Fujitsu has only three of the 12 seats on the Amdahl board. The ownership stakes are important; for example, in 1990, some 60% of Fujitsu America's $1.5 billion sales was to Amdahl Corporation.

<center>5</center>

The current formal organizational structure of Fujitsu's US operations is as follows:

Fujitsu Limited - Divisions (Japan)

Fujitsu Computer Packaging Technologies, Inc. (San Jose, CA)
Fujitsu Microelectronics, Inc. (San Jose)
Fujitsu Components of America, Inc. (San Jose, CA)
*Fujitsu Network Switching of America, Inc. (Raleigh, NC)*
Fujitsu Systems Business of America, Inc. (Santa Clara, CA)
Open Systems Solutions, Inc. (Emeryville, CA)
Poqet Computer Corporation (Santa Clara, CA)

Fujitsu America, Inc. (San Jose, CA)

Fujitsu Business Communication Systems, Inc. (Anaheim, CA)
Fujitsu Canada, Inc. (Ontario)
Fujitsu Computer Products of America, Inc. (San Jose, CA)
 *Intellistor, Inc. (Longmont, CO)*
Fujitsu Customer Service of America, Inc. (La Jolla, CA)
Fujitsu Imaging Systems of America, Inc. (Danbury, CT)
*Fujitsu Network Transmission Systems of America, Inc. (Richardson, TX)*
Fujitsu Systems of America, Inc. (San Diego, CA)

All four functions of manufacturing, research, development and marketing/sales are present throughout this corporate organization, though they do not always coexist.

The differentiating criteria between those operations in the US which fall under the Fujitsu America, Inc. umbrella, and those which are owned direct by Fujitsu Limited in Japan, seem related to a combination of three factors. The more: (i) that funding is required from Japan, (ii) that sales are either less well developed or are not into mass consumer markets, and (iii) that the US-based activities involve a high level of communication with the Divisions in Japan for the purposes of technology and product development, the greater the likelihood of direct ownership by Fujitsu Limited, Japan.

The advantage of the Fujitsu America, Inc. holding company structure is in bringing together the more mature, revenue-generating parts of the organization, so that more effective coordination is possible in sales across the US. It also avoids the potential problem of start-up companies draining the resources of the US parent company before significant market penetration has occurred.

In October, 1991, Fujitsu reorganized and divided its US operations into several smaller companies, with greater direct reporting to Japan. This was effectively a form of local decentralization which had, as its declared purpose, the improvement of communication between the various divisions in Japan and their overseas subsidiaries. Prior to this, Fujitsu America, Inc. had acted as much more than just a holding company, coordinating activities across the US. This represented, therefore, a fundamental shift from the dominance of a geographic form of organization to one based on technologies and products. It was, perhaps, the beginning of a move from what was primarily a global market segmentation, based on geographical regions, to one recognizing the more important differences between technologies, products and customer segments (e.g. business versus household). There was projected to be enhanced and more direct contact between Fujitsu Limited in Japan and the local market. This was especially important in areas of rapid technological development, and where lead users were located in the US As Mr. Masuo Tanaka, President of Fujitsu America, Inc., said in October, 1991:

"We want to be quick to make decisions and quick to deal with our customers. The reorganization will give more autonomy to each subsidiary."

(The Business Journal, San Jose, October 14, 1991)

Moreover, as a senior Fujitsu executive explained in 1992:

"Last October we split the Company into many small companies. One of the reasons why we decided to do this is that in the past, in the Fujitsu America organization......we had two major business groups - FNTS [Fujitsu Network Transmission Systems of America, Inc.], which is one of the business groups in Fujitsu America (until last October), and the company FCPA [Fujitsu Computer Products of America, Inc.], which is selling computer periphery equipment including disk drives and so forth mostly on an OEM basis. They are also part of Fujitsu America, which had been under the strong control of the Fujitsu overseas marketing organization, and so Fujitsu America cooperated/communicated with the Fujitsu overseas marketing organization. And then they communicated with each product group. And decision making was very slow and product development often times missed the market window. So Fujitsu finally decided that we had better have more direct communication between local sales organizations and the Fujitsu [Japan] product divisions. We have still today an overseas marketing organization, but we now have less autonomy. Companies like FNTS and FCPA have stronger ties with each product organization. So by doing this, probably we can improve on the product development cycle."

However, the flip side to the organizational change was that of the subordination of "within country" communication to "between country" communication:

"The problem is that in each product area [we have] improvement. But, and this is my opinion, Fujitsu is targeting to become a solution business provider by providing CPU, basic O/S, peripherals and application programs. To do that, to provide that kind of system solution, the division of the company may not be a good idea. Its division may make it a little difficult to communicate and cooperate across the company. So I think that that is probably the next task."

In establishing a US organization, issues such as proximity to users, local product market adaptation, decentralization and labor market skills had been important drivers. Some other recurring themes that influenced Fujitsu strongly in its efforts to establish product development activities in the US were consistent with the framework presented in section 1.0, and included:

(i)     Standardization. In the computer business area, many standards are created in the US by American companies rather than in the Japanese market-place. As an example, the UNIX operating system, written in 'C', had its origins at Bell Laboratories in 1969 and began to be distributed to universities in 1974 and commercially a few years later. It has, over the last ten years or so, developed a momentum of becoming a standard in minicomputers in the US. ICL, Fujitsu's UK majority-owned associate company had played an important part in the development of the UNIX standard and many UNIX-based product developers are currently forming consortia in the US. Fujitsu has announced a move towards the UNIX standard and its 1991 acquisition of the UNIX program developer Open Systems Solutions, Inc. was an attempt to gain a greater participatory role in the development of the standard. Standardization in software is driven from the US.

(ii) Industry structure. Related to the development of standards is the issue of different industrial structures between Japan and the US. In semiconductors, for example, most of the large semiconductor producers in Japan are captive semiconductor divisions of large computer manufacturers (e.g. Hitachi, NEC). This is quite different from the US, where companies such as Intel, Motorola, and National Semiconductor are not tied to their customers. This factor has probably been related to the greater innovation of the US semiconductor producers, but it is also a driver of standardization, as producers for a general market-place have greater pressures to develop a standard so that their product can be acceptable to as large a potential customer base as possible. In the US, when one company develops a very good product, system vendors rapidly take up the new product and incorporate it into their computers. Second-sourcing then begins, as companies such as Motorola buy products developed by other companies.

The significance of this was confirmed by a Fujitsu strategist in the US:

> "I think that the industry structure itself has better potential to create industry-like standards. In Japan, since semiconductor groups belong to, and are just dedicated to producing semiconductors for, one company, other companies may make different products. So, even if Fujitsu's semiconductor division in the past produced certain integrated circuits for Fujitsu computer division, and Hitachi semiconductor division produced fractionally similar but a little bit different products (pin out is different or something), those are of course viable products for the computer division of each company, but that kind of environment is not creating any kind of industry-wide standard. So later on, Fujitsu recognized that a functionally similar product, but a little bit different device, was becoming a standard in the US, So Fujitsu decided to second source that also. So I think that many standards are created in the US. So it is really beneficial to increase development efficiency by actually belonging to US industry rather than just deciding the development direction within Fujitsu organization."

Standards have also been important in communications. It has been a problem for Fujitsu trying to simply sell telecommunication products outside Japan to countries that have equipment based on the various international standards, such as those set by CCITT. In Europe, the drive towards standards has been especially strong, since if the European market-place is to become a single market, then all the country-based government-controlled or regulated communication authorities have to develop new standards. The US, in contrast, has not always followed the emerging standards in communications, but it has historically been ahead of Japan. It has, however, moved significantly towards European in the last three or four years.

(iii) Fujitsu was likely to become more involved in joint development work, not only for reasons of standards, but because of the high cost of researching and developing new technologies and products. In addition to Fujitsu's relationships with Amdahl and its US acquired Hal Computer, it was expected that Fujitsu would be other industry partnerships in the coming years.

(iv) In the management of R&D in the US, it was made clear that conducting a clearly defined, and well-structured research project was easy, given sufficient resources. However, problems arose when the task was not clearly defined. In any project scheduled to take three years to complete, during that time it was expected that the technology would change. For example, in computers, semiconductor technology would have been greatly enhanced, and prices greatly reduced. So, in many cases, Fujitsu has had to retain significant flexibility. It was said to be extremely difficult to define the

totality of a product development task at a single point in time. This had implications for new product development in the US:

"Between definition of the task and completion, in many cases we have to change the target and so forth. Managing the organization in that kind of environment is probably the biggest task in managing an organization in the US. It is also difficult in Japan, but especially in the US. We have to manage people very carefully. Changing target frequently will obviously discourage people and create some confusion. Some engineers feel insecure.

The Japanese are more flexible because they are secured. They don't have to worry about losing their job. Once people join Fujitsu - in the extreme case that [losing their job] may happen, but I have never seen Fujitsu lay people off. That is not true in the US, so people feel very insecure if management keep on changing targets and so on. That is probably the most difficult portion to manage in development projects. If the work is clearly defined and appropriately staffed and funded, I think that development efficiency is very, very good. My feeling is that efficiency is better in the US. It is more expensive, yes, but time is very expensive so if we spend too long in Japan that is very, very expensive."

## 2.3 R&D Organization at Fujitsu

R&D at Fujitsu is clearly divided into "research" and "development". In most cases, the separation is formalized by a hand-off of technology from one group, having completed the applied research, to another with the responsibility of developing manufacturable products. The development of core technologies are focused at the level of the corporate laboratory, but the divisions have an increasing involvement through participatory meetings, as the research moves towards the stages of applied technology and product development. Success in this process at Fujitsu is seen as an outcome of the density and quality of communication, something that was recognized in the October 1991 reorganization of Fujitsu's US activities. The input of manufacturing and marketing through the divisions is also an important part of product development success at Fujitsu. An important contributing factor to high technology product market success is process technology. It is process technology that enables miniaturized components to get from the drawing board into the final product, and process technology continues to play a role as technology diffuses, through relative cost differentials. Process technology at Fujitsu includes the transfer process; it is more than simply manufacturing process, but includes management processes.

Fujitsu's corporate R&D is focused through a special purpose company, Fujitsu Laboratories Ltd., based in Japan. Fujitsu Laboratories was established in 1968 through a merger of R&D sections previously managed by separate technical divisions. Initially based at Kawasaki, a second location, at Atsugi, was established in 1983. Longer term research (over 10 years or more) is conducted at the International Institute for Advanced Study of Social Information Science at Numazu, and a new laboratory facility is to be opened in Kansai this year. Currently, some 1,600 employees come under the Fujitsu Laboratories umbrella, of which 57% are based at Atsugi. R&D activities are divided, so that Kawasaki provides research to the Communication and Space Division, the Information Processing Division, the Personal Systems Division, and the Information Processing Center. Atsugi works with the Electron Devices Division, the Electronic Systems Division, and the Materials Division. The largest R&D area, involving some 27% of Fujitsu Laboratories' employees, is in electron devices, at Atsugi, followed by 21% in information processing at Kawasaki.

The Divisions at Fujitsu, therefore, receive two types of research results, or technology, from Fujitsu Laboratories: exploratory research and product oriented projects, with the former more heavily dependent on headquarters' funding.

Consistent with the observations of this researcher, in a 1989 visit to Fujitsu Laboratories that included an interview at Atsugi, MIT's Professor D. Eleanor Westney noted that one of the key organizational differences of the Laboratories, compared with what might typically be expected in a Western company, was that of the central position of the customer in the functional organization of Fujitsu, compared with the value-chain approach of its US high technology competitors. A value chain moves from R&D, through manufacturing, to marketing, sales and the final customer. At Fujitsu, given that the customer is the center of the organization of functional operations, R&D organization is driven by the importance of lead users and customers. Such a form of organization is facilitated by the generally superior horizontal communications in Japanese companies compared to US companies. This is also an important driver behind the internationalization of activities other than marketing and sales; to achieve proximity of product development teams to customers.

It was explained that the Laboratories carried out two types of research, one product-oriented and based on ideas suggested by the Company's Divisions, the other exploratory, and based on ideas suggested by the Laboratories. Product oriented projects are mainly applied or development research. Exploratory research, in contrast, investigates new ideas and is not tied directly to current business or products. Funds for product oriented projects come from the divisions sponsoring, or commissioning research. Exploratory research is funded by headquarters. Technology developed at the Laboratories is transferred to Fujitsu's Business Divisions.

At Fujitsu Laboratories, a basic research project generally lasts about five years, and accounts for about 20% of the total research budget. This depends, however, on the particular technology. Medium term research projects, which usually last from three to five years, account for 40% of the R&D budget. The target here is to develop basic technology needed for the next generation project. The third category is short-term research projects, which usually last about two years, and account for another 40% of the research budget.

Professor D. Eleanor Westney found that the time horizon of the more basic "research" was about ten years - and lengthening - and that of product cycles and, therefore, product development, was shortening. Two-thirds of the Laboratories' funding came from headquarters, of which about one-half was allocated in cooperation with the business divisions. The remaining one-third of the funding came directly from the divisions. In 1993, still around 70% of the funding of Fujitsu Laboratories came from headquarters, with the remainder from the Divisions.

Technology transfer of headquarters' funded R&D projects to the Divisions could be especially difficult, but much depended upon the efforts of particular laboratories. Some of the factors which Fujitsu has found to have contributed to the success of technology transfer are:

- laboratory R&D leadership and responsibility for technological design and development
- a rapid response to Fujitsu's needs and problems
- transfer of management responsibility from laboratories to Fujitsu development divisions
- movement of key technical people
- continual technical support through design, manufacturing, and marketing
- important role of basic research in R&D
- developing methods to evaluate effectiveness of technology transfers

The method of technology transfer depends upon the particular technology. Communication between more advanced research laboratories and divisions required much effort, and was not always easy.

Fujitsu's corporate research function remains entirely in Japan, in contrast to efforts to internationalize this activity at other companies, such as NEC, which has a long-term research facility at Princeton, New Jersey. To date, Fujitsu has clearly found that the benefits of corporate research centralization (including economies of scale, interaction among those working in converging technologies, and so on) outweigh those of decentralization, or internationalization. Figure 2 shows the relationship between Fujitsu's US product development activities, in seven principal locations across the US, and the Divisions in Japan. The Divisions in Japan, in turn, liaise with Fujitsu Laboratories.

INSERT FIGURE 2 ABOUT HERE

The internationalization of R&D is a more complex process than the models of global networks typically assume. There are significant constraints, in addition to communication and technology transfer difficulties, as the following account suggests:

> "Now, Fujitsu Laboratories people are not directly concerned with overseas activities. Fujitsu's Divisions are more strongly connected with overseas activities. So, it depends on each Division, case by case. We have no research facility in the US, but we have some cooperation with Universities, such as MIT, and we have some sponsored, or collaborative research. We would like to open some software laboratory in the US, but there is no money. My feeling is that if we have developed some technology in the US, it would be difficult to move that technology from the US to Japan; some barrier I think. But NEC opened a very, very basic research - it is doing research like universities - so it is long-term research. I think that the major problem would be with technology transfer. I think that the US government will prohibit it. [Even within the same company?] I think so. There is some restriction on transferring technology, even within the same Company. MITI permission procedures concerning COCOM....We hope to open some advanced research laboratory in the US, but we have no plan. In some areas, we need some skilled, or smart people. As for standards, we have a UNIX company in the US [OSSI]...I think that they are doing rather independent work, not connected to the Japanese Divisions." [the author's question]

In spite of the complexity, Fujitsu has achieved a significant degree of success in international product development and in the shorter-term research related to this. The three examples described below highlight some of the issues in international organization and product development, and show how Fujitsu has been adapting its organizational structure to accommodate the communication and other challenges associated with internationalization.

### 3.0 Fujitsu Network Switching of America, Inc. and the FETEX-150

### 3.1 Background

"Nynex Taps Fujitsu to Supply Advanced Multimedia Switches" was the headline of an article that received prominence in *The Wall Street Journal* on January 7, 1993. The article continued:

> "Nynex Corp. tapped Fujitsu Ltd. to provide telephone switching systems designed to route full-motion video pictures and mountains of data through the telephone network as easily as today's switches handle ordinary conversations......For years the market

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has been dominated by America Telephone & Telegraph Co. and Canada's Northern Telecom Ltd. But with new demands for high-speed digital switching systems the Japanese manufacturers have found an opening. Later this decade, phone companies are expected to begin retiring today's digital switches and replacing them with ATM equipment."

Similarly, in March, 1992, Fujitsu announced that it would be working with Southwestern Bell to explore new customer uses for advanced broadband telephone switching. Fujitsu Network Switching of America, Inc. ("FNS") was to provide its all-bandwidth FETEX switching system for application trials, as it had also done with US West and Bell South. Fujitsu was a late entrant into the US market for central office switches, after AT&T had been joined in the early 1980's by Northern Telecom, and Siemens towards the end of the decade. It was able to enter the market by offering a technologically superior and more flexible product, which included enabling regional operating companies to buy a switch that had the facility for ATM communication to be handled as well as today's narrowband communication. Its success has been the result of four principal factors:

(i)   first-class basic hardware component technology (e.g. HEMT transistors);

(ii)  tremendous foresight and judgment of senior management in Japan, both in terms of the selection of technology to develop, and in devising a successful market entry strategy for the US market-place;

(iii) the high value-added at all stages of international software technology and product; and,

(iv)  an environment of deregulation, in which the regional operating companies were anxious to reduce their technology and product dependence on AT&T.

A central office switch provides the connections among local telecommunications terminals, typically telephones and computers, so that communications can take place. It might be thought of as a computer with large input/output devices, and extremely complex software. In addition to identifying the calling and called parties, and completing an electrical switch linking them, the basic switching operation involves a number of functions. These include call maintenance, call ending, and billing.

In 1980, AT&T had a market share of some 80% of central office switches, but this has since shrunk to perhaps less than 50%, as first Northern Telecom, and then European and Japanese competitors have begun to make significant inroads into the market. The Europeans are led by Siemens, and the Japanese by Fujitsu and NEC. The principal battle in the US market-place is between Siemens and Fujitsu, the outcome of which will determine who will become the third vendor to the operating companies. It is a battle that Fujitsu may be winning.

Hausman and Kohlberg (1989) have noted that, because of their extremely high development cost, switches have to be developed for international, rather than national, markets. This has led to the decline of an earlier "country champion" industry structure, in which a government-controlled (or -regulated) telecommunications company bought almost all its switches from a closely affiliated domestic supplier, and its replacement with an international market-place dominated by a few global equipment suppliers. Other recent changes noted by Hausman and Kohlberg (1989) were the high costs of R&D, which increased the minimum efficient scale of production, the breakup of AT&T in 1982, and the divestiture of the 22 Bell operating companies into seven regional holding companies. They saw the result as being the emergence of three to five competitive groups made up of international collaborators. Currently, it seems more likely that six large competing suppliers will dominate the industry,

namely Alcatel, AT&T, Fujitsu, NEC, Northern Telecom, and Siemens. Depending on the outcome of the battle in the US market-place, this may reduce to five competing suppliers.

The demand for fast, high capacity data transmission, and a combination of competencies in different technologies among national technology systems, is fueling a rapid rate of technological development in switches. In this, digitalization and high speed, broadband transmission have created the future possibilities for the telephone operating companies to provide complex integrated services encompassing many media, including voice, data, image, text, and video. It is the enhancements necessary to the current infrastructure to provide these services that is creating the current market opportunities. By the late 1990's, it is projected that the US will be served by a multimedia intelligent network, based on the switching technology and the carrying capacity of transmission equipment.

A precondition to the provision of these services is the adoption of standards, of which Asynchronous Transfer Mode ("ATM") is one important standard of broadband transmission. Equally, the network must be capable of carrying the higher data capacities. For the operating companies, equipment that meets today's switching demands will not meet those of tomorrow, and the development of standards and the high rate of technology development mean that considerable flexibility and upgradeability must be provided, if their investment in switches is to be fully recovered over product lifetimes.

## 3.2 Product Development at FNS

It is with this background in mind that Fujitsu developed the FETEX-150 digital switching system as a flexible switching platform for the worldwide market, with a useful life projected well beyond the year 2000. Key to the flexible design is the modularity of the product, with an open-ended architecture that allows new modules, including processors, to be added as circumstances change. Figure 3 shows the principal elements of the FETEX-150 functional subsystem, with an indication of those parts of the product that were developed in the US, and those elements developed in Japan.

INSERT FIGURE 3 ABOUT HERE

Software is a major element in the development of the switch. The responsibility of Fujitsu's US organization in the development of the FETEX-150 is, therefore, very significant. The provision of software is not simply "icing on the cake." Complex multiple layers of protocol software are required both for the switch operator, and at the interface between the processing subsystem and the signal path subsystem, in its narrowband and broadband elements.

Within the US, the software technology and product development work associated with Fujitsu's successful entry into the US market-place is carried out at FNS, located at Raleigh, North Carolina. FNS is directly responsible to, and supported by, the Switching Systems Division of the Telecommunication Network Systems Group of Fujitsu Limited in Japan. In turn, this Division works especially closely with the Communication and Space Division of Fujitsu Laboratories Limited.

In Japan, Fujitsu started R&D in ATM switching technologies in 1986, with the first successful laboratory experimental system developed by 1988. This work was done by Fujitsu Laboratories. At that stage, Fujitsu proposed a new switching architecture known as Multi-Stage Self Routing ("MSSR"). A total system applicable to the future needs of broadband communication was developed, including the switching system, transmission system, and terminal equipment. The total system development was an important point. This experimental system was demonstrated at Supercom 89, in Anaheim, California, and was the first

demonstration of a broadband ATM system in the world. The demonstration had a great impact on the broadband ISDN research field.

What this brief history conceals is the importance of the judgment and decision of the key researchers at Fujitsu in 1986 to work towards the development of ATM equipment. At that time, in 1986, some similar concepts to ATM, known as Asynchronous Time Division ("ATD"), had been proposed by France Telecom's Laboratories. France Telecom's researchers proposed this technology-defined standard to CCITT, the Geneva-based international standards setting body for the telecommunications industry. Fujitsu realized that the standard that emerged would become a very important technology motivation trigger for the future communication network. Two key individuals at Fujitsu took responsibility and decided to start research related to ATM technology, rather than to technologies and standards proposed by other suppliers. It was this decision that has given Fujitsu its current technological lead.

By 1989, Fujitsu Laboratories had joined with the Switching Systems Division of the Telecommunication Network Systems Group to develop a prototype system, which means almost a fully operational commercial system. This step was taken because Fujitsu considered that a practical system was necessary to prove the feasibility of this technology for customers, especially the Bell operating companies. The collaboration of the laboratories with the product group was considered essential to have achieved the rapid transfer of technology to product. It was undoubtedly assisted by the physical presence of both groups in Kawasaki, Japan. Subsequent to the product development, the Division took over the promotion activities and service trials of the commercial system that had been developed for the broadband ISDN market. In persuading potential users to buy into new technology, the development of a practical system and equipment was essential and required high front-end costs.

In addition, from 1986 there was regular contact with potential customers, even at the stage of development of the basic technology. Fujitsu was, for example, meeting at least twice yearly with Bell South in the US. Fujitsu was heavily influenced in the direction of its research and technology development by the customer requirement inputs that it obtained at that early stage, confirming the 1989 findings of Professor Westney in her visit to Fujitsu, on the importance of customer input, even at the earliest stage of technology development.

In 1993, the Laboratories continue to be involved in the field, and are working on the development of very large scale, high definition television broadband switching systems. In relation to the US operation, the view in Japan was that the Laboratory was supporting the Division, and so is working with FNS in the US only indirectly. From the hardware point of view, the main responsibility of the US operation was in customer feedback.

Turning to software development, a major element of the product design and flexible capability, there are a number of other overseas subsidiaries involved in the development of switching software. In addition to the US, there are other subsidiaries in Singapore (FSL), in Hong Kong (FHK), and in China (FFCS). The responsibilities of these companies is very similar. In addition to software, FNS is responsible for sales and marketing, as well as for engineering and R&D. For software, responsibility is for the basic product development as well as for customer support. Figure 4 shows FNS's activity in software both currently, and in the future. The plan is for a move for all software development to be carried out in the US. In this case, reusable software technology transferred to Fujitsu Japan would involve the sale of the locally developed and funded technology.

INSERT FIGURE 4 ABOUT HERE

In terms of the various stages of product development, from product planning through to the customer oriented system test, Figure 5 shows that the product development process

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requires a high degree of cooperative development at various stages. Function sharing is complex, work is overlapped, and multiple hand-offs are required at different stages between Japan and the US. The input of FNS was considered critical at the very commencement of the product design, even though many of the component hardware technologies are standard. Software technology was considered an easier first step to international product development, but it was expected that FNS participation in hardware design would develop.

INSERT FIGURE 5 ABOUT HERE

However, international product development has a trajectory. As it was explained:

"Currently, the US customer requirements are very variable for each product, so the basic software is common, but the final content is quite different. But, I believe that the tendency in the future is for the US specification to be transferred to other countries, so the common parts will increase in the future. I think that FNS must become the center for US [as opposed to a world center] software and, as I explained, the content of the US software should be exported to other countries. That can be done only through Kawasaki. It depends on the business situation, but basically, Kawasaki must control it. That means that, if we do business in countries other than the US, we should have the whole world proprietary rights of that product: the software, hardware, and so on. This means that, even if such software is developed by FNS, we have to buy back from FNS, to have ownership or proprietary rights in Fujitsu, otherwise we cannot do the business with other countries, because that country is expecting Fujitsu to have all the ownership of the product. If some area of a product belonged to FNS, it would be very difficult for us to use. That is why we must have all the rights to use it in Japan.

If FNS develops the software, the proprietary rights to that belong to FNS. And we will buy the right to use that. Singapore and other countries can buy the right to use that from Fujitsu, but not from FNS, because FNS cannot develop the whole of the product, so the main part belongs to Fujitsu, and the additional part of the software will be developed by FNS, with the rights transferred to Fujitsu, otherwise we cannot do the developing of the total system. To transfer the rights, we have some negotiation process. In the future, FNS will do at least the tasks related to the US market.

Currently, if FNS writes a specification or conducts a system test, FNS is funded from the Fujitsu side. As a result, the output, or product, belongs to Fujitsu. But, in the future, FNS will develop itself, by its own funding. Then the product or output is belonging to FNS. At that time, we will buy back from FNS."

The product development experience of Fujitsu across borders had, from the Japan point of view, three critical success factors, namely (i) the communication link; (ii) the development environment; and (iii) management styles.

Communication, for Fujitsu, meant not just voice or TV communication, but also computer interactive communication, assisted by Fujitsu's proprietary system known as "COINS." Telephone conferencing and video conferencing were popular, but the Japanese engineers were not used to communicating in English by e-mail, which Fujitsu was evaluating. The development environment meant sharing the same programming languages, in this case YPS tools and the C language. The same testing environment is also necessary. Management styles were seen as being required to be both locally appropriate, and as needing to have a degree of commonality, or overlap. The driver to common management styles was the

technology - shared development meant, to a significant degree, shared management systems.

In Raleigh, FNS is a stand-alone R&D facility, without a local manufacturing capability. FNS considered that its mission would eventually extend to include the development of products that could be used globally. A primary mission of FNS's R&D was, nevertheless, described as to help in business promotion in the US. This was especially important, as:

> "...the US is the most advanced country in telecommunications. Every other country is following the US technical trend. So once we establish our technology in the US and that technology is accepted by its customers, that technology can be applied in the worldwide business. This is at the leading edge."

The facility was opened in April 1988 and cost several tens of millions of dollars. In 1992, there were more than 200 permanent employees at FNS. Its budget was decided mainly by head office (final approval), and the business plan was revised every half year. Funding came mainly from Tokyo headquarters. Within a couple of years or so, it was anticipated that funding should be more localized and the ultimate goal was to have all local funding. Special projects would continue to be funded by Tokyo, but the view was that basic R&D activities should be fed locally. FNS considered that, since it was better aware than Japan of customer requirements, so it was right that it decided how it used its funds. So, although Tokyo provided all of the funding, the local office had a very strong say on the budget allocation - maybe a 60:40 split in favor of the local office. The budgeting criteria for projects were set in Japan, but the budgeting process, monitoring and evaluation, selection of project team members, and hand-off to production were done locally. In what appeared to be, all in all, quite a localized operation, with significant decentralization of power and responsibility, the funding mechanism was summarized in the following statement:

> "We say first what we need because we know the customer, then Tokyo approves."

There were no scientists at FNS, but the 200 permanent employees included just over 130 engineers involved in R&D, of which only nine were Japanese, and the others were American nationals. There were a few PhD's, but mainly it was a 60:40 split in favor of BS over MS degree employees. Of the balance, there were 20 administrative staff, three or four managers and 40 sales and marketing executives.

In terms of performance criteria, the primary mission of the R&D operation was to understand customer requirements, and to translate those requirements into system specifications in order to correctly drive back-end development teams in Tokyo. Also some significant development work was done locally and the facility had to coordinate its work with Japan and to keep to its time schedule. The primary challenge for the facility was how it could coordinate development plans and resources locally and in Tokyo. In R&D, on-time and quality of work were seen as key.

FNS had no alliances, but in the future it might pursue an alliance with ICL in the UK, which is owned 80% by Fujitsu. It was put that:

> "We have been closely discussing how we might make strategic alliances with them and how we can get a synergy effect with the ICL people. This has been happening from here. The main reasons to enter into the alliance would be to get access to specific technology and skills and to get access to the local market, followed by the desire to influence the nature of industry competition and to improve the capabilities of our people. As you know, Fujitsu has very big product lines, so for the majority of our work we can discuss it with Fujitsu's business units. But in some cases, because

the telecommunications world is changing very rapidly, I think that we need to make some cooperative work with other parties. So there may be much opportunity to make alliances with other parties. For example, we need for our switches to connect to terminals, and so we must discuss compatibility with other companies during the development period."

The technical objectives that were most important in funding the US research facility were to take advantage of the availability of talented technical people, to develop a better capacity to respond to local product market requirements, to gain a highly visible local presence, to participate actively in standards setting within the US in new technologies, and to become a real insider in the local market. The non-technical objectives included the need to match competition from other foreign organizations making foreign R&D investments in the US, and a shortage of research engineers.

As for the current location at Raleigh, it was considered that this location was acceptable. The major reason why Fujitsu had established the facility there had been to facilitate the recruitment of qualified people. It was mentioned that there were a research park, two good universities and competitors locally - including IBM, Northern Telecom and Alcatel - so for human resources/recruitment this was considered to be ideal location initially. Also, the cost of living, including housing, was low. In comparison, Cambridge, MA, was considered to be a good location, but expensive. As for the future:

> "If we started again, today, we may be in a different location, as we have so many different factors to think about. Where are the potential customers, where is a good source of universities, and so on. For example, in two years' time, we could have a different decision, as the situation is changing in some sense. So if we were to make a decision from zero in 1993, or 1995, the decision could be a different one. Our customers are located all over, but we are in serious discussions with US West (in Minnesota, Colorado, Washington and Arizona) and we also have discussions with NYNEX in the New York/Boston area. Actually we have several candidate locations, including Boston. Chicago also would be possible, since AT&T now has a big facility there and some western areas. But we are happy for the time being. If we get a large volume of business with one customer, then we may have a satellite office containing R&D facilities, because we need tighter communication with that customer."

From the perspective of the business trajectory, it was pointed out that FNS's early need had been to hire experienced people, rather than college graduates, as it needed to start up operations very quickly. The current location was clearly very good from this point of view. As the operation grew, it would need younger, less experienced people to expand its capabilities. Put succinctly:

> "At that time, the universities would be considered a good source for new engineers. As the technology matures and we get nearer market, so it is more appropriate to have younger people coming in. The reason for this is in the nature of the telecommunications industry. As you know, the market for telephone switches is growing very quickly, reflecting customers' needs. The customer requires many features, and the US has its own very strict standards in every necessary characteristic of the machine. So we need to adapt our basic machines into the US market-place, and we need to have some authorizations before we actually operate a switch into the network. So we need people who know American requirements and who have experience in the US telephone industry. They know what is needed and what adaptations we should make in such and such time-frame. The experienced people establish some channels and links, and figuring out the necessary organizations here. Then, once we have established our foundations, we need

additional younger engineers, for example, to actually develop some software. We need young blood to do software development. So, the average age will fall as we develop. The younger people will actually carry out the development. So now we have one software group here, containing younger engineers, who are doing that software development work."

Siemens Stromberg was one important benchmark for the facility. As was mentioned above, Siemens was also breaking into the US market from Europe, by a similar process. Its R&D facility was in Boca Raton in Florida. It had bigger local facilities than FNS, a longer history than FNS and was having some success. But it was believed to have had identical difficulties and constraints as it had proceeded to build its capability in the US market. As for other Japanese companies:

"Also NEC and we are all Japanese, so we share some commonalities in behavior and way of thinking. So NEC always gives us a mirror image of ourselves. NEC is also watching how Fujitsu behaves. We are different companies, but both are giants in the Japanese market, and so we follow each other closely."

The major disadvantage of being remote from a home country that was based in a distant location, across a continent and the Pacific Ocean, was that the R&D process suffered relative to domestic, home country competitors on account of the greater communication difficulties. In particular, decisions took longer. Other than this, there were no other serious disadvantages seen in being Japanese in the US, notwithstanding the fact that at the time of the interview in the US, FNS considered that it needed to be very careful because of the general sensitivity in the area of Japan/US relations.

There had been no particular difficulties in establishing the facility in the US, and FNS and its engineers were members of various bodies, including IEEE, and ACM. It also enjoyed the benefit of US Government sponsored R&D from the current location - some very important projects were going on under government support. FNS planned to increase its R&D investment locally within a year or so.

In terms of the relative quality of the US versus the Japanese environment, Japan was considered to be better from the point of view of salaries, in that it used money more efficiently and the intensity and dedication of effort in R&D was stronger there. A relative weakness of US engineers, that was found at all R&D centers visited, was well described by the following observation:

"As you might be aware, Japanese engineers are more generic - more universal. American engineers like to have their own areas - 'this is my area' - 'I am professional in this'. In R&D, for hardware, Japan is more efficient. For software, the US has its own advantage, which is very obvious. But we need more initial investment to start up. The American engineer tends to have a very established work environment with very specific tools. Then he can make some innovative ideas."

Returning to the issue of the breadth of skills and thinking of the US engineers, and the consequences of this for productivity, the difficulties were expanded upon, as follows:

"We need a more versatile type of people; more universal types. Right now, we have some difficulty in getting the right people with the right skill set. It is easy for us to get people who have a specialty in this area, but it is much harder for us to get people who can have very wide views. We need people who have one major area but who also can pay attention to some related departments. If he/she sees some potential future areas for improvement in the product, or some problem areas, then we need

people who can see ahead (e.g. production problems). That type of person is very difficult to get.

In Japan, in contrast, most people are trained through their corporate career, so I think it is easier for engineers there to understand the whole corporate structure. It is tougher in the US to get that sense. For example, it is easier for us to get developers who are experienced in this software, but tougher for us to get people who have experience in some portion of software, but who also can pay attention to all other areas, such as hardware, documentation, quality control and the marketing interface. "*This* is my major area - so on price I don't care and the factory learning I don't care." Sometimes it is hard to harmonize everything. It is the fault of companies, since it is companies' behaviors, training programs, expectations and cultures that have the greatest influence. So I think that American companies are happier than Japanese companies to have such narrow-viewed people. In Japanese companies, they expect the people to have wider views, so that there may be overlapping strategies, and software people think about hardware, and hardware people think a little about the software. That type of overlapping is what I mean."

With regard to recruitment, FNS used human resources firms and employee referrals; it encouraged people to make recommendations. It was hiring experienced people and was just beginning to expand its human resources unit to establish very good relationships with several major universities, so as to be able to smoothly recruit some younger engineers. The human resources department had just begun the necessary activities to develop good relationships with universities.

It was noted that Japanese parent owned American companies needed to be better able to control the proportion of Japanese assignees they received in the US. FNS wanted to limit the Japanese to less than 10%. Should it strive to be an American, a Japanese or a hybrid company?

"So basically we should show that this is an American company and that it is Americans that are doing R&D. But, at the same time, we need some key people for the know-how and knowledge transfer from the Tokyo side, because all basic research was done once in Tokyo and Tokyo has many people who know every corner of the system. We need these key people to make a bridge, but it should not be too many. So we should carefully pick the people from Tokyo to smoothly give the know-how and conduct the technology transfer."

And of the problems of managing what is effectively a bi-cultural organization:

"The American and Japanese management styles are quite different, and so one of the toughest things is to know how to reach a happy medium between pure American and pure Japanese styles. And also still we should keep the American people motivated. That type of cultural balance is very hard."

For technical training, FNS had periodic meetings with Tokyo to deal with development problems, product line management and such matters. It also had training courses for new employees - generic, very basic courses describing a switch, and on the structure and progress of the development between Japan and the US. For some specific areas, such as call processing software, switch software, or hardware, FNS made use of several courses in Japan. It dispatched key engineers to Japan to participate in courses for periods lasting between two weeks and two months. Several "casual" courses were always going on in Japan, so it dispatched engineers there. It also received many engineers from Tokyo on a business travel basis - for two weeks or so. They would come and have very intensive

discussions on a specific subject. They would reach consensus in the US and go back to Tokyo to advise their own people "as one." Also, FNS had several cultural courses for all employees (Japanese cultural lectures, etc.). There were no specific rotation schemes between the US facility and Japan, but FNS took every opportunity to have face-to-face discussions with Japan. Because of the specializations in the US, each engineer had the chance to visit with his counterpart in Japan. These meetings were not formally scheduled, but there were many opportunities to go back and forth.

For performance measurement, FNS had annual reviews. It set targets and objectives, and then reviewed the performance of individuals against the target. The reward systems between Japanese and US engineers were different, but it was trying to make them as similar as it could. However, since the basic nature of the two systems was so different, it was considered difficult to achieve this. For career ladders, FNS had a path through to line management so scientists and engineers would start of in R&D, but gradually get more management skills and step up into line management. However, there were limitations with this system:

> "I think that right now we need to set up a parallel path for the product developers - something such as senior staff, as not all developers have management skills. So we need to create senior technologists, senior advisory staff or something similar."

In terms of internal communication within the R&D function, it was a loose organization, with no rules of who talks to whom. On a day-to-day basis, engineers at FNS communicated with working-level people elsewhere. All communication overseas, such as to Europe, was still via Tokyo. However, once some channels had been set up, then they could be used for international communication - with Singapore, for example. The most effective types of communication were considered to have been meetings, cross-posting of personnel, and short-term visits. In general it was thought that FNS had kept very good communication with Tokyo, but sometimes it had a problem of information flow (speed) or information thoroughness - sometimes the information became too fragmented - "just broken into little bits and pieces" - especially for some product line changes. Sometimes the information was not organized, not systemized. FNS sometimes needed to reorganize the bits and pieces into one package. In a macro view, the flow was very good, but from a snapshot, the flow was not constant. Part of the problem was put down to language problems.

For external linkages, customers, professional societies and consultants were the main links. FNS did not have especially strong links with universities. It used, not just business consultants, but also technical consultants who were very good in a specific area, such as traffic studies. FNS had some links with universities, such as for research projects. In some specific areas it had some direct communication with Fujitsu Laboratories, but mainly the path was through headquarters.

Critically, the main issue for FNS, in its R&D activities, was of how to find an optimal balance between the Japanese style and the American style, and of how to show itself in front of the customer. The conflict was between having a Japanese company as the parent, but being a local, American company, also located in a particular region within the US What face to show to the outside world, to suppliers, customers and potential employees?

> "We need to show an American presence to customers. We need a balance. Right now, Tokyo's R&D is much bigger than here so we need to rely on them a great deal, but we must show to customers how we can manage our internal organization, and to show our local presence. We need to make some good balance. We must become more Americanized, so we need to take over some R&D parts from Tokyo. This is not achieved overnight.

Being an insider in two systems - Japan and the US - I admit it is very difficult for almost all Japanese who have assignments here. But I don't think that I have a problem in getting involved in either the decision-making process here, or on the Tokyo side. I think that American business is most crucial right now, so I believe that Fujitsu is putting up more and more power in the American business. Our voice is getting more and more crucial, and also I have been working very hard to let them know what is going on in the market-place, and in actual R&D at the front-end. I think that I have communicated well with Fujitsu Tokyo. Fujitsu is listening to my voice, so actually I don't feel out of place with Tokyo. Within a couple of years, I shall have to make a decision as to whether to put more effort on the Tokyo, or on the US side. If we achieve our goals here, Tokyo will appreciate this. Our work here is with leading edge technology, and so that gives us an advantage. Also, we are talking to new customers, and American customers are ahead of NTT, so Fujitsu itself needs some input from the American front-end. American customers are more demanding - I believe that they have the strongest and most advanced requirements in the world. So we need to meet that requirement to reinforce our strength to cope with the world-wide market. If everything should happen in the US first, we should stay in that market at the front end, to listen to that customer's voice, to see where the technology trends are going. So the US is a very important place for all Fujitsu companies I think."

### 3.3 FNS: Concluding Observations

Some of the experiences of FNS were common to other companies interviewed in Japan involved in cross-border R&D between Japan and the US With specific regard to FNS, the following aspects were of interest:

(i)     Successful joint, cross-border product development is essential to the successful penetration of overseas markets in telecommunication products, such as central office switches, where the product is an open system, where its constituent technologies are rapidly developing, where customers are highly sophisticated, and where there is a heavy software component. As one estimate, probably 20% of the hardware and 80% of the software in switches has to be specifically developed and tailored to suit local market conditions. This is partly due to the more exacting user requirements of US consumers. From this perspective, complete centralization of R&D in Japan is not an option in high technology industries, because of the additional needs to work closely with lead users (Von Hippel, 1986), as well as to be perceived as having an American identity. That standards in telecommunications are being set outside Japan, in the US and Europe, is also a factor driving research, as well as technology and product development, offshore.

(ii)    In the case of the FETEX-150, the product could not have been developed in either Japan or the US alone. Fujitsu was able to combine the strengths of its entire network, including Fujitsu Laboratories, the Divisions in Japan, and FNS, to produce a unique product, a product that none of its competitors had been able to offer. It also used a continual flow of ideas, or innovations, that came from different parts of its global organizational network.

(iii)   As for technology transfer, as may reasonably be concluded from the FETEX-150 project, unraveling the direction of flows in joint product development is almost impossible. Those who bandy about aggregated data on technology flows might well consider how to break down the quantity of technology flows between Japan and the US in the case of the FETEX-150. At the level of the inter-organizational network, reality is more complex.

Such an evaluation would have to take into account the transfer to the US of the advanced hardware, and the element of the base software developed in Japan. It is also possible that some of the software developed in the US might be transferred to Japan. Of this software, some lines of code might be used at some point in the future in Japan, or Singapore, or elsewhere. Also to be measured would be the free flow of ideas and suggestions between Japan and the US over the years during which development of the FETEX-150 has taken place. Moreover, should this component technological aggregation take into account the contributions and guidance of the users? For they have been important in guiding the direction and pace of technological development.

It would then be necessary to assess the value of the technology transfer to the US in terms of the ability of the base code supplied from Japan to encourage the development of additional applications in the US. For, the supply to the US of leading edge technology will undoubtedly improve the overall level of development of the industry, as well as the technology of the applications. Maybe multimedia communication will arrive months or years earlier, because of the technology development and transfer. The technology transfer statistics aggregators will have to be sure to take this into account, in addition to code counting "by country."

The point is that the FETEX-150 is a case of a Japanese company simultaneously developing in two locations, for introduction into the US market-place, technology of a sophistication that does not even exist in its home country. For those who suggest that successful technology and product development depends on a strong "home base," with selective "technology tapping," the FETEX-150 should need to be treated as an exceptional case if the theory is to hold. Not only does the joint development of the FETEX-150 not fit this model, but if Fujitsu had adopted the home base model, it would have been most unlikely to have achieved its current degree of success. From customer contact, to the development of the product prototype, the US operation has been a major contributor to the process.

(iv)     There seems to be a high degree of local influence with regard to the amount and allocation of the budget. This is different to the finding of Bartlett and Ghoshal (1989) in their study of Matsushita, and in their characterization of Japanese coordination processes as "coordination through centralization." In the development of the FETEX-150, there has been, and continues to be, a significant degree of local control in the US, on which Japan increasingly relies for guidance in the development of the total product. Partly, this is because Japan recognizes the contribution to the total product being made by FNS, beyond local product market adaptation, but it also reflects a degree of decentralization of power quite different to the stereotypical model of the Japanese organization as occasionally depicted in the international business literature.

(v)     The location trade-off was between being near an adequate labor supply or near lead users. The labor requirements were also changing - as FNS became more established it would need additional younger engineers. In the early stages, developing a labor pool of experienced engineers had been of paramount importance. However, in the years ahead, FNS might relocate, or restructure its operations, so as to be nearer its lead customers. As the technology matures and younger, less experienced engineers are needed, so there will be less of a need for FNS to be near its competitors.

(vi)     Benchmarking covered both market penetration and technical aspects, and was not confined to Japanese companies. In fact, in the case of FNS, the major benchmark was a German company. Moreover, in this case, the major battle in the market-place was between a Japanese and a German company. It is most unlikely that the domestic supplier would have developed switching technology at the same rate without the

opening up of the market-place to foreign competitors. This will undoubtedly contribute to the planned development in the US of a sophisticated information highway infrastructure, ahead of both Europe and Japan.

(vii)    The strengths of the US in software engineering, and of Japan in hardware engineering, were confirmed, and complementary. However, the responsibilities for each were not defined exclusively on geographic criteria.

(viii)   One of the key management challenges was of how to cope with the tendency of US engineers to specialize, and not to think more broadly about manufacturability, quality, marketing and other activities. For FNS, the ideal engineer should have one strong field, but there were difficulties in that the managers had to cope with managing the development process as a whole. This was at a more detailed level than would be found in a Japanese product development center, where Japanese engineers might more easily be relied upon to take account of broader issues in the development process.

(ix)     There were difficulties in combining the management and human resource systems of Japanese and American companies, and in deciding which face to show to the outside world, especially to customers and suppliers. The local preference was to show an American face, whereas arguably the strength of FNS was from its hybrid nature, containing the strengths of both systems.

(x)      The development of the FETEX-150 switch showed the importance of the linkages and synergies between the three core technologies of Fujitsu (computers, telecommunications, and electronic devices) quite clearly. From one perspective, a switch might be thought of as little more than a particular kind of computer, with a large input-output module. It uses electronic devices in its hardware, and switching transmission software. There was a clear technology and product synergy with other parts of Fujitsu's operations in the US, although most direct communication was to Japan in the first instance. No significant local communication network had been developed within the US, even though other companies, such as are responsible for the transmission business, produce products that clearly relate. It is to one of these that this paper now turns.

## 4.0 Fujitsu Network Transmission Systems, Inc. and the FLM 150 and FLM 6 Multiplexers

### 4.1 Background

The business of Fujitsu Network Transmission Systems, Inc. ("FNTS") is concerned with advanced network technology, including the development, manufacture and support of high performance transport and access systems. These are based on multiple emerging industry standards. These standards ensure that the digital loop carrier systems, digital multiplexers and fiber optic transport systems that FNTS produces can be integrated into new and existing networks. FNTS is a wholly owned subsidiary of Fujitsu America, Inc., and is one of the three main Fujitsu subsidiaries involved in communications in the US.

The R&D group for transmission systems started in the US seven and a half years' ago. Initially, two Japanese staff came from Japan to San Jose and hired US employees. The group gradually grew so, that there were, by 1992, some 120 engineers, of which 41 were in R&D as a supported function, and of which only three were non-degreed. Approximately 30% had Masters degrees with the rest having Bachelors degrees. In 1992, FNTS was setting up a new systems group, in which it was planning to employ PhD qualified engineers, in what was an extension of its commitment to build a R&D capability in the US The probable head of the

new group was to have a PhD. In addition, there were 11 people supporting the R&D engineers. In the whole plant, there were about 800 people, including the 52 in "R&D" as a designated function.

Of the 120 engineers at FNTS, 70 were working for local support and 50 on product development. The work of the 50 was mainly in software and product planning for the domestic (US) and technology-compatible international markets. The software group was still located in San Jose, where there were about 40 software engineers. The remaining 80 had moved to the current location, alongside the sales, marketing and manufacturing groups.

It was the view of a senior Japanese managers at the facility that there were two methods of establishing an R&D group in overseas countries. One type of approach was to acquire another company. This was seen as the "easy way." The other approach was to start from the beginning. In this scenario, Japanese managers come to the US, interview candidates, and hire good engineers. In this way, an R&D group grows more gradually. This type of approach results in a cross-cultural R&D group. As at FNTS, Fujitsu then has to try to mix the American and Japanese styles of management. The result is always a kind of culture friction, or "cultural collision".

In FNTS's history, it started as a research and planning group. This group surveyed the market and technical situation in the US, and prepared a product plan and customer specification - a very rough specification. This was then sent to Japan for detailed design. Many other Japanese companies started their R&D from this function in this way, because they could gather the necessary marketing and technological information for the US market-place only within the US.

Subsequently, as it moved to product development, FNTS focused on software, because software, in the view of FNTS, should be based on local culture, especially given its position at the human:machine interface. Moreover, it was recognized that US software technology was ahead of that of Japan, so Fujitsu could also study advanced software technology in the US.

The next step was hardware design. There were many hardware technology factors. In many cases, Japan was ahead of the US in hardware, especially in fiber optical transmission systems, where Fujitsu has an excellent bank of basic technology in Japan. However, it could not be assembled without other ancillary equipment. FNTS needed key components and many other peripheral circuits, so it decided to bring key technologies from Japan. Other equipment would be purchased locally, or designed locally and manufactured in the US Also, FNTS tried to establish a cross-cultural design environment for design standards and drawing systems. In Japan, Fujitsu had established design standards, and so it had to translate many Japanese drawing standards from Japanese to English. Local employees reviewed these and modified the documents. A long time to was required to establish an ideal design environment in the US, and this was still being developed.

One advantage of the US location was that FNTS could gather customer requirement information. Based on that information, it could custom design products for the American consumers. But its core technology in devices could be used in different markets, by many customers. In the US, Fujitsu was proud of its key technology which was developed in Japan, especially in Fujitsu Laboratories. One view was:

"We need a lot of money to develop such key technology, for example in conductors, laser diode - several hundred million dollars is needed to develop ever such a small chip. So we want to use such key components for many applications."

FNTS's R&D unit had two missions. One was to support the transmission system business in the US market. Another mission was to develop products for the US market, but which could also be exported to countries compatible with the US standards and level of technological development in transmission equipment, such as Hong Kong, Korea, and Taiwan. FNTS in fact sold locally manufactured products into Japan, Australia and elsewhere in the Far East. International sales were, however, coordinated from Japan - FNTS itself did not have a sales force operating outside the US. To support the US business in transmission systems, FNTS decided on issues of product development locally. However, for international products, FNTS relied on a close communication with Fujitsu Japan.

The American head of R&D considered that the domestic market-place in the US was opening up and leading in certain telecommunication areas to do with CCITT standards. The types of communication interfaces that FNTS was developing were expected to rapidly move to Europe. Japan had, in contrast, a slightly different architecture and system, and so it might be only the third region to move to the evolving international standard for transmission equipment.

There were four principal reasons why FNTS had chosen to recently locate to its current location, at Richardson, near Dallas, Texas. Most important was the fact that MCI, a particularly important customer, had asked FNTS to move to Richardson, because it also had a plan to move to the same area. As planned, two years ago, MCI built a big facility near to FNTS. A second reason was that there were already many other telecommunication companies in the area, which was known as "Telecom Corridor". This meant that it would be relatively easy to hire good telecom engineers. Third, the local area had a reputation for good workers, both in R&D and in manufacturing, where labor costs were also lower than elsewhere. Finally, land prices were lower than alternative locations, especially Silicon Valley.

Two years previously, a local Japanese manager had proposed to Fujitsu headquarters' top management that the transmission system R&D unit should be divided into three locations: on the East coast, the West coast, and with the headquarters of the R&D group being located in Dallas; the software group would have continued to be located in San Jose, California. The feeling was that FNTS should have a research group on the East coast, because there were many research universities and laboratories there, including Bell Laboratories and Bell Communication Laboratories, and it would also be near many leading universities. The proposal was, in essence, to expand and relocate the research function to the East Coast.

FNTS communicates with Fujitsu in Japan every day by telephone, its most important communication medium. Fujitsu made use of its own dedicated line, known as Corporate Information System ("COINS"). This network was used for both voice communication and fax. TV conferencing and electronic mail were also available on this network. For internal communication, the American manager explained that:

> "We report to Fujitsu America - the holding company of which we are a wholly-owned subsidiary. Especially in engineering and manufacturing, we have very strong dotted line ties back to our counterparts in Japan. In marketing and product management the ties are not so strong - it is mainly for a domestic type of environment. In FNTS, we have a very direct solid line back to Kawasaki and Oyama. In Japan, this business comes together under Mr. Sugioka, and Mr. Fujisaki runs this part of telecommunications. So it has its way back into a hierarchy of a business unit, but in a different way than you would in a US company."

Communication between cultures was not easy. From a management point of view, the Japanese management style was considered to be very flexible. On technical matters, Japanese managers were more able to communicate with any person, whereas, in the US,

each engineer or staff typically had only one designated, particular superior to whom he/she wanted to report. But, in Japan, communication could take place between any related persons. Engineers tended to share information, so:

"When we call Japan, initially we try to reach a certain person, but if he is not in we change to another person, and we can communicate because these two shared the same college, but in the US, management is difficult."

FNTS held weekly meetings, in which all department heads participated. Each engineer communicated with Kawasaki engineers on a daily basis and management meetings were held twice a year. Management communicated by telephone each day, and they met at least twice a year, either in Texas or in Kawasaki. Whereas the marketing and sales group had close contact with Fujitsu's US headquarters, the R&D group didn't need contact with corporate headquarters. Manufacturing communicated with Kawasaki and with the Oyama factory; Oyama was Fujitsu's large factory for the manufacture of transmission equipment in Japan. The design group had a weekly meeting with manufacturing and the planning group maintained close contact with marketing and sales. While the hardware design group had close contact with manufacturing and planning:

"One problem is with R&D in our group. We had intended to increase local staff but in manufacturing they have still many Japanese staff. American staff have difficulty in communicating with the Japanese staff in manufacturing. Almost all the managers in the manufacturing group are still Japanese. Almost all R&D managers are American. That is our current problem. It is both language and different styles of working. The manufacturing group has a good American director who came from the Oyama factory last week. He stayed at Oyama for two and a half years. He was a professor at Carnegie Mellon University. He will be useful for those communications."

The American manager talked about FNTS' business. Switching, he explained, was mainly circuit switches. In essence they were the office switch resident in either a local office or a long distance office. These were developed by FNS in Raleigh in conjunction with Fujitsu in Japan. When a signal departs, it goes over transmission equipment and that is the piece of equipment that FNTS makes. It is the piece of equipment that takes the primary tributary and transports it some distance. In the US, it could go all the way across the country, it could go downtown to a different exchange and so on. Switches can either be for Class 1 to Class 5 centers.

The American manager explained a little more of Fujitsu's philosophy at FNTS:

"This is our strong point and I think it is our most difficult point. Fujitsu does not do international business, we do global business. We are not a company that happens to do international sales - we are truly a global company in nature. When you have a global company, you deal with a lot of different issues, and the parent:child (or subsidiary) issue becomes a little different than if you were dealing with something that was within a completely homogeneous environment. We deal with a lot of things managerially speaking - we try to blend a lot of things here. We have taken things that are strong in Japan and strong here and have tried to put them together to give ourselves a competitive advantage in the market-place. In doing that, you begin to deal with a lot of cultural differences. Fujitsu is not trying to transplant a Japanese company into the US or into Europe.

In my view, the US senior manager is not as knowledgeable as the Japanese or some European managers, because they have never had to deal with truly cultural differences. I am lucky working with [my particular Japanese manager], as he lets me

run the business, but he is always there to discuss things plus [another Japanese] is our window to Japan. We have what we call "windows," and by the discussion between the three of us I learn an awful lot about how the Japanese do business and then when I make my trips back to Japan, I have also been very fortunate in that I have been with Japanese only."

Talking of the engineering culture in the facility:

"Everyone here is an engineer - all our executives came from laboratories - it is quite a bit different to a US company. The previous "window", who became ill and so had to return to Japan, was a development engineer and he was one of the senior engineers in Japan. We had a little different relationship, because both of us came from the bench let's say - we had a history and a lot of mutual understanding and experiences. [His replacement] is more of a systems type of engineer, and so consequently the role that [he] plays is that he looks at budgeting, at how to communicate to Japan, at misunderstandings, whereas [his predecessor] would work a little differently. [The new man] does a very good job in translating and consequently he does a lot of that type of interpretation. [My number two] reports directly to me and he is invaluable - especially on our shared development projects with Kawasaki. We have wholly owned projects and shared projects. [He] is invaluable in shared projects."

The budgeting process in the R&D supported function was a little different from that of the rest of the plant. The American manager wrote the five year plan and gained consensus for it in the US and in Japan. Budgets were essentially half-way compromises between a five year plan and market conditions. More specifically:

"My budget is in two halves. I have certain accounts that are funded totally out of the US, and that is a profit center structure. That is negotiations with our manufacturing side, because manufacturing funds R&D here. I also have funding from Japan. That funding is run on a P&L basis and that funding is a negotiation directly with Japan and that is done with me through [my window]. On the Japan side, and for tax purposes, I am required to make a profit, and so consequently on services that I provide, there is a gross margin on those services. The income statement is a true P&L, whereas on the US side it is a cost center, which is more typical of a what you would have on the income statement of a company. Finally, there is customer funding and that is through sales obviously. I think that within the next three years we will be funded almost totally out of the US. The only thing with Japan will be that if we do shared developments, then we will fund each side of the development on our own."

The American manager spoke of the division of management responsibilities across the plant:

"In any Japanese company, there are two areas that are almost sacrosanct and that is engineering and manufacturing. I am the only engineering vice president here. Steve Miller just came back from a two year stay in Japan, where he learned manufacturing from the Japanese. He was a professor at Carnegie Mellon. He will be a director in manufacturing. Now, there is a manufacturing vice president - a very smart individual named Don Blackwood. Now, he is mainly in charge of production control but Tanaka-san is in charge of manufacturing. What is interesting is that this is Mr. Tanaka's first assignment in manufacturing. He was an engineer prior to this in development systems, and Mr. Tanaka had trained under Mr. Kawakami for over a year for preparation for his assignment. These are the two areas that contain Japanese and American management and we work very closely together. There is no figurehead here - it is Japanese and US managers truly working together. I had

previously worked for Rockwell International and had a close relationship for many years with Japanese companies. I have seen the other half of that equation."

The most important performance criterion was the additional new products in the portfolio, and how they are applied to domestic sales and then to global sales. Finally, FNTS used patents as a performance/productivity measure, and had to cope with the situation where it was passing knowledge back before a patent had been filed.

As for strategic alliances, FNTS had outside alliances with suppliers and suppliers/competitors. Previously, at Rockwell, the US manager had set up strategic alliances with some very large companies. When he came to FNTS, the individuals at those companies knew that he had moved and so they contacted him to renew the relationships that had existed before. The motivation at FNTS for the local alliances was clearly explained:

> "FNTS needed certain technologies here that we did not have necessarily access to, plus the other very key thing is local content. This is a "5+", OK. Local content is a significant issue in our Company. To get the content of the parts in our products raised significantly percentage-wise. I had relationships at specific very large companies in the US that we could sit down with and talk about that problem, plus they wanted sales and they had specific technologies too that we needed access to. We also had technologies that they needed access to, but in our case the number one issue was local content - trying to get the American content up in the products. That is a real key reason why we build these alliances. As of today, many of our parts come out of Japan still."

As for the reason why FNTS still had a low local content:

> "Some people misinterpret why. It is not so much that we are supporting the Japanese economy, but there is a difference in the parts - I mean a fairly significant difference in many cases - and we are very, very reluctant to put a part in a product that could significantly affect our reputation on quality and then, from my point of view, that could significantly affect my ability to go forward and develop new products and cost down products, simply because I have people in the field repairing problems, or I have people redesigning constantly to get away from problems. And so, consequently, we are very, very careful about parts we use.

> Some people say that we go significantly overboard on qualifying parts - and we are very judicious about our analysis of a part before we put it in a product. It is very exacting. A lot of our vendors can get very frustrated. By the same token, you have vendors, like Motorola, that very clearly understand why we do what we do. And we look for value in a product. We look very hard. In many cases, we do not use the cheapest product. We will use the most cost-effective. We look at yields. We would like to make sure that when the product goes in our system, we never have to rework things in manufacturing, we don't have big drop-outs. But by the same token, we are diligently pursuing local vendors, and I think that we have made a tremendous amount of progress in developing relationships and, in a number of cases, now we are at the qualification stage. We are actually going in, using teams from here, using teams from Japan, and working with qualifying vendors, making recommendations on their processes and preparing to use American built parts. On some of our products, believe it or not, they are almost 100% US-built. On others, there may be 5-10%, but I think that sometimes in the newspapers and the media, they misinterpret how long it takes even in Japan to get a part qualified."

In terms of benchmarking, the American manager interviewee believed that, in 1995, there would be just three dominant suppliers in the transmission market-place. He thought that FNTS was going to be one of them. The others would be American and Japanese (AT&T and NEC, respectively). FNTS looked very closely at what its competitors do, and how they do it, especially as far as technological relationships go. To this end, it was setting up more formalized benchmarking processes.

FNTS looked at its business thrust from an R&D standpoint, at how its products were evolving, and at what type of management schemes were used. There was also a surprising degree of trading information in the R&D function among what were obviously fierce competitors:

> "Also, I have very, very close friends in all those companies. We don't give away trade secrets by any stretch of the imagination, but we also very clearly understand what is going on, and I was a national committee chairman for about six years and so...You never change trade secrets, but those relationships are such that you very closely watch as to what is going on. In other words, you are sitting there saying 'I see the market-place going this way' - 'we are going to use a bi-directional line switch range'....'Well...we were looking at that but...'..'we think that the path switch might be.......' And it is these types of things. Actually. in AT&T, because I do have so many relationships in there, we are actually doing some fairly good technology discussions, but it is with one of the SBU's that is not our competitive SBU. And I think, too, that as business begins to globalize, you are seeing more of a softening of those relationships where everybody realizes that we may need all of us in here in order to pull this off. I think that you are seeing that, as US companies get more global in their thinking, the Japanese companies are beginning to be global in nature. There is a softening in their thinking - it is not the Iacocca mentality that is beginning to drive business. I think you are seeing more of a global relationship about maybe what is good for one is good for all. I think that we are moving away from the concept of running guy A out of business, but maybe it is a good idea for guy A and guy B to be in business and grow."

Concerning external relationships with universities, if FNTS was seen as a Japanese company with Japanese managers, then the American manager considered that there could be a problem with some university relationships. With industry committees, being Japanese was not an issue. The only issue that he could think of was the effect on alliances of the present political atmosphere. In alliances, especially with an entirely domestic company, the thoroughness - what the partner perceives as the slowness - with which a Japanese company moves could be a big frustration. Yet, this was due to Japanese companies trying not to make a mistake.

Great care was taken by FNTS in recruitment, especially given that both Japanese and American systems were in place:

> "Right now, I will tell you how we recruit. We recruit by people we know. We are very, very particular about people we interview and we want to feel like when we interview somebody, that they are on the short list already. Almost everybody in here has been brought in by somebody else. Since I have been here, we have had very little open recruitment. The reason why is that I am very, very cautious about who I bring in simply because I want them to be technically strong but I also want them to have the personality that will work well in our Company. In doing that, I have to blend the Japanese and the American aspects. It would virtually be a disaster if I brought a manager in here who was a real rear-end kicker - a screamer, cursor, kicker and an abuser. Technical skills are important - most of our people here have some form of

reputation in the industry, but we also look for that other piece of the puzzle because we realize too that Japanese companies really don't like conflict. They feel like conflict drains energy that could be used somewhere else and so consequently, we look for people who are very strong technically, but who are very team-oriented - that are able to work with other people and that are able to allow other people to contribute and that don't seem to have turf positions. That is what I always tell people: if you have a turf and you guard that turf, you don't need to be at least in Fujitsu, because we invite people to run all over our turf to help us figure out what the problem is so that we can get it behind us and move forward. So, we look at the other half of the equation every bit as hard and, in some cases, we may look at that harder."

FNTS had cross-cultural programs. It sent people back and forth to Japan, although mainly the traffic was from Japan. There were assignees from Japan and, every once in a while (constrained mainly by budget), FNTS would send someone to Japan. It was explained that FNTS was a new Company that was only given more autonomy in the October 1991 reorganization of Fujitsu's US interests. At the time of the interview, in 1992, it was only beginning to put in place a lot of its policies, procedures and training programs. Regarding language, the top management view was that a senior manager (vice president) needed to go on a program of learning Japanese. The Japanese executives and assignees all spoke English - many of them were very close to being fluent - and it was considered important that, on certain occasions, American researchers and product developers could understand Japanese. Other than that, being aware of the cultural differences and of the organization of the company were seen as being important. However, conversational language needs only really arose at the higher levels of management. To facilitate communication, rotations were used within departments and R&D generally, but not with Japan.

Performance appraisals were carried out according to the standard EEOC-type system, because the facility was still governed under the laws of the US for this purpose. The performance appraisal systems and human resource systems were in direct line with the US Government's policies and procedures. In Fujitsu, compensation plans and other aspects were aligned with local practice. The Japanese assignees' performance appraisals were, however, done under the Japanese method and they were handled out of Japan. This could cause problems, and one of the senior Japanese managers was trying to work out what could be done to try to evaluate the Japanese assignees in the US, avoiding conflict between the two systems.

Career ladders were described as being similar to other companies. There were technical levels and then, moving up in the Company, there was some seniority, as employees gained knowledge. There was a basic management ladder structure, but it was a very flat management structure, which was different to Japan - this was mentioned as a fundamental difference.

On a day-to-day basis, blending the two cultures was held to be the most difficult issue in the R&D function. Three particular examples of this were given. First:

"If Japan has a problem employee, they will keep directing, directing, they will actually move him probably - they will just keep going. In the US, it is more of a reprimand - requiring him to perform in the area that he is in and, if he doesn't, then we will demote him or do something like that. It is more of a harsh punitive action, whereas the Japanese will keep directing the individual to change his behavior, and maybe move him numerous times, trying to find a more compatible situation. This, I think, is maybe the one area that I think that we need to work on the hardest. With employee issues, Japan handles them one way, and the US handles them in an entirely

different way. This difference can cause a problem between the Japanese and the US management."

The second type of problem arose from differences in the Japanese management style, whereby it was not unusual for Japanese managers in one area to go in and to make comments on the work being done in another area. In one particular case when this had happened, the American manager had become resentful, and FNTS had had a real problem.

In the third situation, some Japanese employees were being paid overtime in accordance with their usual terms of employment (this is a usual practice for R&D engineers in Japan). One day, three American researchers came to see the American head of R&D to say that they thought that that was a little unfair, since they were all actually working overtime, but the Americans were not being paid for it. The head of R&D invited them in and explained that he would be happy to consider paying them overtime, but they would also have to agree to various other changes to their contracts, including: a lower base salary, reduced pension entitlements, a seniority system, whereby their salaries would only rise by a fixed amount each year, and a promotion system in which they would have a one-off chance at moving from being an engineer to becoming a manager, at the age of 35. If they failed in that, then they would have to agree to remain with the company as engineers with no real promotion for the rest of their lives [note: this is perhaps an overstatement of the rigidity of the career system based on interviews in Japan].

In the same meeting, the American researchers also expressed concern that the Japanese engineers appeared to sleep at their desks during the day. This was handled by explaining that, whereas American researchers rush home at 5.30 pm or so each day, and maintain a fine distinction between home and work, the distinction between home and work for Japanese is less clear. It was considered true that Japanese may often sleep for a while in the day, but it was suggested that the Americans might also have noticed that the Japanese were usually still in the laboratories until after the Americans had left each day.

## 4.2 Research at FNTS

At FNTS, "research" and "development" exist side by side, but have very different functions. Research activities are focused on participation in various standards committees, and in the incorporation of emerging standards for telecommunications network management. Product development at FNTS, and in transmission equipment globally, is heavily driven by these emerging standards. The structure of standards making bodies, and of the standards themselves, is complex. However, to give an idea of the importance of this to the transmission equipment business, a brief summary of some of the elements is given below.

For network management internationally, the key standards committees are those within the Geneva-based CCITT Study Group IV on the Telecommunications Management Network ("TMN"), within CCITT Study Group XV on the management of the synchronous digital hierarchy ("SDH"), and within CCITT Study Groups XI and XVII on ISDN management. In the US, the American National Standards Institute ("ANSI"), a voluntary US organization, has accredited Committee T1, the first telecommunications committee, which is sponsored by the Exchange Carriers Standards Association ("ECSA"). Inside Committee T1, there are a number of technical subcommittees, each of which is responsible for developing standards on a particular topic in telecommunications. They are Committees T1A1, T1E1, T1M1, T1P1, T1S1, and T1X1. For network management, the important Sub-committees are T1M1 and T1X1. The former is responsible for all the maintenance standards - the operations support systems ("OSSs") and protocols, and message development for generic network elements. The Director of Transport Product Planning at FNTS is Chairman of Sub-committee T1X1, which is responsible for network to network and synchronization interfaces. FNTS is a voting

member of the T1 Committee, and is supported by Fujitsu in Kawasaki in its contribution on this Committee. Fujitsu Laboratories provides much of the information needed as input to the T1 Committee. In turn, this comes back as a Bellcore standard, finally as an ANSI standard, and then this represents the US telecommunication standards.

The emerging telecommunications networking standard in the US, comprising a multitude of component standards, is known as Synchronous Optical Network ("SONET"). It is being developed and implemented in three stages, of which Phase I standards have been published, and Phase I compatible products developed. Some Phase II standards, dealing with the operations, administration, maintenance, and provisioning ("OAM&P") portion of SONET, have also been produced, and the industry is currently waiting on the production of so-called Phase III standards, dealing with the interfaces between the OSSs and network elements, and between network elements.

Standards in telecommunications networking vary internationally. There are, for example, differences in the digital hierarchy, and the way networks are organized, among European and most Pacific rim countries, as well as with the US. The US, Canada, Singapore, Korea, and Taiwan, use what is known as the North American Hierarchy. The rest of the world uses what is called the Stepped Hierarchy. Some changes were made to SONET when it got to CCITT, so as to make it easier to accommodate the Stepped Hierarchy. SONET was developed specifically for the US, although its structure was modified somewhat at the CCITT so as to accommodate other signals. The US decided that, in an effort to keep a worldwide standard, it would change its SONET specification to match Europe's Synchronous Digital Hierarchy ("SDH"). Historically, the US had tended to go its own way, because it was powerful, but in the past three or four years, it had tended to be more international and flexible. Japan, in contrast, had tended to follow the European standards, so the more isolationist position of the US had posed a problem for Japanese manufacturers, given the relatively favorable business opportunities in the US.

The change in the US position on standards - the move to a greater acceptance of international standards - had an important potential implication for the internationalization of product development. It meant that, for the first time, it would be possible to develop a base product in the US, and then to carry out only slight modifications for it to be suitable for the European market-place. Just as important, it was now possible to share the costs of LSI development, and the development of a number of basic functions, such as optical modules, among products to suit a worldwide market-place. This has been a key advantage for companies, such as Fujitsu, which have been able to develop products for each major global market, as the basic product functionality could now be developed for an international market-place. However, this would not imply a greater tendency to centralization of transmission equipment product development in Japan, as:

> "Even though we may have very common technologies that we may develop, there is no reason why it has to be centralized, or placed in one part of the world. Now, you can look at a global development effort and determine which portion, or which development team, is ready, and has the manpower and the expertise to implement a particular function."

One factor in favor of the US becoming more of a likely center for global product development, however, was that European markets were regarded as effectively closed to foreign companies, even to companies from elsewhere in Europe. France, especially, was seen as almost totally closed in transmission equipment, the Germans tended to rely heavily on Siemens, the Swedes on Ericsson, and so on. The UK had been the first European country to open up, which is why Fujitsu set up a standards research center in London. Fujitsu also acquired the majority stake in a former subsidiary company of British Telecom, known as

Fulcrum, to assist in building its transmission business in Europe. The standards information fed back from Richardson and London are reflected into global product design specifications for core components. Fujitsu had a similar group to its research group at FNTS at its 1991-established telecommunications research center in London.

Currently, all major manufacturers are building equipment to SDH or SONET standards. In the US, FNTS's customers were very clear on the fact that they would not deploy fiber optic transmission systems, unless the SONET standard was implemented. Therefore, it has been important for Fujitsu and its competitors to develop transmission equipment to these standards. In addition, given the emerging standards, upgradeability of products sold has been a key advantage in persuading customers to accept SONET products based on Phase I and Phase II standards. This has influenced the product development process, and has been an important factor in motivating foreign companies such as Fujitsu to build up activities such as product development in the US, so as to provide sufficient commitment for customers to believe that it will be around to implement the upgrades.

As for technology research, Fujitsu in Japan was clear that, over the next five to ten years, its overseas research centers would become more application oriented, so that they could define product by themselves, conduct manufacturing locally, and "do everything like a miniature Fujitsu Limited." However, they would not be expected to fund or carry out basic research, such as in semiconductors or neuro technologies. This would remain the global responsibility of Japan. Fujitsu expected however, that in the area of applied research, a network of offshore specialized centers would develop. It was, from this perspective, perfectly possible that the US could supply the necessary research to Japan for product development.

In transmission equipment, Fujitsu's early business success in the US was in part due to the needs of MCI, following the opening up of competition in the long distance carrier market. Initially, in 1984/5, MCI had not followed European or US standards for fiber transmission equipment, and so Fujitsu was able to supply a standard specification export model to MCI. Gradually, however, MCI had moved to the US standard of equipment, as urgency of need (AT&T would not supply it) was replaced by a wish to be served by a larger number of suppliers, for price and compatibility reasons.

This move, by its early customer, did not have a major impact on FNTS which, in any event, had to begin work on products that would meet US standards if it was to become a supplier to the regional Bell operating companies. So, Fujitsu decided to move from an export strategy to local development, for which a US location was important. It is to product development at FNTS that this paper now turns.

## 4.3 Product Development at FNTS

Product development at FNTS is either vendor-, or customer-driven. In either case, the first stage is requirement capture, based on specific customer requirements, or from market or standardization trends, including T1 Committee trends, Bellcore requirements, customer requirements, and some competitive situations. The sales groups gather information, which is analyzed by a product planning group. The product planning group then prepares a product specification, based on market trends and a business plan. The product specification is prepared by the FNTS product planning group.

The product plans are then taken to Fujitsu in Japan for discussion. There, a decision is made to develop a product by a certain time frame, at a certain cost, for sale at a projected price. In FNTS, sometimes one planner handles one product; sometimes two or three planners. The product planning group has other international responsibilities, such as for Europe. Development then moves through system design, equipment design (hardware, software),

detailed design (unit design, LSI design, physical design), and on to trial production, either in Japan or the US.

The three stages of testing are the hardware test, the system test (ST2 test), and the initial qualification test for the system as a whole. The initial qualification test ("IQT") is done from the viewpoint of the customer. This IQT includes a temperature test; temperature variation, and power variation. A conformance test is then conducted by the customer, to verify the equipment functions and the system, followed by the first office application (test on site). These tests are usually conducted in Japan.

For second and subsequent shipments, and depending upon the scheduling or customer requirements, various stages are combined or omitted. Thus, for example, trial production may be omitted, with a move direct to mass production, and the hardware test may be going on as a routine. The IQT may also be skipped, but sometime later, if there is a customer design change, the IQTs will be rechecked: a requalification test. This then completes the product development life cycle for SONET and transmission products.

One of the products that Fujitsu manufactured at Richardson is the Fiber Lightwave Multiplexer 150 (the "FLM 150"). Multiplexing is a scheme by which transmission media are divided into many communication channels in order to transmit several signals. By multiplexing many signals onto one transmission medium, a much higher percentage of the medium's capacity is utilized, allowing more users to be served. Frequency Division Multiplexing ("FDM") divides a single transmission medium into a number of smaller frequency channels for simultaneous, separate transmission, whereas Time Division Multiplexing ("TDM") allows signals to be sent at different times. Multiplexers are the devices for doing each of the techniques of multiplexing.

The FLM 150 was designed to deliver communicated signals throughout campuses, or office towers, whereas its smaller relation, the FLM 6, is a lower capacity multiplexer designed to provide services to smaller premise environments, such as to single office floors, serving a smaller number of terminals. Several FLM 6's may link in to the FLM 150. For example, a 14-story office building might have 14 FLM 6 multiplexers (one serving each floor), accessed by a single FLM 150 for the entire building. There may be more than 14 FLM 6 multiplexers on a campus or in an office building, accessed by additional FLM 150s.

The FLM 150 product planning was carried out in the US, it was designed in Japan, and then production moved to the US. There were four main reasons for moving production of the FLM 150 from Oyama (some 80 km. north of Tokyo) to the US. First, FNTS was required to manufacture locally by MCI and the Bell operating companies (MCI, in particular, was highly conscious about the risks to its reputation in Washington of importing transmission products). Some 50%-80% of other customers also required local manufacturing. Second, Fujitsu wanted to develop its business in the US, and the most convenient way to do this was by local manufacturing, especially local design. "Convenience" for Fujitsu meant providing good service to customers. The third reason was that, as its business was increasing, Fujitsu was forced to produce ever increasing quantities of products. The Oyama factory sometimes simply ran out of production capacity. So, the Oyama factory wanted to share its production line, with part in Japan, and part in Richardson. Finally, and more recently, one of the main drivers encouraging decentralized manufacturing for Japanese companies has been the much higher value of the Japanese ¥ relative to the $. As the ¥ has appreciated in value, it has become more expensive to import product and supplies from Japan to the US, and more difficult to make a satisfactory return to US operations. This was a significant factor for FNTS from the manufacturing point of view, but was also influencing product development planning.

The second product, the FLM 6 (which means a 6 Megabit system) was designed in the US, is manufactured in the US, and the product is fully supported in the US. The basic structure of the product is similar to the FLM 150, but it is a lower capacity SONET multiplexer. To achieve this, a design group was established at FNTS in Richardson, where much of the design work was done by top flight US engineers. Also, some design engineers came from Japan, although FNTS planned the product development process in Richardson. The main reason for this was that the product, designed to serve small local areas within large buildings, had to be very local in design. Fujitsu had developed an equivalent product in Japan, but one that ran at a different speed. It was explained that:

> "The FLM 6 is similar to the FLM 150 in principle. It used some of the knowledge from the FLM 150, but it is a different idea; a small, different shape, and different mechanical size. Not such a large size. This kind of product will sit in the equipment rooms of the Bell operating companies, or MCI, or some enterprise, such as a bank, department store, or industrial park. So, the equipment design requires that more of the customers' real intention should be reflected. It is being produced and sold. This is the first time for the telecommunication/transmission area, not for peripheral equipment. With the development of the FLM 6, we have learned how important is harmony and balance. Because the FLM 6 is part of our total network system, so it should be the best. Interface condition to FLM 150 needs harmony. Also, the equipment architecture philosophy should be the same or similar to the FLM 150, because this is one part of the family of the total equipment group. So, if we supply a different philosophy product, the customer would be very confused. In the FLM 6 development and design team at Richardson, there were several electrical engineers, component engineers, and mechanical engineers. So, for some people it was a full-time job, for others part-time. There was also other equipment in cabinets - accommodation for the equipment for the local field site was also designed in Richardson.

> There are many lessons learned from this. One view, from the engineers in Kawasaki, was: "Oh, it is already done by the US. The next product, also you can do that..." They accepted what the US had done. Now, one of the cabinets designed for the US market is already exported from the US to an Arabic country - the UAE. That particular cabinet protects the equipment against a hostile environment, such as a very high temperature, a very low humidity, or very dry air."

In 1993, Fujitsu had committed to build what, in essence, would be the next generation of transport systems in a new multiplexer system. In designing the organizational structure for this, including the division of particular responsibilities in cross-border product development, there were a number of influential factors:

(i)  The balance between software and hardware. The multiplexer is one of a number of product areas in which both software and hardware are major contributing technologies. In Japan, it is generally accepted that software state of the art is still found in the US, but that hardware is a local (Japanese) strength. This becomes an important issue in internationalization, because of (i) the different strengths of national technology systems in each area; and, (ii) the overlap of hardware and software in terms of functionality, with certain functional needs being satisfied by either hardware or software.

Given that the FLM family is being designed as a family of multiplexers, resulting in compatibility needs in the development process, coupled with a high degree of software reusability and codevelopment, Fujitsu has had to decide where to develop a software *capability* to span a family of products. The US had been selected for this responsibility

and FNTS was, in 1993, in the process of establishing major software development and systems planning organizations.

The main strengths of Japanese engineering were considered to be in hardware, specifically in LSI design. For a major new product that FNTS was embarking on, LSI design was still to be carried out in Japan, but the process was expected to bring a great deal of expertise to the US (technology transfer *from Japan to the US*). The mechanism for achieving this was for Fujitsu to send people to Japan, and to have them work there for a while. Moreover, the *location* of the development itself would affect the product architecture. As it was explained:

> "The product itself really isn't being internationalized, but what is internationalized is the development itself. And where it will have an impact is that because.......the LSI technology within Fujitsu in Japan is well ahead of most companies in the US, that will affect architectures. But that will affect it in a positive way, because you can do certain things that, if you did it here, you would not be able to do.

> The same would be true the other way. When software is developed in Japan, there is definitely a tendency to do more in hardware - things that in the US would have been a software function, in Japan it becomes a hardware function, because the strength is so much in hardware, and not in software. And so, because of local strengths and weaknesses, you will see differences in the hardware and software trade-offs, and because of that you will see sometimes subtle, sometimes not so subtle, differences in architecture, and ultimately differences in product features. So, what we are really trying to do is to make sure that this is based on the strength that Japan has and the strength that we have, and I think that all that it really does is.....it would be the same if the strength in Japan would be resident in the US - I think that you would make exactly the same trade offs - so I don't think that it is so much the internationalization that makes a big difference in this particular instance. It is just that within the two different communities you have different strengths, and you can take advantage of those."

One other factor in the hardware/software balance is the move away from hardware to software, which is occurring for a number of factors. Two of the reasons for this are the fact that software is theoretically non-recurring engineering - the product is theoretically zero cost once the product has been developed (ignoring obvious factors such as amortization of development costs and the high cost of software in terms of memory requirements - especially in telecommunications in which substantial memory back ups are required), and the relative ease of upgradeability.

(ii) Compatibility between development systems was an important factor, complicated by the fact that, within Fujitsu, there were a lot of proprietary, home built systems. For a variety of reasons, FNTS preferred not to use those systems, including the fact that some of them were getting a little old. FNTS was, therefore, selecting its own development systems, but liaising with Fujitsu in Japan to make sure that they retained an acceptable degree of compatibility. Full compatibility was seen as desirable, but not that important.

Software development issues included ensuring that the same operating systems (almost entirely UNIX- and C-based) were used in the systems being developed, to minimize porting difficulties. Porting difficulties were seen as unavoidable in international product development; it was a matter of simply accepting that, once development work was transferred, there would always be some minor adjustments that would have to be made, but that these would be resolvable without too much difficulty.

(iii) For actual transmission, it was pointed out that, for the transference of enormous files, public telecommunication lines were too slow, to the point that it was easier send disks or tapes by mail or courier.

(iv) Overall product development responsibility was with FNTS. The extent to which the product development process was entirely carried out in Richardson partly depended on the manufacturing capability. The local Richardson manufacturing operation was trying to emulate Oyama, and the faster it achieved its goal, the more that product development activities could be entirely local.

Certainly, it had been agreed that marketing, conceptual, and architectural design phases would be carried out in Richardson. Designing product architecture and structure had, it was considered, to be done in one location. Thereafter, as the product development process became modularized, or partitioned, with the software/hardware trade offs having been made, specific tasks, such as LSI development, would be designated for Japan. At this stage, the product development process became one of more-or-less implementation to meet certain minimum defined requirements. FNTS envisaged that modules would be developed in Japan, and others in the US, but that:

"...the developments never really straddle the ocean There are certain tasks that are done here and certain tasks that are done there, but not tasks that are done in both places. And you can do that if you can get through the system definition phase first, which is really the only thing, until you get to the end of the development, that you need to do system-wide. So, once you break it up into little pieces, and then you make sure that whatever piece you have designed is entirely here, or entirely in Japan, then you can manage it. Then it all has to come back together again of course, when you start doing integration, and again that integration will all be here [in Richardson]. So, all the different pieces, all the different hardware pieces - it is most likely that there will not be much software - so all the hardware pieces will come here, they will be integrated with the software here, and then the system testing, validation, and all that will be done here."

(v) One other "country advantage" of the US in the development of telecommunications equipment resulted from a change in the development process itself. Ten years ago, products were developed in very small teams, and were much smaller. In contrast, transmission products in 1993 typically required a total headcount of around 100 people, divided between hardware and software. Whereas, ten years ago, a dozen or so product developers in Japan could meet, and reach consensus, teams of 100 or so now found this a very different challenge, and agreement was difficult. In contrast, it was explained that even a dozen or so American engineers meeting would have been a problem for US engineers a decade ago, so from the beginning, the Americans have relied much more on process-driven product development. A disciplined process was necessary to manage and control the greater individualistic tendencies in American product development. For Japanese engineers, on the other hand, the larger-sized projects are imposing new challenges in the need to set up effective product development management systems, challenges which the American system came to terms with a decade or so ago. This is an additional factor driving the internationalization of product development in transmission equipment.

## 4.4 FNTS: Concluding Observations

As with FNS, many of the experiences of FNTS were common to other companies interviewed. In particular, the following aspects were of considered to be especially important:

(i) A clear distinction between two possible strategies for offshore R&D was drawn: buying an existing company or starting a new group from nothing. The latter results in cross-cultural friction, whereas the other does not deal with it so much as avoid it - not a solution from the perspective of a transnational company.

(ii) The importance of the bank of excellent technology in Japan and the difficulties of transferring it were clear. To meet standards abroad, not just technologies have to be adapted in different ways, but all working drawings - which themselves have standards - have to be translated.

(iii) The importance of the high cost of developing new technologies, and the need to use them in as many products as possible to recoup the development costs was stressed. This is an argument in favor of centralization of the 'R' of the R&D function at least, especially given the need of products to combine different leading technologies. The management practice of having one part of a core technology in, say, Switzerland, another in Sweden and so on clearly is not appropriate for companies structured around the notion of core competencies and technologies. It was certainly observed that Fujitsu made much more use of its lead in technologies such as LSI design because of the centrality of the research effort. This also led to incorporation of technologies in a wider range of applications.

(iv) Again, the need to be near customers (MCI) and an adequate pool of experienced engineers was highlighted. The third location issue, of cost, often came up in subsequent interviews in discussions of the high costs of being in Silicon Valley.

(v) The greater flexibility of Japanese engineers, both in adapting to other parts of the function and in having more fluid reporting structures, was a typical finding.

(vi) The facility placed a high level of importance on cross-functional communication. The strong Japanese control of manufacturing, and the American control of R&D, had presented some problems for FNTS by way of somewhat less than ideal communication.

(vii) The importance of the US in the pattern of emerging global standards gave the facility its global role.

(viii) The importance, not just of an engineering culture, but what type of engineer you might be was clearly a contributing factor in the ability of people to communicate closely and to work together. The American R&D manager seemed to portray his "window" to Japan as more of a translator than as a more significant contributor to meaningful dialogue, compared to the previous "window," with whom he had a common engineering background.

(ix) Local content was an important driver of the internationalization of the product development process, and in the formation of strategic alliances. Moreover, the ability of the R&D unit at FNTS to participate, with competitors, in the subtle trading of information might be an important contributor to future industry structure.

(x) The importance of not recruiting culturally insensitive people was an issue in the hiring process - the usual technical depth and team work criteria were necessary, but not sufficient, to work at FNTS. For the very senior managers, a relevant second-language ability was seen as essential.

(xi)     Three day-to-day examples of work practices differences between American and Japanese engineers illustrated the importance of special management skills in the handling these types of situations. Moreover, the fact that they existed at all, partly due to the newness of the autonomy of the facility, was an argument in favor of more training programs on cross-cultural issues.

(xii)    Finally, FNTS's success in the US was, at least in part, due to country-specific internal organizational factors. Fujitsu was not the first to begin developing SONET products in the US, but was the first to come to the market with an acceptable product, incorporating a significant number of features. There were two reasons for this.

         First, it was observed that, relative to American, French, or German competitors, if there was a problem, everyone in Fujitsu pulled together to solve the problem. There was no discussion on who had caused the problem or on attributing blame; instead energy was spent fixing it. The second factor that contributed to a fast cycle time was a result of the development process, and involved the trade-off between continual product modification and time to market. As it was explained:

> "...the quickest way to get something developed is to decide what it is you are going to develop, and then just don't let anything deviate you. The telecommunication business has been very chaotic since the breakup of AT&T, and it is very hard to make it through an entire development cycle without changing your mind a lot. And there are certainly a lot of influences from the different customers that will tell you that what you are doing is a little different than what they would like. So, in some ways, it is very tempting to change course a little bit. And the problem with most other companies, whether they are European or American, is that what they have done is this: continuously try to inject what they thought their customer needed. Now, that sounds really good, but the problem is that when you keep doing that a lot, you never finish what you are doing. In reality what the customers wanted wasn't that clear in the first place, because they had nothing to base it on, because everything was so different than it was before. So, what ultimately happened was that Fujitsu came out with the products first, and that became what the customers wanted, because that is what the customers got and it had a lot of features. And so we set that leadership, and everybody started following Fujitsu, because that now became the standard for the market. But once you are behind in any business, I think that it is almost impossible to catch up, because every time that someone makes what we just made, we add more features again.
>
> To some extent, Fujitsu bulldozed through customer requirements beyond a point, without worrying too much......and I don't want to say regardless of what customers said, because obviously that wasn't the case at all. But certainly, without worrying about what every different customer said at different times of the year. And certainly, it still happens that every six months, the industry thinks that something else needs to be done, because it is still evolving, and a lot of companies have just tried to follow all these changes in the industry. And because of it, things that should have taken 18 months to develop took three and a half to four years."

(xiii)   There was an evidence of a cycle of internationalization of the product development process in Fujitsu's transmission business. In Japan, the business was divided between a domestic and an overseas development group. The overseas development group in Japan was relatively large, but as the business momentum in the US developed, there was an indication that the responsibility for product development for the US market was

being substantially relocated from the home base to Richardson, where the growth of the R&D group had lagged the growth in local business. Local profitability also enabled more local resources to be dedicated to development work. The overseas group in Japan, at this time, was shifting its efforts to building a capability in Europe, leaving the US to take the lead in the organization of product development to meet future local needs. There appeared to be every willingness to transfer technology from Japan to the US, and a strong home country desire to build a global capability in the development of transmission products, based on product development in local markets. This would, however, need local manufacture and a capable local labor force. This was not a home country model.

## 5.0 Intellistor: 2½" Disk Drive and Embedded Controller for 5¼" Disk Drive

### 5.1 Background

Intellistor, Inc. is a Longmont (Colorado), wholly-owned subsidiary company of Fujitsu Computer Products of America, Inc. ("FCPA"), which is in turn a subsidiary company of Fujitsu America, Inc. Intellistor was established in 1983, began working with Fujitsu in 1985, and was acquired by Fujitsu Limited in 1987. A description of the history of Intellistor is contained in Voisey (1992). Figure 6 shows the relationships with the Fujitsu Divisions in Japan, with which Intellistor works most closely. Intellistor is a Colorado based company with a staff of some 180 persons.

<p align="center">INSERT FIGURE 6 ABOUT HERE</p>

Intellistor is a leading developer of disk drives, and in technologies related to this product area. In Japan, two groups work with Intellistor. From within the Information Processing Devices Group, Intellistor works with the File System Division; product development work here has been on larger, 5¼" disks. In the Compact Peripherals Group, Intellistor works with one of its two divisions, the Disk Division, especially on compact disk drive development, such as for inclusion within notebook computers.

The market for small, rigid disk drives is the most highly volatile of the three product markets described in this paper, and is the most dynamic market with which we are familiar. It is an industry dominated by smaller companies, fierce competition, and fast changing technology. Gone is the dominance of a few large international multinational companies, such as is the case in the central office switching or the transmission equipment industries. Christensen (1993), for example, found that of 130 firms that entered the rigid disk drive industry between 1956 and 1990, 103 subsequently failed, and six others disappeared through acquisition or absorption by competitors. In the same period, seven different firms held the largest market share at some point, and between 1962 and 1990, six waves of "architectural" change (using the Henderson and Clark, 1990 definition) swept through the industry.

Briefly, the evolution of the disk drive business has been one of downsizing of the basic (core) "Winchester" disk drive, of reductions in part counts, and of redesign in the way components interacted within the architecture (Christensen, 1993). As the size of the drives has reduced, at the same time new technology and engineering have enabled disk storage capacity to increase. For example, when the 2½" disk drive was introduced in 1989/90, it had a storage capacity of 20 Mb to 40 Mb. In September, 1991, Fujitsu/Intellistor began to market a then market-highest capacity 90 Mb 2½" disk drive, but by September 1992, Fujitsu/Intellistor had committed to the development of a 250 Mb 2½" hard disk drive. By January 1993, Fujitsu announced the successful development by Intellistor of a 240 Mb 2½" disk drive, slightly less than target. Provided the move to manufacturing could be made rapidly, forecast sales of this product were one million units in the first year, at a price of ¥160,000 ($1,500) per disk, for a

total forecast first year's sales revenue of $1.5 billion. Equally, the size of disk drives has reduced to 1.8", or even 1.3", with a probable storage capacity of 40 Mb. In February 1993, for example, Fujitsu announced the marketing of a pen-entry PC containing a 40 Mb 1.8" removable hard disk drive measuring 54 mm x 85.6 mm x 10.5 mm, and weighing 90 grams. The most popular capacity disk drives are currently around 200 Mb.

The key elements of the design of a multiple platter disk, such as the 2½" disk, are shown in Figure 7. Its emerging industry standard measurements are 70 mm x 100 mm x 17 mm, and Fujitsu's 1991-released 90 Mb version weighed 175 grams.

INSERT FIGURE 7 ABOUT HERE

While there are various types of magnetic disk, the basic design of all disk drives comprises media, heads, a head actuator, and a spindle motor, all contained in a housing. The disk itself is mounted in a disk drive, which consists of the arm, the shaft that rotates the disk, and the electronics needed for the input and output of binary data. The platters have a magnetic coating. For small disk drives, an "ATA controller" is also assembled; in small disk drives, the disk controller is also embedded in the disk unit. In disk sizes of 5¼" or less, almost all controllers are embedded - the trend is towards controllers on larger disk drives being embedded.

At the end of the header are heads for reading and writing data from the disk medium; data is written magnetically. The hardware, or firmware, for controlling these mechanisms can go anywhere outside the housing. The host interface is also outside the medium. The heads come out towards the spindle motor from the head actuator, and a rotary actuator is used.

Unlike the central office switching or transmission equipment businesses, where the open nature of the systems has led to issues of compatibility, and the development of formal standards, standards in the rigid disk drive industry tend to be defined by industry practice, especially OEM requirements. As one example of this, for aluminum platters, it is accepted that the minimum fly height of the heads above the disk should be five microinches ($\mu$ in). Less than this, and it is considered that there is an unacceptable chance of head disk problems. One of the major issues in a technology shift to the use of glass platters has been that the surface of the special, chemically-treated glass is flatter than aluminum, so the fly heights have been reduced to four $\mu$ in. There has been much discussion in the industry of the wisdom of this reduction in fly height, as the new technology means that this previous industry norm has been violated. As the technology changes, to consider, for example, ceramic platters, these debates can be expected to continue. They are not, however, debates that are conducted through the formal procedures of accredited committees, but battles fought in the market-place.

Smaller, rigid disk drives are an "enabling technology." As software programs have increased in memory space requirements, and as the market for computer portability has grown, so the need for smaller-sized, lighter, higher-capacity disks has increased. Market success is, perhaps, most critically about speed, that is, speed to market. The first vendor to develop *and manufacture* a smaller, higher storage capacity disk, can expect to achieve very high short-term sales volume and profitability, until competitors enter the market. In the small disk drive market-place, the industry leaders include Seagate Technology, Conner Peripherals, Maxtor Corporation, and Quantum, all US based companies. The requisite engineering skills in the rigid disk drive industry are in miniaturization and hardware engineering. In view of this, it may seem surprising that the "country advantage" of the small rigid disk drive industry is with the US, but it must be remembered that it is in the US where the PC industry has grown most rapidly.

## 5.2 Product Development at Intellistor

In all cases of joint, cross-border product development in the rigid disk drive business, success was considered by Fujitsu to be directly related to the quality and quantity of communication. There was a recognized need for almost constant communication between Japan and the US to ensure compatibility of the elements of products being developed in different locations. Intellistor has had major responsibility for the development of file controllers (embedded SCSI controllers) and 2½" disk drives, as well as for customization. Fujitsu, in Japan, has been responsible for the development of file controllers, and disk drives/magnetic tape units, and for the manufacture of file subsystems, disk drives, and LSIs. Even in cases in which Intellistor has sole responsibility for the development process, it will still use components produced by Fujitsu, and the developed product has ultimately to be handed off to Fujitsu for volume manufacture.

In joint development work between Intellistor in the US and Fujitsu in Japan, the following six main methods of communication were used:

Project review meetings (four times a year) and budget meetings (twice yearly)
Video conference system
Microcode transferring, via the UNIX network
Document transferring, via the UNIX network
E-mailing, via the UNIX network
3-Dimensional CAD/CAM

Fujitsu Japan and Intellistor usually share responsibility for developing file products. Intellistor is responsible for developing file controllers, especially SCSI controllers and 2½" disk drives. These technologies are subsequently incorporated into Fujitsu products that are manufactured and sold internationally. Some years prior to this, Intellistor had developed a controller more-or-less independently, although Fujitsu had the rights over the product, as it had funded the development work.

The historical trajectory, however, has been one of a move towards joint development with Fujitsu in Japan, especially for smaller-sized file products, such as SCSI products. At Fujitsu's request, Intellistor also develops file controllers for large-scale computers, as well as larger-sized disk drives. The products developed by Intellistor are transferred to Fujitsu in Japan for manufacturing. While Fujitsu has a manufacturing facility at Hillsboro, in Oregon, which does some product development work for Intellistor, manufacturing is carried out at Yamagata in Japan. In the event that Intellistor uses Fujitsu components, such as semiconductors, it makes direct contact with Fujitsu Microelectronics in the US, but all other communication in the product development process is usually with Fujitsu Japan direct.

One of the major hurdles to overcome in joint, international product development, has been the adoption of a common CAD/CAM system. In this case, however, the use of a 3-D system by Intellistor has encouraged Fujitsu Japan to move from a 2-D to a 3-D system. It is now likely that both companies will move towards the adoption of a new 3-D CAD/CAM system - driven by the Intellistor relationship. As an engineer in Fujitsu Japan explained:

> "In the case of microcode transfer and E-mail, they are two-way communication. Now Intellistor is transferring documents by the UNIX network. In this case, it is just one way communication. For transferring actual design knowledge, or designing work smoothly, we have decided to use the same CAD/CAM system. Honestly speaking, the system that we (Fujitsu) are now using is two-dimensional. But, one of our departments has been in charge of investigating, or researching, the 3-D CAD/CAM system for some years. They talked to Intellistor's people, and both agreed to use the

same system. In an earlier time, Intellistor had a different system - a skeleton system. The popular system in Fujitsu right now is a 2-D system. But, from the beginning Intellistor has used a 3-D system. When we talked to them about how to transfer knowledge or information developed at Intellistor, we realized that it was very important to use the same system. As we knew we should start to use a 3-D system, we talked to each other, and then we agreed to use the same system. The system that was used by Intellistor in an earlier time was a different one, but right now, I think that Intellistor has two different types of 3-D CAD. But, for development work related to Fujitsu products, they are basically using the system we agreed upon. Fujitsu hasn't decided to change the system. Now, I think that some people are promoting to use the 3-D CAD/CAM system for many reasons, especially for CAM, in which a 3-D system is much better than a 2-D system. So, in the case of a 3-D system, that system can also generate some manufacturing information, so automatic manufacturing is also possible in the case of a 3-D system. The popular system right now in Fujitsu is 2-D, but in the future when we use the 3-D, Fujitsu has already decided which system we should use. It is different to Intellistor's."

Design information is still, however, transferred by floppy disk, not online, as at FNTS. The main system in Intellistor is a different one; data from design is stored on floppy disks, or magnetic tape, and then sent to Japan for reading and translation. It is not interactive.

While the US leads in the development of storage products such as small rigid disk drives, another important reason for Fujitsu moving product development away from its home base in Japan relates to the need to be near customers, to gauge precise requirements. Why cannot Fujitsu simply develop products in Japan that meet international standards and customer requirements? Other than the need to gauge accurately customer requirements, there another important issue relates to the definition of a "standard," and what the definition implies:

"For example, in the case of the SCSI interface, we sometimes face the problem with customer. For that, I should tell you my experience. Around four or five years ago, I was in Germany. I stayed there for more than three years. At that time, I was responsible for taking care of some customers in Germany for storage products. And what I faced was that the customer sometimes complained that our product didn't meet the standard. However, the fact was that Fujitsu *did* meet the ANSI standard. However, even if a standard exists, the standard may say: 'this is vendor unique' like that. Then, in a most exciting market, there are so many discussions between customers and manufacturers, so that different standards existed. They said 'industrial standards,' but I am not familiar...[So, when ANSI said this is a matter between the vendor and the customer, there began to be a standard there, and unless we were in Germany, there, developing you would not understand that?] In Germany, I was responsible for supporting the business product, and when I talked to some customer, they were complaining that our product didn't meet the ANSI standard for SCSI, for example. But it did. Of course, as soon as I was informed, I contacted the engineer in Japan. He knows that standard very well, and he is very famous in this area in Japan. He carefully checked the standard and we found that there was no discrepancy between the standard and our product. However, when a standard says: 'this is vendor unique,' there was no *definite* description, then some problem was created. For overcoming such problem, having a facility in the USA is much, much better. We can benefit then from such fine tuning. That is the reason why we are sharing the responsibility for development like this.

The 2½" disk drives are developed only by Intellistor within the Fujitsu Group. They are being developed by Intellistor for worldwide products, and the same is true for file controllers. If a customer in the US needs a customized product, Fujitsu and Intellistor

specify either customization or new development, depending on the magnitude of the change required. Of course, now we have some special products requested by US customers. But, even in that case, we are supplying the basic engine to them. Right now, it is very difficult to have a complete product by one party. That is the reason why we have divided the responsibility for development shown here. It would be difficult to do it all in Japan."

These two developments - the 2½" disk drive and the file controllers - were developed in parallel, because different divisions in Intellistor were responsible for the two products. Initially, the Compact Peripherals Group in Japan had asked Intellistor to develop a 2½" disk drive with an embedded SCSI controller. Intellistor subsequently moved on to develop the embedded controllers for the 5¼" disk drives, the host interface controller, and the part of the magnetic tape controller which is positioned between the MTC and the host. The controller is positioned between the host and the drive. Recently, the controller and the drive part have tended to be combined on smaller size disk drives, making development in two or more locations impracticable.

Intellistor did not consider that technology transfer to Japan was significant, or important, for two reasons. First, technology in the industry was evolving so fast, that what was new today would be obsolete, or built on, typically within a few months. Second, there was so much technology leakage from public sources, such as published papers, that Intellistor did not consider that it would fall behind technologically, even if a competitor had some good ideas. Since Intellistor was developing the product entirely itself, there was no technology transfer from Japan to the US in this instance, unlike the situations at FNS and FNTS. Fujitsu in Japan, however, recognized that special technology came from Intellistor, but this was not considered to provide it with a sustainable advantage for the given reasons.

The reason why Fujitsu had asked Intellistor to develop the 2½" disk drive was simply that Japanese companies generally have lagged those in the US in the development of this type of disk drive. This was a very different situation than for other cases, such as 3½" or 5¼" disk drives. The main reason for this is that Fujitsu, for example, while a world leader in larger sized computers, has not developed a significant market presence in smaller desktop or notebook computers, for which the 2½" disk drive has been an important enabling technology. Moreover, the speed of technological change was so fast in this industry, that reverse engineering and imitation strategies would have provided not particular advantage. Put simply:

"Today, you have got to be in the forefront of technology because it is going too fast, and so you have got to be an original thinker when you are doing some of this stuff."

This was the view also in Japan:

"However, with this 2½", as you already summarized, we have many disadvantages to do, and we thought enabling/realizing this type of disk drive in the US might be better. And also, as we have experienced that there were many difficulties for communicating with customers in the area of SCSI, which I explained last time, we thought there might be advantage for [an] American company to get such requirements and information, because they are located near customers. Because the US is the most exciting market in this area."

In the relationship between Fujitsu in Japan, and with Intellistor, two issues posed special challenges. They result from the history of the relationship between the two companies, one of an acquisition of Intellistor by Fujitsu, and from the distance between product development and manufacturing. They are important, and so will be addressed separately:

(i) The 2½" disk drive was developed in the US, using Intellistor's existing vendor relationships to produce the initial run of a few hundred drives. However, the transfer to Japan for manufacturing meant that vendor relationships cultivated in the product development stage did not carry through to manufacturing. As it was explained:

> "The 2½" drive was thoroughly designed and developed by Intellistor, and transferred to Fujitsu for manufacturing, at Yamagata. So, we did all the ground work here, trying to find all the correct vendors, and so on and so forth, to get that product out. We wanted the leading vendors of that to be American companies, but it didn't work out that way. We had found people who could deliver and deliver quickly. Obviously Fujitsu had their own vendors that they wanted to use, and so there was some conversion there on transferring product, that they would go to their own vendors first to get a similar part. You have got to remember, you know, they are the manufacturers, and so if they want to use their own vendors, there isn't a lot we can do about it. For as long as their vendors would provide a similar part, there is not a lot we can do about it. We have our own vendors, and some of them were Japanese vendors and some of them American vendors, and so we chose both depending upon what the part was that we needed. But being Fujitsu, you know, obviously they.......would elect, for volume production, to go to one of their own vendors.
>
> We transfer design over to them, and they go to full production. You know, they obviously can go out and use their volume capability to get better prices. You have got to remember that we don't build volume here, we just go out and buy parts. We build a couple of hundred."

This was entirely consistent with Fujitsu's strategy for manufacturing, which was explained as:

> "Fujitsu's philosophy for manufacturing is to start manufacturing the product developed in the US in Japan first. After some learning curve, with such experience, for some product, we transfer the production of that product to Hillsboro [Oregon]. The learning curve is to do with the whole of the manufacturing process; because for this, a different type of, for example, platter is used. Therefore, we thought there might be different problems. After assembly, physically we can't avoid such phenomena/read data from it...problems because the platter is thinner.....after assembly, we cannot avoid such phenomena. Therefore, after assembling, for controlling of head actuator some special technology might be necessary, or should be necessary."

One of the difficulties is that the defect rates, and other problems, only become apparent in the manufacturing stage. Intellistor considered that the transfer difficulties might have been significantly reduced if transfer had, for example, been to the Hillsboro factory. This would also have resulted in a faster time to market, critical in the small rigid disk drive industry, and continuity in vendor relationships established in the product development process.

There is, in fact, a cleft stick dilemma. So long as the defect rate remains high, so the transfer to manufacture at Hillsboro remains an ever remote possibility. Yet transfer to Hillsboro, and the opportunity for Intellistor both to test their products on a pilot production line, and to work with actual vendors in the product development stage, might lead to a significant reduction in defect rates, as well as alleviate other manufacturing difficulties:

"The problem is that when you develop something like this 2½", and its got to be the same for the 1.8", and you have to have a pilot production line, where you can build somewhere around 2,000 to 3,000 and knowing that you are going to have to throw 50% to 75% of them away, we don't have that opportunity here to rid it of bugs......They don't want to build them, they don't like to take that kind of risk. They will continue to manufacture at Yamagata."

(ii) In testing, while there were different test criteria, and different test equipment was used in Japan and in the US, the main differences were to do with philosophy. Fujitsu's history, as a leader in larger-sized computers, such as mainframes, had emphasized quality and low defect rates in production. In small disk drives, on the other hand, what counted was speed to market. The industry norm was for higher defect rates than were acceptable for larger-sized disk drives. Products that passed Intellistor's tests would fail Fujitsu's more rigorous testing procedures. More testing and care in manufacturing meant slower speed to market for product development and manufacturing functions located in different countries:

"Fujitsu required more time to set up machinery, and they wanted more detail. The work with a lot of detail, and want more and more detail. We don't work with a lot of detail. In fact all the guys came from places like Maxtor, and some of the other places, you know: "Here's a spec., and here's what you got to go do." They always like to go down fifteen layers deeper. So, it requires a lot more work on our part to get things where they needed to understand it. We made a lot of revisions that were related to their requirements for manufacturing. *The way that they do testing is different to the way that we do testing.* We have a product right now which, in the US market place, we would already be shipping this thing in some quantity, whereas on the other side of the ocean, they are reluctant to ship that kind of stuff. It is nothing to do with the distance of the heads from the platters, *it is a problem of strictly the way that you market and strictly the way that you do stuff in two different market-places.* The market for the 2½" went away, and so we went onto another product." [my emphases]

Similarly, for the embedded controller which Intellistor developed for the 5¼" disk drive, a US view was:

"As a development process, we were given a set of specifications to go out and design this embedded controller, both firmware and hardware. That worked fairly well, but we had similar problems there with the Nagano factory in the way that they do testing and the way we do testing. It is a matter of philosophy. They are more rigorous......something that may happen once in ten years. But, by doing that, the product doesn't come out quick enough to meet market requirements. We have come to the point where engineering makes a decision and we think that we should put something out into the market-place. On the other hand, the test people don't think that it is ready to go. So, like I say, you have two different philosophies. I would rather get it shipped out there and get it to somebody then, knowing that it has some problems, and getting them fixed on the customer side."

Fujitsu and Intellistor are working on resolving the differences in testing; Intellistor has installed some test equipment introduced by Fujitsu, for example. The product development and production stages required more interfacing, and both parties were aware of each others' different histories and philosophies.

## 5.3 Intellistor: Concluding Observations

The following summarizes the issues of importance in the Fujitsu/Intellistor relationship for the purposes of this paper:

(i) Unlike FNS or FNTS, Intellistor became part of Fujitsu's international product development capability by acquisition of an existing company. It was acquired as a supplier of new products to be manufactured in Japan. This was reflected in the relationship between the two organizations.

(ii) As a consequence of this history, Fujitsu and Intellistor were still learning how to integrate their activities, especially with the transition to manufacturing and in different testing criteria. The latter issue did not arise at FNTS or FNS, for example, where (i) there were only one series of tests conducted (in Japan); and, (ii) the product development process was planned and implemented with the future testing benchmarks and only one set of vendors in mind. At FNTS and FNS, there was one philosophy, not two.

(iii) On the integration of the design stage, the adoption of a common 3-D CAD system might be expected to lead to enhanced communication between Intellistor and Fujitsu in Japan.

(iv) "Standards" are typically seen as formal requirements, that a home-based MNC might be able to easily tap into either from abroad (by reading the regulations), or by a small, local scanning presence in offshore markets. What the small rigid disk drive industry illustrates, however, is that standards of industry practice may be more important than the formal standards. To understand, and work within accepted industry practice, requires a globally organized product development process. Moreover, of product development is to be globally organized, there is a strong argument for co-location with manufacturing.

(v) The value of technology transferred to the US was of short duration. Given (i) the fast pace of technological change in the small rigid disk drive industry; and (ii) the rapid diffusion of new technology and engineering knowledge, through reverse engineering and imitation, or other means, the real need for a new entrant to the industry is not to acquire current state of the art knowledge, but to develop an organizational capability. In this case, Fujitsu's choice presumably was to build an in-house capability, or to buy product from vendors. Successful organizational integration is necessary for effective capability.

(vi) Intellistor had an additional value to Fujitsu beyond the specific products that it developed. This was that it provided an additional product development platform for situations in which Kawasaki did not have sufficient development resources for work on new projects due to ongoing commitments. Intellistor provided spare capacity.

(vii) For Fujitsu, which has an industry reputation across its range of products for very high quality, in moving into the small rigid disk drive industry it had to confront a situation where the norm was for lower quality products than were accepted in other product classes. For example, in March, 1992, Fujitsu replaced Seagate Technology as Motorola's "supplier of choice" for 520 Mb 3½" hard disk drives, to be used in Motorola's Multipersonal Series 8000 servers, which are based on its 88000 RISC microprocessor. It was reported that Fujitsu won this position on the basis of quality evaluation. This is, however, a very different criterion from that required to supply small rigid disk drives for the notebook computer market. Quality, here, is important, but arguably not as important. The dilemma for Fujitsu was whether it should put at risk its industry reputation so as to compete effectively in the small rigid disk drive market. Closer integration between manufacturing and product development might, however, solve some of the difficulties.

## 6.0 The Global Organization as Core Capability

This paper has described the historical evolution of three US-based subsidiary companies of Fujitsu Limited in the US. It has emphasized the need to incorporate the organization within studies of product development, and for the need to extend theories of product development to include a distinctively global dimension.

The products focused on in this paper are supplied to different categories of consumers. The FETEX-150 central office switch of FNS is supplied to a limited set of consumers, the regional Bell companies. The FLM 150 and FLM 6 multiplexers are sold by FNTS to a much wider consumer base of sophisticated end users. The small disk drives of Intellistor, in contrast, are sold to computer manufacturers/assemblers for onward sale to mass market consumers.

Moreover, the competitive situation faced by each company was very different. FNS faced a competitive environment of no more than half a dozen global firms, FNTS faced a much larger range of competitor suppliers of its multiplexer products, and Intellistor was in competition against a large number of mainly small company US manufacturers.

Each of the US companies had different histories, contrary to the export/local manufacture/R&D chain patterns of internationalization that are sometimes used to describe the overseas evolution of MNCs. In the case of FNS, participation in the central office switching market in the US was led by the initial internationalization of an existing product development capability from Japan. In the case of FNTS, the pattern was more stereotypical, in that the initial export to the US of transmission equipment was followed by local manufacture, and finally by the establishment of a significant local product development capability. In the case of Intellistor, Fujitsu acquired an existing company as a "supplier" (Voisey, 1992) of new products for transfer to Japan for manufacture in the home country. Whereas, in virtue of their particular historical development, the management systems at FNS and FNTS incorporated elements of both Japanese and US systems, that of Intellistor remained entirely American. In each case, the particular evolution of the US operations ('greenfield' for FNS, a gradual evolution from sales to manufacture to development for FNTS, and an acquisition of an existing product development in the case of Intellistor) required tailored organizational adaptation across the MNC as a whole.

Despite these differences of context, the commonalities from the analytical framework were not invalidated. In each location, Japan and the US, particular resources were combined to serve a general strategy of building a global product development capability.

International product development enables rapid local response, a higher optimal use of (higher quality) resources, technology transfer within the MNC across borders, and contributes to the development of a global product development platform. Technology developed in one part of the network, such as software in the US, can be transferred to Japan, and on to Singapore, for example, providing substantial economies from reuse that would not be obtainable by competitors relying on local development. The complexity of this process requires flexible and adaptable organizational processes that can interpret and interface with colleagues and organizations embedded in vastly different institutional environments. To the more obvious difficulties arising from time, language, and culture differences, must be added more fundamental problems stemming from the work organization. These include what may be very different local supplier relationships, hardware and software performance standards, norms of product development organization, communication protocols, career structures, and particular local training and skills.

The most important factor in technology development in this perspective is coordination capabilities. As Teece, Pisano and Shuen (1992) put it: "A firm becomes superior in a

particular technological domain *because it has certain organizational capabilities*: it allocates resources to more promising projects, it harnesses experience from prior projects, it hires and upgrades human resources, it integrates new findings from external sources, and it manages a set of problem-solving activities associated with that technology" [my emphasis]. A global product development capability is more than the mixing of or resources or factor inputs (Collis, 1991); it is the combination and integration of differing institutionally embedded resources through the MNC interorganizational network.

While Fujitsu has exported from Japan for many years, the hallmark of a truly transnational, or global, company is when it internationalizes the product development process, so enhancing its organizational and technological capabilities. This is a different criterion to economic theories which focus on production, and on least cost production and marginal factor substitution assumptions; these contribute little to our understanding of how MNCs can build core capabilities. Other explanations have focused on various external drivers of internationalization, including science and technology factors, market factors, regulatory factors, and competitive factors. What this paper has tried to do is to present a detailed account of the experiences of three companies at the Japan:US interface and to suggest that the coordinative capability they are developing provides a sustainable competitive advantage. This is linked to the ability to learn, across the interorganizational network of the MNC.

As De Meyer (1992: 169) has suggested:

> "But learning about different markets, different problem-solving methods, different sources of technological progress, different cultures, different competitors, and rapid diffusion of that learning throughout the organization, is definitely enhanced by creating an international network of R&D laboratories. In other words, apart from the result-oriented problem solving, the R&D group has to learn for the company, to enable the company to pursue transnational strategies in the future, and effective technical learning requires the R&D group to go international.....The outcome of the learning process is knowledge that is distributed across the organization, is communicable among members, has consensual validity, and is integrated into the working procedures of the organization."

De Meyer (1992), nevertheless, retains a focus on the intra-organizational processes of *technical* diffusion, validation, and integration. The evidence at Fujitsu suggests that this learning process is perhaps more social than technical, but that it *encompasses* the technical elements of differing technology strengths, market characteristics, and the like. The structuring of an interorganizational network is a social process. Communications may use UNIX, or other technical mechanisms, but the routine, or pattern of communicating evolves through social adjustment, through adapting to the local, foreign institutionalized work practices and structures.

At Intellistor, for example, issues in the link to manufacturing and in differing testing practices are related to insufficient learning, and communication among the respective elements of the interorganizational network. Where the communication and understanding are more widespread, such as at FNS or FNTS, the result is that the product development process is undoubtedly more effective than the single country location assumed by much of the new product development literature. In these cases, global product development successfully competes with national product development. The reason is the special value added by internal organizational processes, the building of an organizational capability beyond that which would result from the simple addition of resources in different national locations. The source of the value creation is at the level of the organization and the global interorganizational network; it is the ability to participate in multiple, conflicting institutional environments, with the MNC creating routines of integration.

In view of this, it is surprising that more sociologically-oriented organization theory continues to shun the MNC, or to see it as no more than a context. One of the difficulties for students of MNCs is that, despite their importance as the location for so many of the phenomena of interest to organizational researchers, including those whose discourse is primarily at the national level, the complexity of MNCs and their organizational networks makes them less amenable to the legitimized, standardized quantitative data analysis techniques used by researchers who focus on less complex organizational structures in one country.

Yet, when we know that, collectively, MNCs account for over 40% of world manufacturing output and a quarter of world trade, that MNCs produce and market 85% of the world's motor vehicles, and 70% of computers (Ghoshal and Westney, 1993), for example, it becomes necessary to begin to tackle these more complex organizations that operate among different international and institutional environments. A concern with relevance has led MNC researchers to focus on comparative analysis of small sets of companies. This is a valuable beginning to the work of understanding MNC organizations, and the theoretical importance of internationalization. The research presented here has focused on a single MNC, Fujitsu Limited, and on three of its subsidiary companies, together with their interorganizational networks. Future research should might concentrate on building a larger data set of products developed globally, for comparison with single country (national) product development efforts. This paper has suggested some of the dimensions of such an analysis, within the overall constraint of providing a greater amount of case detail than such analyses might include.
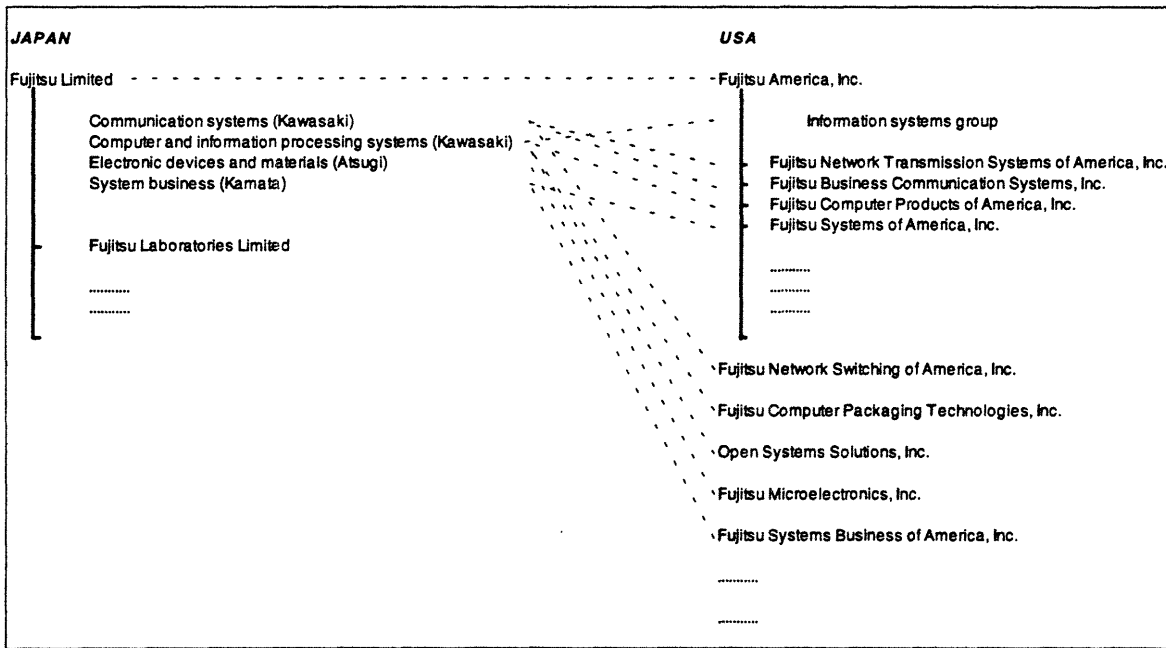
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# FIGURE 1: CONSOLIDATED NET SALES AND R&D EXPENDITURES

Consolidated Net Sales and R&D Expenditure of Fujitsu Limited
(Figures in ¥ million)

| Year to | Domestic Sales | % Change | Foreign Sales | % Change | Total Sales | % Change | R&D Expenditure | % Change |
|---------|---------------|----------|---------------|----------|-------------|----------|-----------------|----------|
| 3/31/89 | 1,859,129 | 17% | 528,313 | 17% | 2,387,442 | 17% | 246,906 | 30% |
| 3/31/90 | 1,941,075 | 4% | 608,698 | 15% | 2,549,773 | 7% | 299,107 | 21% |
| 3/31/91 | 2,233,493 | 15% | 737,969 | 21% | 2,971,462 | 17% | 329,823 | 10% |
| 3/31/92 | 2,415,151 | 8% | 1,026,796 | 39% | 3,441,947 | 16% | 391,885 | 19% |
| 3/31/93 | 2,312,000 | (4%) | 1,149,000 | 12% | 3,461,000 | 1% | 386,000 | (2%) |

# FIGURE 2: R&D RELATIONSHIP BETWEEN FUJITSU JAPAN AND US OPERATIONS



**JAPAN**

**USA**

Fujitsu Limited - - - - - - - - - - - - - - - - - - - - - - - - - - - -Fujitsu America, Inc.

Communication systems (Kawasaki)

Information systems group

Computer and information processing systems (Kawasaki)

Electronic devices and materials (Atsugi)

Fujitsu Network Transmission Systems of America, Inc.

System business (Kamata)

Fujitsu Business Communication Systems, Inc.

Fujitsu Computer Products of America, Inc.

Fujitsu Systems of America, Inc.

Fujitsu Laboratories Limited

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·Fujitsu Network Switching of America, Inc.

·Fujitsu Computer Packaging Technologies, Inc.

·Open Systems Solutions, Inc.

·Fujitsu Microelectronics, Inc.

·Fujitsu Systems Business of America, Inc.

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# FIGURE 3: THE FETEX-150 FUNCTIONAL SUBSYSTEM
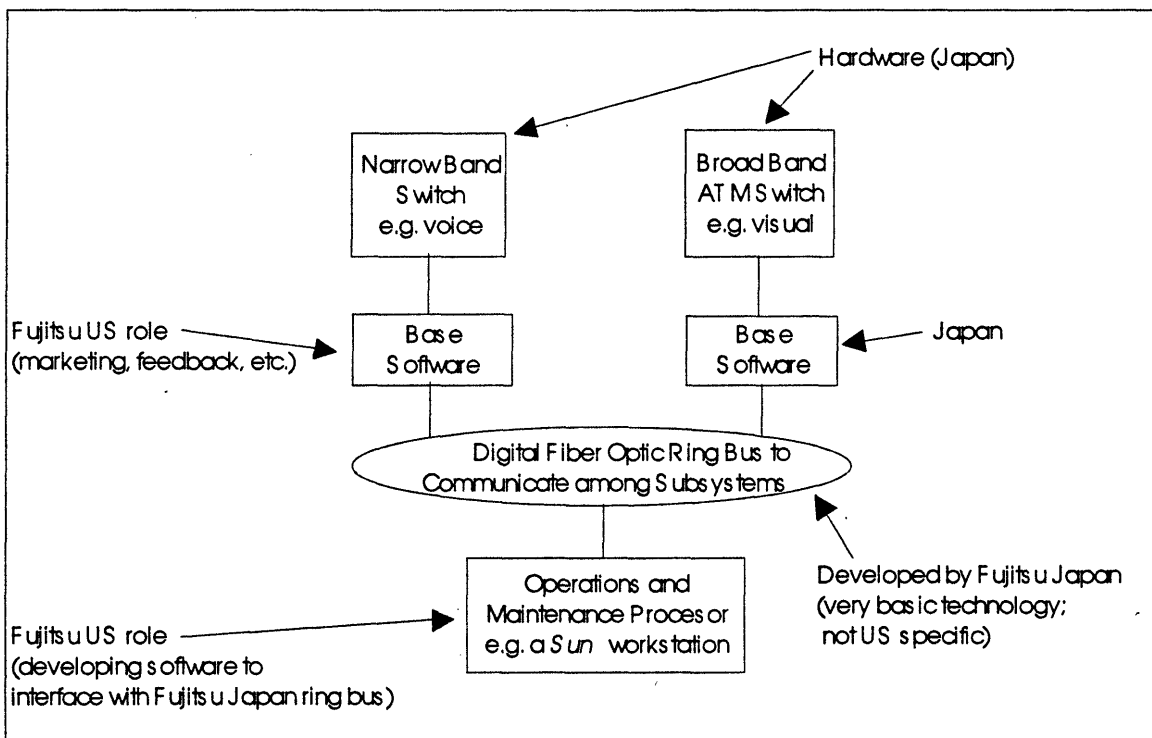
# FIGURE 4: FNS ACTIVITY IN SOFTWARE

| ITEM | NOW | FUTURE |
|------|-----|--------|
| **SWITCH SOFTWARE** | | |
| Development | - Specification<br>- System Test (CST, FST) | → Total Development |
| Provisioning | - Office Data Generation<br>- Generic Update | |
| Problem Management | - Problem Tracking (Including Track)<br>- Fix Test | |
| | ⌐ - - - - - - - - - ⌐ | → - Fault Localization<br>- Fault Fixing (Patch) |
| Configuration Management | ⌐ - - - - - - - - - ⌐ | → Generic Management |
| **SUPPORT** | | |
| Test Tool<br>Support DB | - Emulator<br>- PMR DB etc. | → - Other Tools<br>- Other DBs |

Source: Fujitsu Limited

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**FIGURE 5: FNS AND FUJITSU JAPAN - GLOBAL FUNCTIONAL ALLOCATION IN PRODUCT DEVELOPMENT**

Product Planning

System Design

Basic Design

Functional Design

Detail Design

Coding

Customer Oriented System Test

Eng. System Test

Integration Test

Component Test

Both
FNS/FJ

FNS/FJ responsible for each responsible area (Module, Feature); total responsibility is FNS

FNS responsible

Source: Fujitsu Limited
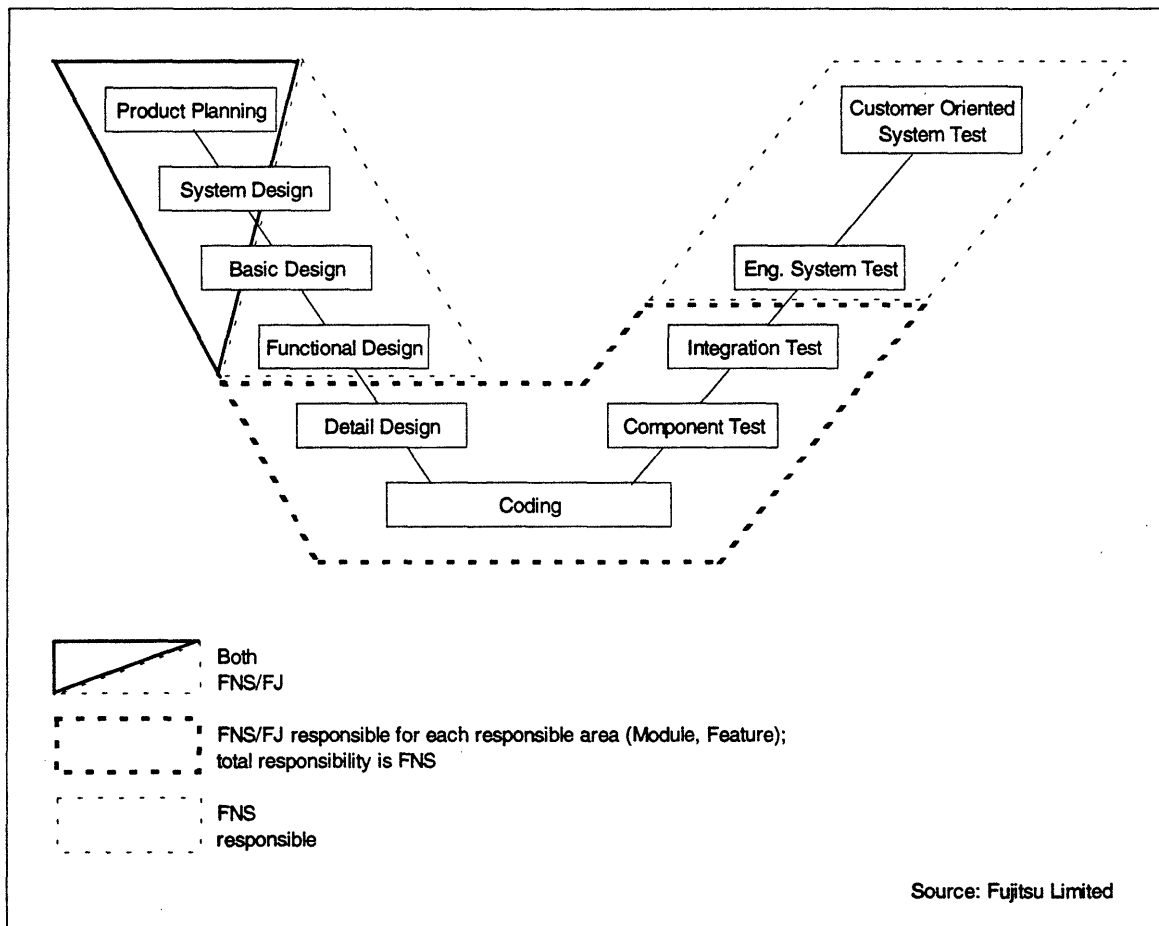
# FIGURE 6: FUJITSU LIMITED JAPAN AND FUJITSU COMPUTER PRODUCTS OF AMERICA, INC.

Information Processing Devices Group
- File System Division (Mr. Suzuki) 5 1/4" Disks
- (blank)
- (blank)

Compact Peripherals Group
- Disk Division (Acting: Mr. Sugihara) 2 1/2" Disks
- (blank)

Computer Products Business Group
- Engineering Support Division (Mr. T. Hasegawa - immediate superior to Mr. S. Okada)

Fujitsu Computer Products of America, Inc.
- San Jose HQ Operation (sales and marketing)
- Intellis for R&D Operation
- Hillsboro Manufacturing Operation

# FIGURE 7: DESIGN ELEMENTS OF MULTIPLE PLATTER DISK

Host Interface Controller

DISK SUBSYSTEM

Magnetic Tape Unit
(drive part)

Host ⟷ MTC ⟷ MTU

Magnetic Tape Controller

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Industry Standard Dimensions of 2½" Rigid Disk Drive

Height: 17 mm.

Width: 70 mm.

100 mm. depth

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Simplified Profile of Rigid Disk Drive

platters

heads

head actuator
(rotary actuation)

media

bottom/top is firmware