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TELECOMMUNICATIONS IN FRANCE:
THE IMPACTS OF TRANSATLANTIC FIBER OPTIC CABLES
ON SATELLITE COMMUNICATION INVESTMENTS

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Richard Stephen Carl

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Joseph D. Straubhaar
Major professor

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by

Richard Stephen Carl

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ABSTRACT

TELECOMMUNICATIONS IN FRANCE:

THE IMPACTS OF TRANSATLANTIC FIBER OPTIC CABLES

ON SATELLITE COMMUNICATION INVESTMENTS

By

Richard Stephen Carl

The French government is a leading investor in high-capacity fiber optic cables crossing the Atlantic to achieve three goals: modernizing its domestic networks, increasing its transatlantic telecommunications circuit capacity, and leading Europe in advanced telecommunication services. These goals will enable France to maintain its lead in telecommunications and telematics in preparation for the unified market of Europe 1992. This would allow Europe to better compete with the US and Japan and thus solidify its position as the third hub of international commerce.

The major research question posed in this study is:

> **"How have the technical advantages of transatlantic fiber optic cables impacted on France's investment in communication satellites?"**

In answer, this study employs descriptive analysis to identify and analyze three primary factors of France's large fiber investment: the technical advantages of undersea fiber optic cables over satellites, overall French telecommunications policy goals, and the economic benefits of such investment at the present time and in post-1992 Europe.

DEDICATION

To my wife, ***Irene Savoyat***, whose love, support, and patience are the bonds which helped me complete this thesis;

to my mother, ***Mary Carl***, who instilled the desire to go beyond learning in order to question and so better understand;

and with loving memory of my late father, ***Earl George Carl, Jr.***

"Great is he who puts the needs of others before his own."

Such a great man was my father.

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CHAPTER I

Introduction to the study

International telecommunication is experiencing explosive growth in the 1980's and will continue to expand rapidly into the 21st century. Fueling the growth are three important trends. The first is the global shift away from trade in manufactured goods to trade in data services, especially telematics. Second is the rising demand for worldwide telecommunications services and circuit capacity by those transnational enterprises and manufacturers which require global coordination of resources, production, and delivery of their products and services. Third is the emergence of end-to-end digital transmission systems--especially undersea fiber optic cables--that provide exceptional capacity at low cost. These trends underscore the pivotal role of telecommunications in world trade.

Global telecommunication networks depend on high quality, reliable, and secure transmission media. Currently, two methods provide this. The first is microwave radio signals, used for either line-of-sight terrestrial "hops" or as space links with communication satellites in geostationary orbit 22,300 miles above the earth's equator. The second method is "long-haul" cable which employs two different transmission methods. Coaxial (coax) copper cable uses analog electronic techniques. Fiber optic cable uses digital technology exclusively which endows it with particularly useful properties for high capacity international telecommunication.

Fiber optic transmission systems, known as FOTS, are crucial to the continued growth of global telecommunication networks. They are replacing coax cables for long-haul telephony, especially for undersea cables connecting islands, countries, and continents. Too, they are affecting communications satellite organizations like Intelsat by competing for profitable, high-density routes such as the North Atlantic, increasing competition against Intelsat's twenty-five year international telecommunications monopoly. FOTS are thus becoming the transmission medium of choice for the rapidly growing global network.

Many countries are choosing FOTS to meet their ever-expanding telecommunication requirements. Why then study the French investments in undersea fiber cable links with the United States? Undersea fiber cables represent an important medium to ensure future French economic security. France is one of the world's largest consumers of--and leading investors in--FOTS, primarily due to the French information industry policy which emphasizes retaining European leadership in the evolving worldwide telecommunications and telematics markets. To do so, France is rapidly modernizing its domestic networks via digital transmission and switching technologies while rewiring its main trunk lines with terrestrial fiber optic cables. At the same time, it is increasing its transatlantic circuit capacity through heavy investment in undersea FOTS. These efforts aim to attract international telecommunications and telematics traffic to French territory for processing, thus furthering its goal of becoming the third point on the US-Japan-

European trade triangle. The above issues provide the overall background to this thesis.

Purpose and scope of the study

The purpose of my study is to identify the technical advantages of fiber optic cables for transatlantic telecommunications and to analyze the resulting political and economic factors behind France's choice to increase its investment in FOTS over more satellite circuit capacity. The scope of the study is limited to the past fifteen years of French telecommunications. The main method is analyzing the technical, political, and economic documentation published in France and abroad in the past five years to reflect the rapid change occurring in this dynamic field.

Structure of the study

We now discuss the five chapters of this thesis. First, the Introduction presents the research problem under investigation, the aim of the study, and its timeframe limitations. Second, the Literature Review examines two important issues: the global shift from trade in manufactured goods to trade in data services, and the continuous overcapacity of Intelsat's international satellite circuits. Third, the Research Methodology section discusses how I conducted my research, how I answered the preliminary and research questions, and what resources I used. Fourth, in the main body of the study, Chapter Four, I pose topical questions to focus on the central subject, the impacts of fiber optic cables on French investments in transatlantic telecommunication links. I begin with three preliminary questions, discussing in turn the European context of global telecommunications expansion, how France is positioning itself for the growing European Telecommunity, and the current types of transmission media linking France to the United States. These serve to narrow the discussion down to my research question,

> **How have the technical advantages of transatlantic fiber optic cables impacted on France's investment in communication satellites?**

I answer this by subdividing it into three subtopics: the technical characteristics of fiber cables and satellites, French telecommunications policy goals, and the economic factors of France's growing investment in FOTS over satellite communications. Fifth, in the Conclusions and Implications section I summarize the global, European, and French telecommunication situations and the major impacts of FOTS on French international satellite communications. Finally, I suggest directions for future research on this and closely-related topics.

As a result of my preliminary investigation into this study, I anticipated finding two primary trends occurring in international telecommunications. One was that fiber cables would undermine the cost-effectiveness of Intelsat in providing transatlantic voice and data telecommunications, ultimately causing Intelsat to realign its user charges and traffic-carrying priorities. The second was that

France would shift most of its transatlantic voice and data traffic to undersea fiber cables when they became operational since, first, France had a substantial stake in their construction, and second, because fiber optics provide significant technical advantages over satellites for both voice and data applications. Following are the results I uncovered.

Summary of findings

A summary of evidence from international research literature, the telecommunications industry press, and French, British, and US government studies identifies two overriding global trends involving FOTS and satellite communications. First, fiber will carry increasingly more transatlantic voice and data traffic than satellites due to its inherent high-capacity, digital transmission technology. Second, satellites will evolve into the choice medium for broadcast and mobile communications due to their point-to-multipoint and multipoint-to-point transmission capabilities. Significantly, fiber cables won't completely supplant satellites as both media will co-exist in the future; indeed, satellites will back up undersea fiber cables to ensure continued service in the event of a cable disruption, as happened recently in the North Atlantic.

As for French telecommunications, the literature shows that France is increasingly choosing fiber technology over satellites for its transatlantic voice and data telecommunications. Fiber offers the advantages of high-capacity digital transmission at competitive costs, without the time delay of signals found in satellites. These factors led

French policymakers to shift investment to fiber cables over more Intelsat circuit capacity. This is part of an ongoing pursuit of high technology leadership in Europe in preparation of the integrated market of 1992. These changes include building in France the "networks of the future" that require modern, digital transmission and switching facilities nationwide. Also, growth in network services, notably ISDN, will help France attract ever more international telecommunications traffic to its shores. This will give the country strategic advantages for the future where it expects to become the third corner of a US-Japan-European trade triangle based on advanced telecommunications and telematics. Such plans would carry France into the 21st Century as a leader in the vital and growing world telecommunications markets. Together, these factors combine into France's reasons for shifting investment resources to fiber optics over more satellites for its voice and data telecommunication links to the US.

CHAPTER II

Literature review

We begin by addressing two important elements affecting international telecommunications, changes in world trade patterns and the supply of telecommunication circuit capacity. In the first, we see that there now exists a global shift away from trade in manufactured goods and towards more trade in data services. In the second, we review the Intelsat consortium and its excess capacity of international satellite circuits. These trends provide the background discussion for the analysis of French telecommunications in chapter Four.

The evolving world economy

The world economy is evolving rapidly. Japan recently replaced the United States as the world's leading economic power: an example is that the ten largest banks are now Japanese. Europe is in the midst of forming a unified market that will be complete by the end of 1992. The Soviet Union and China are both facing monumental restructuring. And developing nations like Korea and Taiwan are competing for global market shares that only twenty years ago were beyond their reach. Alvin and Heidi Toffler (1988) say these fundamental changes "will alter the global balance of power and raise the stakes involved in all political, strategic, and economic competition" (p. 50).

The global trends toward trade in data services

What is driving this evolution? Experts underscore the importance of the ongoing shift from manufacturing of goods to the growth of services in the global economy (Sauvant, 1986; Robinson, 1985; Feketekuty, 1986). Economists that track this growth of the service sector estimate is that by 1986, global trade in services exceeded US$600 billion annually (Feketekuty, 1986, p.590). United Nations Specialist Karl Sauvant (1986) says that in the last two decades, services have taken over as the largest sector of the world economy. He identifies communications, transport, finance, public administration, and defense as leading industries in which over 25% of the world's US$555 billion foreign stock was invested.

Of all the types of services that are growing worldwide, telecommunications is one of the most important. Telecommunication networks "serve as the primary distribution channel for trade in services" (Feketekuty, 1986, p. 591). Indeed, they provide the conduits of commerce for the fastest-rising sectors of all services, informatics and telematics. Robinson (1985) emphasizes that "telecommunications and computing services are integral to national economic development in industrialized countries" (p. 310). Their importance is especially critical for the leading industrial powers since not only has manufacturing given way to services, but there is also a shift underway from data goods to data services. (Sauvant, 1986). This means that countries will invest more and more economic assets into building--or gaining access to--strong national data resources like advanced telecommunications networks and sophisticated data processing capabilities (Jacobs, 1988; Sauvant, 1986; Robinson, 1985).

The oversupply of Intelsat circuit capacity

We turn now to the second topic, Intelsat and its excess transponder capacity. Intelsat is the non-profit international satellite consortium serving 170 countries and territories worldwide. It provides telephone, data, and broadcast services on a non-discriminatory, cost-averaged basis (Burch, 1988). By 1987, Intelsat had an investment of nearly US$1.6 billion in its space segment consisting of 17 satellites. It has orders for five more spacecraft in the coming years to replace aging satellites and to improve their service offerings. Intelsat Director General Dean Burch (1988) points out that these new satellites are the "largest and most sophisticated" (p. 26) in the world. Intelsat celebrates its 25th anniversary in 1989, recounting its role in aiding both industrialized and developing countries by providing each with vital domestic and international telecommunication links (Colino, 1985).

Leland Johnson, economist with the Rand Corporation, discusses the Intelsat system in a 1987 article, "Excess capacity in international telecommunications." In it, he analyzes Intelsat's excess transponder capacity as a result of two main problems: over-optimistic international traffic forecasts and inefficient pricing of existing circuits. Johnson cites a US government study which indicates that less than 50% of satellite circuits were used every year from 1970 to 1985 (p. 282). He further points out that in recent years, Intelsat has a "striking bias...towards over-estimating traffic growth" by 10% in the years from 1980 through 1985 (p. 283). Intelsat relies on the estimates of traffic growth submitted by its members. It "exacts no explicit penalty against a country for poor forecasts, nor does it pay a reward for good ones" (p. 286). The result: by 1987, Intelsat itself identified over 100 transponders, each capable of carrying numerous international circuits, that were excess to its global mission. In 1988, Intelsat's Burch (1988) reported that the consortium had up to 170 transponders available and that both member and non-member countries could use them for dedicated domestic services.

This excess capacity becomes ever more burdensome for the economic welfare of Intelsat and its members when competing telecommunication systems appear. Already, one private transatlantic business satellite service wants to creamskim the profitable North Atlantic route from Intelsat. An even more pressing issue is the emergence of undersea fiber optic cables: in 1988, TAT-8 became the first operational transatlantic fiber cable, offering 40,000 digital circuits. The second-generation cable, TAT-9, is under construction and will provide 80,000 more by 1991. These competitors alone will offer enough combined capacity for all the traffic needs of the Atlantic Basin, further heightening the problem of Intelsat's excess circuit capacity.

CHAPTER III

This thesis is a qualitative study of the impacts of an important new technology, undersea fiber optic cables, on the political and economic structures of French telecommunications. Throughout the study I relied on the most recent pertinent literature due to the rapid changes in fiber optic and satellite technology and the evolving processes in France as a result.

Research methodolgy used

My methodology employs descriptive analysis, the method best-suited for evaluating the type of data in my study. My analysis centers on the qualitative technical advantages of undersea fiber cables over satellite communications and the resulting political and economic ramifications of heavy French investment in them. In addition, I supply quantitative evidence of the impacts of fiber in France through tables showing the investment trends in both fiber optics and satellites for the five years from 1984 through 1988 to provide a recent historical comparison.

Sources of research materials

Sources of research for this study were widespread, coming from France Telecom's and British Telecom's technical libraries; European and American telecommunications industry publications; and government documents from France, the United Kingdom, and the

U.S. I relied on articles from scholarly international journals, chapters from books, private corporate reports, and the industry press of the US and France (including published interviews with the leaders of the French telecommunications ministry--I've translated into English all French quotations used).

Organization of the study

The organizational pattern for the main body of my study follows the classical "funnel" shape to continually narrow the discussion down to my research question. First, I present an introduction which covers the explosive growth in telecommunication needs worldwide and the digital technologies developed to answer them. Second, I pose three preliminary questions that serve to focus the discussion:

What is the current European context for the rapid expansion in international telecommunications?

How is France positioning itself to compete in the context of the developing European Telecommunity?

What are the current methods used to supply telecommunication links between France and the US?

Third, having framed the context for this study and laid an orderly groundwork, I put the research question,

How have the technical advantages of transatlantic fiber optic cables impacted on France's investment in communication satellites?

I divide the answer into three major sections discussing technical, political, and economic factors which I then analyze individually. I finish with a summary chapter presenting the conclusions and implications of my findings and suggestions for future research. A glossary of technical terms and acronyms appears after the List of References.

CHAPTER IV

Descriptive analysis

Telecommunications links are vital to global commerce and economic growth. They are the channels over which trade among nations, corporations, and individuals occur. In 1987, the world telecommunications market was worth over $600 billion a year. The US market share accounts for more than 35%; Japan 11%; the bulk of the rest going to Europe with no one European nation accounting for more than 6% of its total. Telephony accounts for the largest portion of telecommunications trade (Gilhooly, 1987a). The countries of the Pacific Basin have 60% of all telephones worldwide, and the US trades more with Asia than Europe (Podmore and Faguy, 1986, p. 349). The following table lists twelve developed countries which accounted for 77% of the world's telephone connections in 1985 ("Telephone Lines," 1988):

Table 1

Countries with the Most Telephone Connections in 1985

Country	Telephone lines in millions	Percent of annual growth
USA	118.3	3.40
Japan	46.1	13.80
USSR	28.0	6.50
FR Germany	25.9	4.00
France	23.0	4.10
UK	21.7	3.80
Italy	17.4	5.50
Canada	2.5	11.60
Spain	9.3	6.90
Brazil	6.9	6.20
Australia	6.5	4.80
Netherlands	5.8	3.60
	total = 321.4	average = 5.35

Explosion in worldwide needs for telecommunications capacity

The need for ever more telecommunications capacity is explosive by most measures. Estimates for annual worldwide growth in telecommunications capacity needs range from 15% (Johnson, 1987) to 25% (Voge, 1988), and is usually put at around 20% (Rowbotham, 1987; Runge and Trischitta, 1986). Such phenomenal growth fuels lucrative R&D industries to develop technologies that fulfill the need for increasing capacity. These new technologies must meet three for increasing capacity. These new technologies must meet three criteria: 1) high reliability, 2) quality, and 3) security. These factors lead network operators and research centers to invest enormous resources to develop new techniques that exploit digital technologies which best answer these criteria.

New technologies that exploit digital techniques

International telecommunications experts identify digital transmission and switching technology as the best solution to the global hunger for increased communications capacity (Horne and Langridge, 1985; Pal, 1985; Runge and Trischitta, 1986). Digital techniques provide vast increases in transmission rates over analog means due to their large multiplexing capabilities. Digital multiplexing currently results in a five-fold increase in capacity over standard transmission while analog multiplexing allows only a two-fold rise. This advantage results in higher throughputs over existing channels, leading to lower costs of transmission--a significant factor to telecommunications users and operators. Once "broadband" digital technology becomes widespread, transmission rates will skyrocket from millions of bits (megabits) to billions of bits (gigabits) per second (which will happen in the near future), further lowering costs and increasing capacity (Carrelli and Decina, 1987). One expert estimates that demand for transatlantic telecommunications capacity could reach almost 100 gigabits per second within 25 years (Rowbotham, 1987).

The communications need: digital networks, ISDN, undersea cables, satellites

All-digital transmission is also the basis for rapid expansion of highly modern telecommunication networks and the services they support. One major objective is to introduce digital systems into national networks quickly to provide global digital connectivity (Horne and Langridge, 1985). This would allow wider access to other nations' networks (as well as their data and telematic services) based on common standards among network operators. Achieving transparent connectivity is the goal of international standards agencies.

Foremost among the new technologies to realize this goal are undersea FOTS and digital satellite circuits. These systems compete for users by emphasizing their own specific technical advantages for certain telecommunication applications. The major new service on the international scene is the Integrated Services Digital Network (ISDN). The ISDN concept arose more than twelve years ago with the public networks' desire to provide transparent supply of advanced information services. ISDN offers the following five attributes: 1) end-to-end digital connectivity, 2) integrated voice, data, text, and video services, 3) a reduced set of global standard interfaces, 4) "intelligent network" services which allow customer control of network resources, and 5) enhanced networking services such as protocol mediation and telematics (Carrelli and Decina, 1987). European and US telecommunications industry literature is bursting with news and analyses of sophisticated applications for ISDN services which have one point in common: they rely on the digital technology of modern networks.

Modernizing public networks today often means investing heavily in terrestrial and undersea FOTS. Replacing the outdated technology of analog coaxial undersea cables, fiber cable is the leading choice for international delivery of ISDN services. According to Ira Jacobs (1988), formerly of Bell Labs, "Fiber has supplanted coaxial cable as the cable medium of choice for undersea applications" (p. 8.20). He points out that fiber optic systems are more cost-effective because of their larger transmission capacities, smaller diameter cables, longer distance between repeaters, and inherently digital technology. Jacobs calls fiber systems in the undersea plant "a key step in the evolution to an end-to-end digital transmission capability spanning the globe" (p. 8.21).

Major advances in international telecommunications transmission produces changes in national policies. The cost effectiveness of fiber systems challenges national policymakers and planners alike (Pal, 1985). Their goal becomes integrating the new technologies into an existing telecommunications structure that includes older, analog cables and satellite channels. Planners must consider the complementary strengths of both the newer and older systems for two reasons: first, to provide for their networks operational flexibility; and second, to maintain a high quality of service at the national and international levels (Pal, 1985).

The challenge of optical fibers

How does the challenge of fiber optics technology affect international telecommunications? Peter Robinson (1985) points out that fiber's technical benefits will influence two important evolving worldwide trends, one being the evolution to ISDN services, the other being the Open Systems Interconnection model, or OSI. Robinson sees ISDN and OSI as complementary. He calls ISDN "the development of networks by telecommunications carriers to provide the necessary links" (p. 316) for new digital services. OSI, he states, "relates to the development of interface specifications so that...new equipment can be plugged into the [ISDN] networks" (p. 316) with minimum protocol conversion problems. These two trends affect most directly the countries involved in their development: the United States, Japan, and several European states have invested enormous resources to realize commercial benefits from ISDN and OSI. Since the US-Japan-Europe triad lead in their development, they are best-situated to profit handsomely from the advanced networks of tomorrow.

An overview of European communications policy

In view of these global shifts, we will turn next to a discussion of European telecommunications. I pose my first preliminary question:

What is the current European context for the rapid expansion in international telecommunications?

As a preamble to this European context, we must briefly consider the European Community's overall economic policy goals and its proposed elimination of internal trade barriers, especially those regarding telecommunications services and equipment.

The European Community (EC) began in 1958 as a customs union to allow unhampered trade across its member states' internal borders. Its ultimate goal was to ensure the political and economic unity of its members:

> EEC policies aim to integrate and give cohesion to the social, industrial, and economic variations that exist between member states (Lera,1988, p. 8).

In June 1985 the EC adopted a "White Paper" encouraging it members to realize its goal of forming a unified market by the end of 1992 (Elling, 1988). This would result in Western Europe becoming the largest single market in the world with over 325 million consumers; hence, with its new-found strength through cohesion it could compete with the two other economic powerhouses, the United States and Japan (Toffler and Toffler, 1988).

The integrated markets of Europe 1992

This section discusses the EC's "Europe 1992" plan and highlights the role of telecommunications as an important element in the historic unification of the European Community. 500 years after their landing in the New World, Europeans today envision a "New Europe" of open borders and expanding internal markets. The notion of a united Europe is not new: in 1945, Winston Churchill suggested forming what he termed a "United States of Europe" (Elling, 1988). Years later, with the birth of the European Community in 1958, people, goods, and services had easier--but not perfect--means of flow between EC countries. Another major advance came in 1985 when the Commission of the EC adopted the visionary "1992 Plan" in the White Paper entitled, "Completing the Internal Market." This document defines what steps the EC must take to achieve a single, unified market structure by integrating the economies of the twelve member nations (Elling, 1988). This structure would give Europeans greater importance in world trade, especially in the face of continuous American and Japanese economic strength.

The White Paper seeks to unify EC members into a strong, cohesive political union that would eliminate barriers which inhibit intra-European flows of goods, services, and people (Harrison, 1988). Which barriers would fall? Harrison (1988) points out three to be eliminated: physical or frontier barriers that result in slow movement of people and transport of goods; technical barriers that lead to little standardization among competitors, especially in telecommunications; and fiscal or tax barriers that end in vastly different (and uneven) taxation schemes even among neighboring countries. Removing these and other barriers would result in more open markets and enhanced trade between EC member countries. In addition, a united Europe could gain more leverage in international trade. The European Commission estimates that the economic benefits alone would include some $200 billion in savings in the short term, creating 5 million new jobs, and raising the EC's gross domestic product by 7% (Harrison, 1988).

Considering the protected markets of the past in Europe, the openness emphasized in the White Paper is laudable. But what led the EC to undertake such vast change? Elling (1988) indicates that support has emerged across Europe for three principal reasons: transformations in the international economy; growing permissiveness in the domestic political climate of the leading EC countries; and the past instability of East-West relations which gave European leaders reason to cooperate in economic as well as political matters (p. 30).

1992 and the European Telecommunity

These reasons illustrate the changes underway in Europe's economic and political climate. They also evince realignment of European telecommunications policies as, in Boesveld's (1988) view, "there is no doubt that telecommunications will be a mainstay of Europe's economic development in the years ahead" (p. 199). Recognizing the important economic implications of the telecommunications sector as an engine of growth, especially with the influence of rapid digitization and the spread of fiber optics, two trends have appeared recently that will fundamentally change the telecommunications market in Europe, leading to a "European Telecommunity" (Boesveld, 1988). These trends are towards 1) liberalization of national telecommunication operators' policies, and 2) standardization between telecommunications equipment and protocols. Together they will afford greater competition in the EC market, stimulate new telecommunications services, and will create a large unified domestic market for European suppliers (Jones, 1988). Filippo Pandolfi, the EC Commissioner responsible for telecommunications, states that is why the commission is placing so much emphasis on rapid progress in telecommunications administrations, on the liberalization of services, and on international standardization (Madison,1989, p. 9).

The resulting European competitiveness could thus challenge the Americans and Japanese in world markets and in the long term, estimates West Germany's Chancellor Helmut Kohl, European integration would form a third hub in the global economic triad along with North America (the US and Canada) and Asia (Japan, China, Korea, and Taiwan) (Harrison, 1988).

In light of this goal, the EC offered proposals to coordinate its members' PTT strategies. These include developing ISDN, mobile communication services, and future broadband applications; creating a European Telecommunications Standards Institute (ETSI), to develop equipment standards; coordinating research and development efforts (the RACE program); and developing services and networks in peripheral areas of the Community (the STAR program), among others (Gilhooly, Atlanic).

The EC Green Paper on telecommunications and its impacts

These proposals led the European Commission to issue, in June 1987, its "Green Paper on the Development of the Common Market for Telecommunications Services and Equipment." This future-looking document seeks to ensure Europe's ability to compete in global telecommunications markets. In brief, it recommends separating regulatory from operating functions of Atlanic; opening terminal equipment markets to more competition, thus liberalizing the strict control over telecommunications equipment that many European countries have long maintained; and accepting the status quo of PTTs to retain their exclusive provision of telephony as well as the basic network infrastructure. The main goals of the Green Paper were twofold. First, it meant to create one large unified European telecommunications market enabling its equipment suppliers to compete effectively with the US and Japan (Jones, 1988). It also meant heavier investment in internal European telecommunications, since per capita spending on telecommunications equipment in Europe was only $32 compared with $80 in the US and $46 in Japan ("Towards a dynamic," 1987; Gilhooly, 1987). Second, the Green Paper seeks to stimulate growth in telecommunication services, including competitive value-added network services or VANS (Jones, 1988; Gilhooly, 1987). In 1988, service provision in the world market is estimated at $200 billion, with the equipment market worth $40 billion. Of that, Europe has 25% and 27%, respectively. The United States controls 52% of the service market and 48% of the equipment market, while Japan has 10% of each (Lera, 1988).

These imbalances pose problems for European leaders and policymakers, and their opinions vary greatly on what course of action would be the appropriate response for Europe to regain a competitive stance. On the critical side, some analysts argue that the Green Paper has not gone far enough to promote Europe's economic interests. Solomon (1987) argues against the Green Paper's lack of "potency":

> until there is a radical change in European political thinking about telecommunications, the dangers of Europe being left behind in the race to the broadband information era must be great. (p. 324)

Others are less skeptical and support most of the positions taken up in the Green Paper. The Executive Director of the International Telecommunications Users Group (INTUG), George McKendrick (1987), champions the Paper's proposals including the need for increased competition, plans to bring about a single European market, plans to promote broadband facilities/ISDN throughout Europe, and the harmonization of type approval. (p. 329) for future telecommunications equipment. Finally, others point out the importance of the document for its attention to expanding Europe's telecommunications sector as an economic vehicle to create national wealth and improve its quality of life; to realize, in fact, the European Telecommunity. To this end, Rich (1988) writes that

> countries are realizing that telecommunications policy can no longer be the sole domain of telecommunications bureaucrats because of the larger implications for their economies. (p. 7)

In sum, the European Community is facing the 1990's with its energetic Europe 1992 plan that will result in the largest unified market in the world. Its Green Paper proposals will improve Europe's telecommunications products and services, further expanding the choices for Community users. The biggest benefit of the Paper, however, would be the resulting boost in competitiveness for EC telecommunication companies that could better challenge US and Japanese firms for market shares in the vital and growing global telecommunication sector.

France's leadership role in telecommunications for 1992

Our discussion now focuses on France and its policies to lead this expansion of European telecommunications. We'll cover why French telecommunication policy centers on taking aggressive steps to achieve its leadership goals and what impacts this stance will have. We will see that the French government heavily invests economic and technical resources in ongoing telecommunications research and development. To focus the discussion, I pose the second preliminary question:

How is France positioning itself to compete in the context of this new European Telecommunity?

Official French telecommunications publications and government policy documents provide the clearest explanation to this question. We'll focus here on policy papers and reports that France Telecom, the French telecommunications authority, publishes since they provide the clearest overall picture of French telecommunications leadership efforts. We will see that France seeks to become an information-based society in large part by improving the country's network and services, ultimately to attract profitable, large-scale telematics and informatics. These steps are crucial to France's ultimate goal of leading Europe in telecommunications into the 21st Century.

France is taking a leadership role in the European Telecommunity through a combination of economic and political efforts. Economically, France supports the cooperative moves toward overall European integration offered by the EC's Green Paper. The French President, Francois Mitterand, saw Europe's "renewed integration" as a chance for his nation to demonstrate greater leadership in the Community (Elling, 1988, p.31). Politically, its role as an original member of the NATO Alliance, formed in 1949, and co-founding member of the European Community in 1958 imbue France with a high-profile stature as a leader among its neighbors. Too, the historical and cultural importance of the country (witness its recent bicentennial celebrating the 1789 French Revolution overthrowing the Monarchy) remain significant reminders of its strength in Europe. The largest country of Western Europe, France is situated at its center in a very strategic geographic location. These factors, plus a strong industrial and political infrastructure, enhance France's role as a leader in the Telecommunity of 1992.

French strategies to lead the telecommunications revolution

France's leadership stance extends most prominently to the European telecommunications arena. France is home to the fifth largest telecommunications market in the world, valued at US$4.5 billion in 1986 and expected to increase 51.1% to US$6.8 billion by 1995 (France: 1992 Telecom Studies, 1988, p. 6). Expanding its telecommunications sector is the key to France's leadership foresight. A long-term investment of 33 billion francs, or US$5.27 billion, focuses on further improving the digital makeup of what is already the world's most advanced public network (Anderson and Inan, 1989, p. 29). In 1988 alone, France invested US$902 million in improvements to its telecommunications structure (Resultats 1988, 1989, p. 1). The 25.8 million telephone lines installed by the end of 1988 represented a growth rate of 3.9% for the year (Resultats 1988, 1989, p. 1), and by 1990, 27 million lines will be in place.

The PTE and France Telecom: A Step Ahead of the Future

French telecommunications is facing the future with a forward-looking approach. The former post-telecommunications-telegraph (PTT) ministry was recently streamlined into a newer form called "postes, telecommunications, et espace," or the PTE (post, telecommunications, and space) to encompass the growth in space-based telecommunications services foreseen with expanding digital, mobile, and broadcast satellite services. Another change involved renaming the national telecommunications operator, now officially known as "France Telecom," effective January 1, 1988. This new trade name serves both a public relations function, emphasizing its role as France's network operator, and as a marketing statement, establishing a clear identity for itself domestically and abroad (Rapport d'Activite, 1987, p. 56). In a major promotional campaign undertaken by France Telecom in 1987 entitled, "Un Avenir d'Avance" ("A Step Ahead of the Future"), it highlighted its priorities of strengthening itself domestically by "building the networks of the future" while making quality its watchword (Rapport d'Activite, 1987, p. 56). This also positions France Telecom to expand further into the international telecommunications arena, not only facing US and Japanese firms, but especially other European competitors that will operate in the single European market of 1992.

Director General Marcel Roulet states that the overall goals of France Telecom are "to go from the telephone to telecommunications," in order "to meet the international challenge" (Anderson and Inan, 1989, p.30). Domestically, the world's highest level of network digitization allows France Telecom to carry voice, data, video, and text through its fully operational ISDN system ("France Telecom helps", 1989, p. 41). Internationally, France Telecom's goals include broadening its offerings with pan-European mobile telephone services, investing in the new Eucom value-added services project, and expanding further into the North American telecommunications market.

CNET: Telecom R & D leadership from under the seas to outer space

French telecommunications leadership depends on both innovation and quality in products and services available now and those under development. To this end, large investments in telecommunications research and development continue to provide a competitive stance. The National Telecommunications Research Center, or CNET (the French acronym), formed in 1944, is a national research organization under the direction of France Telecom. It researches all areas of telecommunications and provides expertise and technical assistance for France Telecom's ongoing operations. The CNET assists France Telecom with two major objectives: modernizing the telecommunications network and developing new technologies for the networks of the future, including broadband facilities (Rapport d'Activite, 1987, p. 28). Seven operational centers make up the CNET, two in the Paris region, two in Brittany, and one each in Grenoble, Rennes, and Caen. Of its 4200 personnel, some 2420 are directly involved in research support (CNET, 1989). So important is R&D to France Telecom that in 1987 it invested 2.7 billion francs (US$440 million), or 8% of its total volume of investments of 34.2 billion francs (US$5.5 billion) in telecommunications research (Rapport d'Activite, 1987, p. 6).

France Telecom directs the R&D efforts of CNET in concert with its overall strategies in the telecommunications market. Developing new technologies and the services they provide are critical to these efforts. CNET research trends involve internal French network applications and external technology sales and transfers. The primary trends are towards 1) further digitization of the French network, 2) space-based telecommunications, including digital business services and broadcasting applications; and 3) fiber optics development, especially in high-wavelength monomode technology for land-based and undersea systems ("Recherche et expertise," 1988).

Major R&D accomplishments to date are numerous. The French videotex system, Minitel, came from CNET labs and is now the leading such system in the world. According to Director General Roulet (1989),

> the commercial success of French videotex is well-known: at the end of 1988, more than 9000 services were accessible from around 4.2 million terminals ....and France Telecom's turnover from Minitel in 1988 was approximately 1.5 billion francs [US$242 million]. (p. 2)

Minitel logs over 30 million calls a month (Resultats 1988, 1989, p. 1), paying out some 1.35 billion francs (US$218 million) to independent providers of "Kiosque" services ("Performance Data 1988," 1989, p. 3). While 1988 figures show an 8% decrease in home use of Minitels since 1987, business applications have grown 26% from 1987 to 1988 and France Telecom forecasts further growth in this sector (Roussel, 1989c, p. 12).

Another important success of CNET is space-based telecommunications, especially through its development program for France's Telecom-1 national telecommunications satellite network.

Two Telecom-1 satellites carry French business, governmental, and broadcast communications plus they assure connections with France's overseas departments. On the international satellite scene, CNET is a participating party to three major organizations: Intelsat, Eutelsat, and Inmarsat (CNET, 1989). In addition, it participates in many international standards bodies, including those of the ITU, the CCIR and CCITT; in the European community, the CEPT; and in European telecommunications initiatives such as the RACE, ESPRIT, and COST R&D programs (CNET, 1989).

Fiber optics technology is the third major area that the CNET develops extensively. As long ago as 1980, France Telecom linked two Paris telephone switches in a trial with a CNET-developed optical fiber system operating at 34 Mbit/s, the first such attempt in the world (Rapport d'Activite, 1987, p. 22). The success of this test led to broad-ranging plans, undertaken in 1982, to "rewire the nation" with optical fiber (Mexandeau, 1985, p. 5). The goal is to develop an all-optical public network, and CNET research is helping to achieve this. To date, France has the world's most advanced network with 71% digitization of its interurban tranmission equipment while over 60% of its automatic switching devices are time-division multiplexed (TDM) ("Performance Data 1988," 1989, p. 3). Other factors include the growth of the TRANSPAC public packet switched data network, now the largest of its kind in the world ("Performance Data 1984," 1985, p. 8).

These successes result from the French focus on introducing nationwide ISDN services. In this, too, CNET has been pivotal by developing proprietary techniques and also coordinating standards with other European PTTs. France has been leading Europe in ISDN development since 1983 when the CNET-RENAN Project began with an ISDN trial in Brittany. Commerical ISDN services began there in December, 1987 and were inaugurated in the Paris region in 1988. By 1990, the entire nation will have ISDN services under the new French trade name, NUMERIS. By moving toward an all-digital ISDN structure, France Telecom will provide digital connections through a single, universal plug all the way to a subscriber's set, whether it be a telephone, computer, video signal, or facsimile machine (Vallese, 1987). This ensures the integration of network services through digital transmission, assuring France its "network of the future" based on all-optical, broadband technology.

Current transatlantic telecommunication links

Now that we've seen how France positions itself to lead Europe in telecommunications technology, we can consider the communication links between France and the US in the third preliminary question:

What are the current media and methods used to supply telecommunication links between France and the US?

Two telecommunications transmission media link France to the US, satellites and undersea cables. In this section we'll discuss satellites, and in the next, cables. We'll first look at domestic satellite communications in France.

Domestic satellite communications in France

Telecom-1, the French national telecommunications satellite system, begun in 1979, launched its first satellite in 1984 (Voge, 1986). A second was launched in March 1988 to ensure 100% backup. Together they provide domestic telephone, data, and television service to France and most of its overseas departments. Video transmissions relayed via Telecom-1 also cover most other European countries and account for a large portion of the system's operation which had a growth rate of 260% in 1987 (Rapport d'Activite, 1987). Another important use is for the TRANSDYN digital data services which offers high quality data transmission at varying bit rates, up to 2 Mbit/s,to business users (Voge, 1986). At the end of 1987, the Telecom-1 TRANSDYN digital TDMA business service achieved an average throughput of 256 kbit/s, double that of 1986 (Rapport d'Activite, 1987, p.34). Also, Telecom-1 satellites deliver the 5th and 6th TV channels to France. The next generation of satellites, dubbed Telecom-2, is in the planning stage and will replace Telecom-1 spacecraft by the end of 1991 (CNET, 1989).

Space platforms connect France with the world

Beyond their specifically domestic satellite communications, France participates in several important satellite organizations, including Eutelsat, Inmarsat, and Intelsat. The regional Eutelsat network (European Telecommunications Satellite Organization) is the satellite system that Howell (1986) calls "world broadcasting's most ambitious regional satellite system" (p. 255). It coordinates satellite communications applications for Western Europe that include television broadcasting, digital telephony, and business data transmission services. France Telecom ranks second as Eutelsat's investors with a 14% share (Rapport d'Activite, 1987). Inmarsat (the International Maritime Satellite Organization), begun in 1982, is the navigational satellite network providing maritime positioning telemetry. It also offers duplex telex and telephony, and will soon offer data transmission services and communication with aircraft and mobile land-based vehicles (Gerbner and Siefert, 1984). France owns a 2.5% share in Inmarsat and has 115 ships equipped with its navigational equipment (Rapport d'Activite, 1987).

The French investment in Intelsat

France's largest and most important association is with Intelsat (the International Telecommunications Satellite Organization), a non-profit consortium of 114 members that operates 17 satellites and provides 2/3 of the world's international voice, data, and video traffic, including most live TV transmissions. Over 70% of Intelsat's traffic is voice communications (Gershon, 1987) which accounts for 75% of its income (Howell, 1986, p. 254). France Telecom uses three main services from the Intelsat spacecraft: telephony; television broadcasting, mainly to connect to its overseas territories; and digital data services, including the International Business Services that transmit at 64 kbit/s. France has a 4.5% investment in Intelsat's shares, the third largest amount behind the US and the UK (Rapport d'Activite, 1987). These affiliations point out the importance that France places on maintaining shares in these regional and international communications agencies.

France and transatlantic telecommunications cables

We now turn to international telecommunications linking France to the US by cable. Undersea cables use two media, copper wire and optical fiber. Those cables installed before 1984 were made from coaxial copper wire and used analog technology (Rowbotham, 1987). The newest cable, installed in 1988, uses fiber optics and employs all-digital techniques. The benefits of fiber technology are so great that they have completely replaced copper coax as the medium of choice for undersea cables (Jacobs, 1988).

The worldwide web of undersea cables

France has historically held an important role in the development and installation of undersea cables in order to connect with the US, the UK, and nearby Mediterranean countries. The world's first submarine cable, a telegraph line, linked France to the UK in 1851 ("Cables blaze new trails," 1981). Since then, the oceans of the world have become a "web of undersea cables" ("Light beneath the waves," 1983). Four countries have dominated the design and manufacture of cables: the UK, France, the US, West Germany until 1970, and Japan after 1969 (Rowbotham, 1987, p. 7) By 1981, the UK's Standard Telephone and Cable Company, STC, controlled about

38% of the world market; France's Submarcom held about 25%; the US-based Western Electric, part of AT&T, had about 25%; and Japan's Nippon Electric and Ocean Cable Co. held the remaining 12% ("Cables blaze," 1981).

A brief survey of previous systems identifies the importance of undersea cables for transatlantic telecommunications. In 1858, the first transatlantic cable was used for telegraph service. In 1956, the first re-amplified signal telephone cable, called TAT-1 (TransATlantic repeatered cable number 1) linked the US, Canada, and the UK with 36 voice circuits. Technical improvements followed that increased transmission capacities significantly. TAT-7, laid in 1983, carries 4246 voice-grade transatlantic circuits costing $13.50 each at the time of its installation, compared to the $382 cost per circuit for TAT-1 (Rowbotham, 1987, p. 9). Since 1956, some 250,000 km of cable were laid between the continents of the world ("TAT-8: fibre optics," 1989). Those remaining in service across the Atlantic, TAT-4 and TAT-6 linking France and the US; TAT-5, Spain to the US; and TAT-7 from the UK to the US, are the last copper cables.

Undersea fiber cables: the future of telecom is hair-thin glass

Over thirty years ago the first submarine repeatered cable tied Europe to North America with copper wire. Today, fiber optics in undersea applications has led to "a complete cessation of the construction of coax systems" (Rowbotham, 1987, p. 5). Optical fibers offer economies of scale over copper in several important ways. They are smaller, lighter, easier to manufacture and lay at sea; their low-signal loss design and low-dispersion properties allow much greater distances between submerged repeaters, saving costs of materials; and, significantly, they have much larger inherent circuit capacities (Podmore and Faguy, 1986). Fiber also offers immunity to electro-magnetic and radio-frequency interference. Too, whereas coax copper uses analog electronics which can be multiplexed to double its capacity, fiber cables achieve a five-fold increase by circuit multiplication through its use of digital technology. This fact underlies the observation that undersea fiber cables are "a key step in the evolution to an end-to-end digital transmission capacity spanning the globe" (Jacobs,1988, p. 21).

The evolution to global digital transmission continued with the installation of four optical fiber systems since 1985. Optican-1 links Tenerife to the Gran Canaria island; the UK/Belgium-5 goes from Broadstairs to Ostend; the Honshu to Hokkaido, Japan cable; and the Okinawa to Kyusu link (Rowbotham, 1987, p.10). Transoceanic cables necessarily take longer to plan and install, but they usually connect important regions that rely on high volume telecommunications lines. The Pacific Ocean is the site of the HAW-4/TPC-3 project, actually two cables, that links California to Hawaii (Hawaii-4) and continues on to Japan, splitting off to Korea, Hong Kong, and Guam (TransPacific-3). This is part of a scheme to link Great Britain with Japan and the Far East to expand telecommunications access for the global financial community ("Press notices," 1989).

TAT-8: the first transatlantic fiber optic cable

The global fiber cable network took a leap forward on December 14, 1988 when the first transatlantic fiber optic cable, TAT-8, opened for service linking Penmarch, France and Widemouth, England to Tuckerton, New Jersey. TAT-8 doubles the current transatlantic cable capacity with digital voice, data, video, and text telecommunications. It supplies about 40,000 voice-grade circuits over two operational pairs of fibers, while a third pair is retained for backup needs. A submerged branching unit off the coast of France splits the cable into a "Y" shape that provides three direct fiber pairs: France-US, France-UK, and US-UK. The main segment is 5830 km long, from the US landing point to the branching unit. From there, the British and French segments are 540 and 330 km long, respectively ("Press notices," 1989). The three companies that constructed TAT-8, AT&T, Britain's Standard Telephone and Cable (STC), and France Telecom's subsidiary, Submarcom, adopted universal standards for this first-generation system, including a 1.3 micron wavelength and common line codes for the cable. Each pair of fibers carries 140 Mbit/s of capacity, for a total of 280 Mbit/s over the two operational pairs. These standards were necessary so that each country could build and install its own section of cable up to the branching unit, thereby assuring each country's domestic cable industry a portion of the project, and hence, the profits. In fact, AT&T's bid to construct the entire cable was 7.2% lower than the contract ultimately approved in order to accomodate "certain countries' demands for participation by their domestic industries" (Johnson, 1987, p. 292). The financial funding of the cable is complex: 29 telecommunications administrations and private companies on both sides of the Atlantic jointly own TAT-8. Three main participants, however, together own 62% of the system: AT&T, 36.7%; British Telecom, 15.5%; and France Telecom, 9.8%. The TAT-8 cable was designed in 1981, even before TAT-7, the last copper cable, was commissioned (in 1983) due to growing demand for transatlantic circuits ("TAT-8: fibre optics," 1989). TAT-8 follows the same route as the previous TAT-3 cable, comes into service 25 years after TAT-3, has a 25-year lifespan, and will provide 25 times the telephone traffic capacity of TAT-3 over its US-UK section (Rowbotham, 1987, p. 10).

TAT-9 and PTAT-1: the second generation FOTS systems

These facts are indicative of the growth in optical fiber as the medium of choice for undersea telecommunications. Already, scientific advances in lasers, transistors, and glass technology are improving the ability of fiber to carry ever more information. Thus, the "second generation" of submerged cables are already being installed. Following is a short overview of those systems underway.

TAT-9 will be the second transatlantic fiber cable, 9000 km in length, and will begin operation by the end of 1991. It will use 560 Mbit/s fibers to carry up to 80,000 voice circuits, doubling TAT-8's capacity ("TAT-8: fibre optics," 1989). TAT-9 will connect points in the US and Canada to France, England, and Spain with two submerged branching units that will control real-time circuit switching among its users, a first for underwater systems. With traffic levels forecast to grow enormously over the coming years, there is already some indication of a need for even more sophisticated technologies to further increase circuit capacity.

In the short term, another transatlantic cable enterprise is currently underway. The Private TransATlantic cable, or PTAT, is the first privately financed system to cross the Atlantic. It will consist of two cables, PTAT-1 and PTAT-2. Due to begin operation in July 1989, PTAT-1 is being jointly developed by Britain's Cable and Wireless Group (including Mercury Comnunications) and America's US Sprint. PTAT-1 will connect the UK and Ireland with the US and Bermuda using two submerged repeaters ("The PTAT system," 1989). The system will carry broadband telecommunications including ISDN and voice and data services for national and corporate users. PTAT-1 will carry three fiber pairs operating at 420 Mbit/s each, retaining a fourth pair in reserve. It will use about 140 repeaters over its 7000 km length (Calton et al., 1989, p. 78). PTAT-2 is planned to come into service in the early 1990s.

The North Atlantic will also see other fiber systems in the 1990s. The Submarine Lightwave Cable Company plans to install its Transatlantic Video Cable in the near future. It will carry 144 broadcast TV channels (Podmore and Faguy, 1986, p. 350). This digital capacity could also be used for voice, data, or other telecommunications services if needed or in the event it can't fill its capacity with TV programming alone. Finally, as transatlantic traffic continues it upward growth, a TAT-10 cable could be organized to fill the need for capacity. These systems highlight two facts: one is the importance of the North Atlantic region as the central site for telecommunications links between Europe and North America; the other is the reliance on submarine fiber cables as the favored transmission medium to supply their growing capacity needs. Later on we will compare fiber and satellite technology and see why fiber is overtaking satellites for delivering international telecommunications.

Advantages of fiber optics and resulting French reactions

We have explored four subjects that frame the topic of this thesis. First we overviewed how the explosive growth in telecommunications capacity needs led to the development of new digital technologies. Next we answered three preliminary questions to narrow the discussion. We considered the European context of rapid telecommunications growth and the EC's Green Paper. We described the French leadership position in the new European Telecommunity and how CNET research supports this stance. Last, we discussed transatlantic telecommunications and the rapid rise in use of fiber optic cables. We can now address the primary research question of this thesis:

> **How have the technical advantages of transatlantic fiber optic cables impacted on France's investment in communication satellites?**

We will divide the answer to this question into three separate sections which allows us to identify and analyze the pertinent factors of each:

The technical advantages of fiber over satellites.

The French policy goals for choosing fiber optics.

The economic benefits of investing in fiber cables.

Each of these sections contribute important reasons to why France is increasingly choosing fiber technology over satellites for its transatlantic voice and data telecommunications. Regarding the first section, my research shows that fiber optics offer certain technical advantages over satellites, including high reliability, quality, and security without much signal "propogation" or time delay--fiber`s primary advantage. In the second section I show how French policy goals also impact heavily on the choice of fiber. France is pursuing a high technology future through concerted state planning of its telecommunications sector which contributes a significant portion of revenues to the French economy. After the 1978 Nora and Minc report on computerizing society, France developed a national industrial policy resulting in three major telecommunication objectives. The first is modernizing the domestic networks while preparing for ISDN leadership in Europe. Second is contributing to harmonization between regional PTTs to support the Europe 1992 Plan. Third is making France a focal point for telematics by attracting international telecommunication flows with a nationwide fiber optic infrastructure. The final section explains the economic advantages of transatlantic fiber cables over satellites. The primary factors include France's advantageous position vis-a-vis the increasing competition in the undersea fiber cable market, France's decision to invest in high technology fiber systems to strengthen its economic future, and how it uses its industrial capacity and expertise in the fiber cable industry to earn export income. Together, these factors combine to explain the major reasons for France's shift to fiber optics over more satellites for its voice and data telecommunication links to the US, as the following paragraphs will explain more fully.

Certain technical considerations led the French to choose fiber optic cables over more satellite capacity to increase its international telecommunications

We consider first the most important technical characteristics of communication satellites and fiber optic cables. Our analysis begins with the fundamental factors for choosing one technology over another. Experts cite four primary factors: cost, reliability, quality, and security. The "principal criterion" for choosing one telecommunications medium is "cost per channel mile" (Whitty and Roberts, 1988, p. 9.1). Reliability involves the length of time a system is built to operate and for how long it does between failures (Goldstein, 1988). Quality in transmission connotes accuracy and is often specified in terms of bit error rate probabilities (Jacobs, 1988). Security means immunity from external interference (Gershon, 1987), from physical damage, and invulnerability from eavesdropping (Whitty and Roberts, 1988). Other factors include bandwidth, wavelength, attenuation, speed, and channel capacities when multiplexed. We will analyze cost factors in the section on economic benefits. In the following paragraphs we focus on technical attributes where we see fiber's superiority in most of these areas.

Reliability factors for satellites and cables

We discuss now the reliability factors of transmission media. Goldstein (1988) defines reliability as a "measure of unexpected failure of network components" (p. 15.7). He indicates that the "mean time between failures (MTBF)," given in hours or days, is the typical mode of measurement. Both satellites and undersea fiber cables operate in harsh environments and high reliability is paramount to their successful operation: temperatures in space are at absolute zero while those at on the ocean floor, at depths up to 5500 meters, are 2 degrees centigrade (Rowbotham, 1987).

Satellites have traditionally been very reliable. As we concentrate here on Intelsat spacecraft delivering transatlantic telecommunications, we'll focus on its record. Director General Dean Burch (1988) cite's Intelsat's space segment operational reliability over the years as 99.9% (p. 26). This figure applies to spacecraft built for Intelsat from 1971 through 1985, each of which had a design lifetime of 7 years (Colino, 1985, p. 26). With improvements in electrical storage technology, new nickel hydrogen batteries now provide twice the capacity of older cells, and may support 15 years of service (Wheelon and Miller, 1988, p. 15). The newest generation, Intelsat-VI, "the largest and most sophisticated commercial communications satellite either in orbit or in production"

(Burch, 1988, p. 26) is built for 10 years of operation (Colino, 1985, p. 26). However, repairs on orbiting satellites are not a practical reality: if they fail and cannot be remotely restored, they are usually abandonned. Identical satellites are often orbited in tandem to provide 100% backup in case of the complete failure of one.

The reliability of undersea cable has also been high, averaging between 93 and 95 percent for analog copper cables (Burch, 1988, p. 27). This figure rises substantially with the first generation of fiber cables. The TAT-8 system is designed to operate for 25 years with no more than three ship repairs (Horne and Langridge, 1985, p. 14) through a combination of extremely strong fiber and ultra-reliable optical components (Jacobs, 1988, p. 20). Stringent testing of microprocessors and optical receivers and amplifiers result in the highest-quality components going into each repeater. Another important factor to ensure near-perfect operation is to build in critical component redundancy: TAT-8 and other undersea systems have spare fiber pairs and standby transmitters in each submerged repeater which can be switched on remotely (Rowbotham, 1987). These precautions provide submarine fiber cables an overall reliability of 99.98 percent, or an average annual projected downtime of only 0.02 percent (Goldstein, 1988, p. 15.12). This translates into the TAT-8 cable having a bit error ratio (BER) of less than 4.4×10^{-8} in 24 hours and no more than 4 seconds per day with a BER > 10^{-3} (Rowbotham, 1987, p. 12). These figures are particularly important for real-time applications that include data transmission and television broadcasting.

Quality of service issues for satellites and fiber

We next discuss quality of telecommunications service. Quality implies accuracy of transmission, often measured as exactness of reproducing an originating signal at its destination (Goldstein, 1988, p. 15.5). We'll consider first communication satellites which transmit and receive microwave radio signals from an altitude of about 36,000 km (22,300 miles), positioned in an arc over the equator in a geosynchronous orbit (GSO). Their signals must pass through the earth's atmosphere which sometimes adversely affects their accuracy in bad weather, and they may also experience interference from other satellites' signals (Potts, 1988, p. 5.19). These two facts have significant effects on the quality of transmission that satellites can deliver. Of these, the time delay inherent in satellite transmission constitutes a definite drawback ("Satellites and submarine cables," 1984). Since signals require between 240 and 275 milliseconds for demodulation and to traverse the distance from earth to satellite each way, two-way voice conversations may have an annoying echo. If the echoes are loud enough, a one-half second delay in communication can result (Potts, 1988, p. 5.19). Modern echo cancellers can reduce the irritating echo, but the delay remains. Data communications throughput is somewhat hampered by the inherent time propogation of satellites (Pritchard, 1988, p.23). To eliminate propogation problems, data transmissions must employ special algorithms called forward-error-correction techniques (Potts, 1988, p. 5.19).

When AT&T started to use satellites for long-haul transmission, it received complaints from computer center operators who wanted terrestrial-only lines to eliminate the time propogation. AT&T thus had to offer land lines as another class of service to business customers (Podmore and Faguy, 1986, p. 346). The problems of time delays led AT&T to convert much of their satellite traffic to fiber optic cables. Thus, AT&T reduced satellite-delivered domestic voice traffic from 25,000 circuits by 1981 to 11,000 by 1985 (Lowndes, 1985, p. 66).

Fiber systems have none of the problems that affect the quality of satellites' signals. The fundamental measure of the quality of digital transmission is its bit error rate (BER) (Goldstein, 1988, p. 15.11). Fiber optics have such high levels of accuracy that studies suggest it can achieve BERs of less than one error per 10 trillion (10,000 billion) bits of information transmitted (Gershon, 1987, p. 23). This is due to their all-digital transmission technology that results in an almost unnoticeable propogation delay. Experts call this "the biggest advantage of optical fibers over satellites in long-distance point-to-point communications" (Podmore and Faguy, 1986, p. 345). Thus, all forms of traffic--voice, data, video, text--can be transmitted directly without converting to another form of signal.

Physical and communications security of satellites and cable

The security issues surrounding satellite and fiber systems present the next topic. Security requirements include both physical and communication factors. Satellite systems have some advantage in physical security as the spacecraft are in orbit, out of reach of tampering (Whitty and Roberts, 1988, p. 9.20). However, earth stations could still be targets of violence or sabotage. Another possibility is that satellites could be damaged during transport, launch, or while in operation. Recovery of damaged or non-functional satellites in the past has had little success. Fiber cables, on the other hand, may be more vulnerable physically since they are land-based over their entire length, although submerged. They face risks of being cut due to seabed activities like fishing or shipping, as happened off the US coast in April 1989, or even by shark attacks (Chu et al, 1986, p. 52). As a result, operators take special precautions to secure their cables: for example, in shallow waters (up to 950 meters in depth), TAT-8 is buried on the continental shelf by special "cable ploughs" that dig trenches up to 60 cm deep and then lay and cover over the cable (Smith, 1988, p. 41). Since undersea cables operate in waters up to 5500 meters deep where hydrostatic pressure reaches 6900 psi (Rowbotham, 1987, p. 5), a special pressure-resistant housing made of steel wires wrapped around a thick-walled aluminum tube serves as protection against "micro-bending" of the fibers themselves and also as a water barrier in case of cable rupture or damage by shipping or shark attack (Fitchew, 1986, p. 28).

Another issue of security concerns the communication integrity of telecommunications signals. Satellites, using radiowave signals, are susceptible to interception by unauthorized parties, to interference from environmental conditions, and to electro-magnetic interference

(EMI) as well as radio-frequency interference (RFI) (Gershon, 1987, p. 23). On the other hand, fiber cables, especially undersea systems, are "virtually invulnerable to eavesdropping" (Whitty and Roberts, 1988, p. 9.20). They are also immune to EMI, RFI, and all outside noise sources, unlike satellites (Gershon, 1987, p. 23). In addition, fiber systems are free from channel crosstalk, so many simultaneous conversations or data transfers can be multiplexed over the same fiber with no risk of unintended disclosure.

Summary of remaining technical criteria

We move on to a brief summary of the other major technical criteria of satellites and fiber optic systems: their bandwidth, operating wavelength, signal attenuation, operating speed, and overall channel capacity.

Transmission bandwidth

Our first criterion is bandwidth, the basic measure of transmission paths. Bandwidth is the range of radio frequencies a communication system is designed to operate in out of the entire electromagnetic spectrum. Satellites utilize the Super High Frequency part of the spectrum, especially three primary frequency bands: C-band, 6/4 Ghz (gigahertz); Ku-band, 14/12 (sometimes 11) GHz; and Ka-band, 30/18 GHz (Howell, 1986, p. 248). Fiber systems operate with pulses of laser light and are digital systems which are not measured by bandwidth. The capacity of digital transmission instead depends on its bit rate or flow of bits per second (bps). The three usual ranges for digital channels are: low speed, 110, 300, and 1200 bps; medium speed, 2.4, 4.8, 7.2, 9.6, and 14.4 k (thousand) bps; and high speed, 19.2, 32, 56, 64, and above thousands of bps (Goldstein, 1988, p. 5).

Operating wavelength

The second criterion is operating wavelength. Satellites' analog radio signals are measured in terms of the length of the radio wave for one cycle. The Super High Frequency band that satellites operate in uses microwaves. Fiber cables, by comparison, use laser light measured in micrometers or microns, one millionth of a meter. The current generation of undersea fiber cables use 1.3mm (micrometers) wavelengths, while the next will employ 1.55 mm, the two low-loss bands in silica-based optical fiber systems (Rowbotham, 1987, p. 12).

Signal attenuation

Transmission losses are due to signal degradation (inherent attenuation properties) over distance. Attenuation of satellite signals result from the loss of signal stength sent from the spacecraft to the receiving antenna, or from a sending antenna to the satellite. Employing more powerful transmitters helps reduce the signal loss due to attenuation. Fiber optics too display signal attenuations, but due to refinements in manufacturing the loss has become minimal (Gershon, 1987, p. 24). The state of fiber technology today had reduced attenuation to 0.35 dB/km for 1.3mm wavelength fiber and to 0.2 dB/km for 1.55mm fiber, essentially the theoretical limits for silica-glass (Jacobs, 1988, p. 8.1). With reductions in fiber attenuation, fewer repeaters are needed to transmit signals (than with coax cables) which results in cost savings of hardware and installation.

Operating speed

The speed of operation for satellites and fiber optics varies due to the design of each technology. Briefly, both radio waves and laser beams theoretically operate at the speed of light. But the transmission media they employ and the distances they cross affects their operation. As previously stated, satellites transmit radio waves through the atmosphere 22,300 miles to and from earth, causing a one-quarter second delay in each direction. Yet fibers optics, to their advantage, send laser-generated photons through a medium of "glass so pure that, if oceans were made of it, you could see the seabed" (Podmore and Faguy, 1987, p. 341). Consequently, fibers have an inherent ability to transmit huge volumes of information over long distances at high speeds. It is estimated that by 1991, commercial fiber systems will achieve transmission speeds of 2.4 gigabits per second (gb/s). AT&T's Bell Labs research has already shown experimental work on fibers reaching 4 gb/s (Gershon, 1987, p. 24).

Channel capacity

Channel capacity is the last technical criterion we will consider. Capacity depends on bandwidth for satellites and on bit rate for fiber optics: each can multiplex signals to increase their carrying capacity. The newest Intelsat-VI spacecraft, for example, can carry 80,000 telephone conversations over its Atlantic route (Wheelon and Miller, 1988, p. 13), while the TAT-8 cable will carry 40,000 conversations and the TAT-9 will double that figure ("TAT-8: fibre optics," 1989). As we have seen, the overall trend in international telecommunications is towards digital channels offering larger capacities and higher bit rates as is exemplified in the Atlantic marketplace.

Policy goals also led French policymakers to invest in submarine fiber cables over further Intelsat satellite capacity between France and the US.

We move on in this section to discuss the policy goals that led to heavy French investing in new submarine fiber cables over more satellite capacity. First, we'll look at French telecommunications policy structure, then at its three primary policy objectives and how they're being implemented.

The Nature of the French state

Our discussion of French telecommunications policy begins with the nature of the French state. We will next look at its industrial and information policy, and then the trend toward deregulation and competition in the French telecommunications market.

France has one of the most interesting histories of any modern state. Long a monarchy, 1989 marks the year that France celebrates the bicentennial of its revolution establishing the democratic republic that shaped its future course. Social upheavals continued through the Restoration years until the stabilizing effects of Napoleon Bonaparte's dominance framed the current structure of French society. The nineteenth century saw France rise to economic strength through industrial growth, only to be shattered by the ravages of two world wars. In 1958, Charles de Gaulle became premier and passed a new constitution which featured strong executive power. As President of the "Fifth Republic," de Gaulle led France's economic and technological advancement, especially through support of the European Economic Community. The 1981 election of socialist President Francois Mitterand over then-President Valery Giscard d'Estaing changed the political direction of the country, but the tradition of a strong head of state excercising central authority remains (Ardagh, 1986). The Prime Minister in France is the head of government who appoints ministers and ulimately forms the government (The World Almanac, 1985, p. 539). Its ongoing operation depends upon cadres of well-trained technocrats, mostly graduates of elite "grandes ecoles" (state-run institutes for administrators, economists, engineers, etc.) who have a long tradition of centralized control over budgetary and policy matters (Ardagh, 1986, p. 73). The French term "dirigisme," meaning state interventionism via a planned economy, sums up the French government`s overall fiscal philosophy. Examples include the nationalization of important economic sectors such as oil (Elf-

Aquitaine), automobiles (Renault), aerospace (Aerospatiale, Air France), aircraft (Dasault-Breuguet), banking (Bank of France), and others including railroads, chemical, aluminum, electronics, and the telecommunications industry (Ardagh, 1986, p. 56).

French Industrial and Information Policy

The industrial and information policies of France devolve from this system of concerted planning. In 1988, the renamed Ministry of Posts, Telecommunications, and Space (the French acronym is PTE) has two principal components: the Direction General des Postes, the postal authority; and the Direction General des Telecommunications, or DGT, the state telecommunications authority which is by law the "sole authorized provider of public telecommunications services in France" (Coustel, 1986, p. 233). The mission of the DGT is "to implement and operate all telecommunications networks and services" (Voge, 1986, p. 106).

A short profile of the French policy structure follows. Effective January 1, 1988, the telecommunications authority acquired the new name "France Telecom" to underscore its expanded commercial activity. France Telecom is the national network operator while "France Telecom International" (FTI) is the external division that covers all activities outside the country ("Doing business," 1988, p. 53). The Director General (DG) of Telecommunications is the chief executive of France Telecom, reporting to the Minister of PTE, a political appointee. Here we can pinpoint the overall policy-making authority for French telecommunications. The Ministry of PTE "harmonizes" the DGT's policies, exerting governmental control by acting as the de facto regulator of French telecommunications (Coustel, 1986, p. 233). This regulation highlights the government's efforts to retain control through dirigisme. Although different parties have run the country in recent decades, dirigisme remains the dominant tool by which the technocratic network maintains continuity over the ever-shifting political winds in France.

We now look at the foundations of French telecommunications policy. An important chapter was written in the mid-1970's when the government took steps to investigate the impacts of "information commerce" on its economic and social health. In late 1976, President Valery Giscard d'Estaing, wrote that

> The applications of the computer have developed to such an extent that the economic and social organization of our society and our way of life may well be transformed as a result. (Nora and Minc, 1980, p. xvii)

Soon after, in 1977, Ministry of Justice Magistrate Louis Joinet addressed an OECD meeting on transborder data flows (TDF). Questioning the impacts of TDF leading to losses of national sovereignty, he observed that

> Information is power and economic information is economic power. Information has an economic value, and the ability to store and process certain types of data may well give one country political and technological advantages over other countries (Pipe, 1984, p. 197).

The French government then began to export data processing products, and started to investigate "the informatization of society" (Pipe, 1984, p. 197). In December 1976, President Valery Giscard d'Estaing entrusted Simon Nora, Inspector General of Finance, to conduct exploratory research on computerizing society and how it should be carried out. Nora enlisted Alain Minc of the Ministry of Finance and a team of specialists for the project. Nora and Minc delivered their historic report, entitled "L'informatisation de la societe," ("The computerization of society") in January 1978. It contained one major summary document and four supplementary volumes of research papers and appendixes. Noted communications scholar Daniel Bell concludes, in the preface to the English book version of the Nora and Minc report, published in 1980, that

> The "computerization of society" will shape...an extraordinary transformation, perhaps even greater in its impact than the industrial revolution of the previous century....It is a rare moment in cultural history when we can self-conciously witness a large-scale social transformation. (Nora and Minc, 1980, p. x)

The report identifies computers and data processing as key technologies for France's economic well-being. It points out that future developments in an information economy depend on the spread of telematics, the convergence of telecommunications and computer technologies, and the government's role in telematics. Nora and Minc delivered recommendations on how France should implement wide scale information technology--leading to possibly decentralizing some aspects of French society and its political structure through use of telematics--and what changes may occur by such profound sociological moves. Bell points out in response that

> the importance of the Nora and Minc report is that it calls for and prescribes a unified national policy to utilize the new technology of "telematics." (Nora and Minc, 1980, p. xv)

Here we find the cornerstone of the information policy active in France today. Based upon scholarly analysis and implemented by the President of the French Republic, the Nora and Minc report examined the impacts of new technology on society and how government policy must adapt to meet the economic and social challenges it imposes.

Deregulation and Competition in French telecommunications

Adaptation in the French telecommunications structure reflects the liberal policy trends evolving in many European telecommunications administrations, especially in preparation for the unified markets of Europe 1992. The general trends are toward deregulating national telecommunications operators with a concomitant rise of competition in specific market segments. Deregulation as used here means separating regulation from supply and operational functions. Competition is leading European telecommunications administrations (the PTTs) to restructure their policies to meet two goals of the Green Paper: liberalizing the EC's telecommunications terminal equipment and service-provision markets (Ungerer, 1988, p. 192). This takes place in a general context of ensuring the exclusive provision of the network infrastructure by the national operator. The Green Paper does not mandate this exclusivity: on the contrary, it insists that each EC member determine its own telecommunications structure, either monopolistic or competitive (Ungerer, 1988, p. 204).

The trends in French telecommunications policy reflects these winds of change blowing across the continent. Only five years ago, one PTT official expressed his government's view that "telecommunications is a textbook example of a natural monopoly," the dominant wisdom in most European PTTs in 1984. But the PTTs are shifting towards more market-driven policies calling for Europe-wide deregulation of telecommunications. The French are slowly moving with the tide, recognizing that some forms of deregulation could be "compatible with the French PTT's legal monopoly on the tranmission of information" (Bustarret, 1984, p. 2).

The current telecommunications policy in France is a blend of regulation and competition, or "monopoly and liberalism," according to PTE Special Advisor Jean-Paul Voge (1986, p. 114). He says the current monopoly structure supports the DGT--now called France Telecom--as the "sole authorized provider of public telecommunications services," (p. 116) with the PTE ministry acting as the telecommunications network regulator. This combination as network provider and regulator defines the contemporary French situation: "the supply of telecommunications services in France is a regulated monopoly" (Coustel, 1986, p. 233). Within this context, the state bestows a "power of authorization" on the PTE minister who assures equal access to the public network. Voge (1986) points out that the minister could grant the PTE or third parties authority to operate telecommunications facilities; in practice, however, the PTE totally controls the network while the private sector is authorized to compete in certain niches such as the terminal equipment and PABX markets. Voge (1986, p. 114) cites the principal benefits deriving from this "flexible and liberal" telecommunications structure:

* **universal service throughout the national territory**
* **reliable, secure, and high-quality networks**
* **equal tariffs nationwide that promote regional development and do not favor high density routes**
* **common technical standards for economies of scale**

Today, two major forces are challenging this structure: new competition and regulatory reform. Regarding the former, France is facing growing domestic pressures to adopt a more competitive telecommunications environment to prepare itself for the unified markets of Europe 1992. The French industry press reports on France's "Great Debate" over the shift to competition in its internal telecommunications markets and the effects such moves would have on the employees of the large PTE ministry and the public. The central issue is whether France Telecom "should become a publicly-owned corporation or remain a government administration" (Berry, 1988, p. 40). On one side is the right wing, personified by former PTT Minister Gerard Longuet, proponents of reform who want increased competition in postal and telecommunications services. On the other side is the socialist government itself which, along with the 450,000 civil servants in the powerful PTE trade unions, wants to retain the overall telecommunications monopoly structure and assure the status of its employees as public employees (Roussel, 1989, p. 6). The importance of positioning France for the challenges of Europe-wide competition after 1992 seems to favor the conservatives' position of evolving toward a freer market in the French telecommunications sector.

In the autumn of 1988, PTE Minister Paul Quiles appointed a public official, Hubert Prevot, to analyze the domestic postal and telecommunications structure as a starting point for discussions over the Great Debate. In a preliminary document, Prevot identified three main issues, questions whose answers will form his final report:

> **What is the market situation in France for postal and telecommunications services?**
>
> **What is the state's role in these business areas?**
>
> **How would the changing environment [liberalization] affect ministry personnel?**

The unions and the public will voice their concerns at nationwide hearings involving officials from the PTE, leaders from private industry, and telecommunications network users until July 1989. Shortly thereafter, Hubert Prevot will publish his findings on how France should "effect a smooth transition into competitiveness" (Roussel, 1989a, p. 6), especially in the telecommunications market.

This signals the profound changes underway in the French telecommunications structure which will bring it closer to the EC model adopted for the post-1992 Europe.

The second major shift in French telecommunications policy centers on restructuring the regulatory oversight of France Telecom. An independent group, the Commission National de la Communication et des Libertes, or CNCL, promotes separating the regulatory from the operating authority of the French public operator (Berry, 1988, p. 40). Such separation of powers may occur in the near term: PTE Minister Quiles recently appointed a task force which authored a decree creating an omnipotent Bureau of Regulation, replacing a less-powerful Mission for Regulation. The new Bureau would oversee all regulation in the telecommunications sector and answer directly to the PTE Minister. In addition, it could draft regulatory proposals and formulate ministry directives. This move would strip France Telecom of its current regulatory power, thus redefining its role solely as providing the telecommunications infrastructure and basic services and not influencing the regulation or licensing of competitors. The task force submitted its decree for debate in the French legislature in April 1989. If passed, this document could determine whether France Telecom becomes a "state-owned but privately run organization" (Roussel, 1989c, p. 3), which is still less desirable than the semi-private status that former Minister Longuet pursued. The decree does have some limitations, however, in that it does not propose removing from France Telecom the power to set tariffs for network use and services. Some observers suggest that a new regulatory body should also assume tariff responsibility. In the event that the Bureau of

Regulation eventuates, France Telecom may lose four main powers (Roussel, 1989c, p. 3):

* **international-level representation of France, including in various regulatory fora;**

* **enforcement of compliance to French standards, including service providers and for regulations;**

* **management of radiotelephone frequencies that are important in the growing cellular networks; and**

* **licensing of terminal equipment for connection to the French networks.**

These developments would signal a significant change in the French telecommunications structure. The shifts in power mean the new bureau would be responsible for keeping up with the evolution in European telecommunications. This indicates that the two important rising forces in Europe, deregulation and competition, are already affecting French telecommunications as the government adjusts its position to maintain a high-profile role in the emerging telecommunity. In sum, France can be seen as following the winds of change while preparing for 1992.

Primary French telecommunications policy objectives

Following the trends presented above, we turn now to the three primary policy objectives of France Telecom to continue its leadership role in European telecommunications today. In early 1989, Director General Marcel Roulet summarized these objectives which target domestic, regional, and global markets (Anderson and Inan, 1989, p. 29):

* **to strengthen our position in traditional [domestic] fields while building the networks of the future;**

* **to go from telephony to telecommunications, with special efforts in pan-European digital mobile communications; and**

* **to meet the international challenge, including value-added services and opening the TAT-8 undersea fiber optic cable.**

Modernizing French networks while preparing for European ISDN leadership

One important thread binds together these interrelated objectives: modernizing the French network through digital technology. This concept is key for France to realize all of its other telecommunications policy goals. In a February 1989 forecast, analysts cite network digitization and the rise of ISDN as "two driving forces powering European telecommunications expansion" (Anderson and Inan, 1989, p. 22). By combining these forces, France Telecom can achieve its two international goals of:

1. **At the regional level, contributing to harmonized telecommunications standards for Europe in 1992, and**

2. **Attracting global telecommunications traffic by offering superior networks and data services.**

In time, both are expected to contribute large revenues to the national economy while providing domestic users the best networks and services possible. We'll next look at what the French are doing to achieve network modernization.

France Telecom takes a twofold approach to modernizing its network: heavily investing in digital transmission and switching systems and "rewiring the nation with optical fibers" (Mexandeau, 1985, p. 5). For many years, France has had the most highly digitized network in the world. By early 1989, 71% of interurban transmission capacity and more than 60% of nationwide switching equipment used digital technology, and these numbers are growing (Resultats 1988, 1989). According to Alain Coursaget, Vice President of France Telecom International, "The entire network is new technology. The oldest portions...are only about ten years old" ("Doing business," 1988, p. 57). France's goal of achieving total network digitization before the year 2000 is on target, far ahead of most other industrialized countries.

Rewiring France with fiber began in 1982 as part of a US$5 billion network digitization program (Mexandeau, 1981, p. 2). This allowed

France Telecom to install digital paths between all the digitized local exchanges, leading to the first pre-ISDN services offered in any country in the world (Mexandeau, 1985, p. 5). A 1987 program calls for 17,000 km of single mode optical cables to replace 36,400 km of coax by 1997. In the 1988-1990 period, an initial 2400 km of fiber will form the major interurban trunks connecting Paris with Strasbourg, Lyon, Marseilles, Nantes, and Lille (Rapport d'Activite, 1987, p. 23). To date, over 1400 km of this initial phase is in place. An undersea fiber cable now links Marseilles to Ajaccio, Corsica and, when installed in 1987, this 400 km-long fiber cable was the world's longest. Too, France has development programs underway to connect its networks with all of its neighboring countries; significantly, in February 1989, a Strasbourg-Karlsruhe optical link opened providing 8000 voice or 16 television channels between France and West Germany (Performance Data 1988, 1989).

This fiber optic infrastructure offers numerous benefits to French users. It raises quality and lowers costs while supporting a wide range of new service offerings. Users nationwide receive high quality telecommunications through excellent technical performance of the links. France Telecom reports only one service problem per line every six years for switched services, and every seven years for leased lines--and 95% of all problems are repaired within 24 hours. The cost of intercity voice and data service has dropped substantially, down 33% in 1988. And, according to a British study, France now has the lowest tariffs on business and residential telephony of the four leading European countries, France, West Germany, Italy, and the UK (Grenier, 1989). New services available over the French network increase rapidly year to year. In brief, French ISDN, videotex (the Minitel system), and a packet switched data network (Transpac) are the largest and most successful systems of their type anywhere. Other services include 64 kb/s switched data links (Transcom), mobile communications (radio-telephony and radio-messaging), and an X.400 message handling system (Atlas) that supports EDI, the new Electronic Data Interchange service for business data transfers between previously incompatible European telecommunications networks.

The most important of the above services is ISDN, integrating voice, data, video, and text applications. To realize it goals of attracting profitable telematics traffic in coming years, France must offer users, both domestic and foreign, digital networks and sophisticated ISDN services. Together, these will allow France to best use its expanding data resources for sustaining economic development (Sauvant, 1986, p. 290). French ISDN opened for service in Brittany in 1987 and, renamed NUMERIS, has operated in the Paris region since 1988 with more than 20 service offerings. It already runs through a gateway to the US via AT&T's ACCUNET. NUMERIS will also be available nationwide by 1990; will link British, German, and Italian national systems soon thereafter; and will directly connect with all standardized European terminals with the coming of the single telecommunications market of 1992 (Roulet, 1989, p. 2). Since ISDN is a "driving force powering European telecommunications expansion" and most European PTTs have (or plan) ISDN offerings (Anderson and Inan, 1989, p. 22), France's lead in ISDN development reinforces certain strategic advantages. Robinson (1985) notes that nations with ISDN leadership and proven operational experience will enjoy a strong position for the future, resulting in "long lasting implications of major economic proportions, both nationally and internationally."

Contributing to standards harmonization for Europe 1992

The next section addresses the second major objective of France Telecom, promoting regional cohesion via network standards for the 1992 telecommunity. Europe's proposed large, unified telecommunications market will require common technical standards to be successful. Once achieved, the EC will better compete with the US and Japan in the growing global telecommunications markets (Ungerer, 1988, p. 149).

The French, as leading members, seek a larger role for the EC in international telecommunications. Their purpose is to create "a genuine unified telecommunications universe" through harmonized standards (Roulet, 1989, p. 2). In the past, European countries often developed--with high R&D costs--telecommunications products for their own national markets. This led to a variety of incompatible technical standards that limited the users' choice of products and services. Standardization, however, allows economies of scale in production runs, brings down prices, and improves the choice to users. Ungerer (1988) observes that

> Differing standards fragment the market. Europe-wide standards will be a major link in the future Europe-wide market. (p. 148)

And since the future networks rely on digital technology, they require "a harmonized approach" among European administrations to ensure compatible communications (Ungerer, 1988).

Benefits of harmonized standards will be numerous, according to France Telecom's Jean Grenier, Director of Industrial and International Relations. First, they will help open the EC's members' networks, allowing easier access to other countries' telematic services. Second, they will standardize telecommunication products such as switching equipment and customer terminals, as well as the value-added service offerings that are growing so quickly worldwide. Third, freer trade of these products and services will follow since foreign trading partners need observe only one set of European standards, not twelve as in the past. Fourth, setting common standards allows European countries to present a unified front in consultation with other international standards organizations. Finally, EC countries can combine R&D resources through industrial consortia to develop products better able to compete against the US and Japan, an important European objective (Grenier, 1989).

To further their efforts at standardization, EC members created, in January 1988, the European Telecommunications Standards Institute (ETSI) at Sophia Antipolis on the French Riviera. ETSI will define future European Telecom Standards, or ETSs ("France Telecom helps," 1989). ETSI was not formed to act independently: it will require the cooperation of all EC parties, not only telecommunications operators but also manufacturers, research centers, users, as well as the input of existing international organizations (the ITU, ISO, CEPT) for developing compatible telecommunications standards. Among its most important objectives is to introduce the proposed European Open Network Provision (ONP) that provides for continent-wide value-added services (Grenier, 1989), in much the same way as the Open Network Architecture (ONA) does in North America.

Making France an international telecommunications focal point to attract future traffic flow to its territory with a modern fiber optic infrastructure

We turn now to the third of France Telecom's three major objectives, "meeting the international challenge." To succeed in this objective, France Telecom had to improve its networks and service offerings, as discussed above, and, above all, to increase its overseas presence. We'll discuss each of these areas in the following paragraphs.

Since the 1970s, France Telecom has pursued its international objectives with a dynamic three-step approach. The first required modernizing its domestic networks; the second was building its regional base by helping develop European standards. The third step emphasizes attracting ever more international telecommunications traffic flows. To do so, France Telecom identified major market centers worldwide and then opened liason offices in them. Today, France Telecom International (FTI) operates in New York, Tokyo, London, Bonn, Beijing, Caracas, and Singapore to expand its marketing efforts. As a result, France Telecom is now harvesting "the fruits of clear-sighted but courageous policies" (Roulet, 1987, p. 8).

International traffic volume rose 19.6 % in 1988, compared with 6.7% in 1986 and 2% in 1985. By the end of 1988, France was using 10,500 intercontinental circuits (Resultats 1988, 1989), up from 2500 only a few years ago.

What benefits does France Telecom hope will result from its international policies? Most importantly, observes FTI Vice President Alain Coursaget, "France is well-positioned to be the number one country in Europe with regard to telecommunications." ("Doing business," 1988, p. 57). That position affords France three strategic advantages. The first is that France Telecom will be able to attract international traffic by offering "leading-edge infrastructures" such as fiber optic networks, digital switching, and expanded informatics and telematics services. The most important service is ISDN, and since France has the lead in its development in Europe and will offer nationwide coverage in 1990, it will have a competitive advantage over its neighbors in attracting international telecommunications flows. The second advantage is a continued leadership role for France in the emerging global information society--a role resulting in long term economic benefits, including high levels of employment even with a declining manufacturing sector. Finally, France intends to become the third hub of the US-Japan-Europe global telecommunications network. Citing the rise of international competition in telematics services, France Telecom states that "it is of prime importance...to identify itself as a major player in the worldwide market" (Rapport d'Activite, 1987, p. 56). These policies and the strategic advantages they afford seem likely to assure France Telecom that goal.

Economic advantages were seen for fiber cables over satellite transmission

In this final section we'll discuss the economic advantages for France of investing more in transatlantic fiber cables than satellites in the recent past. To begin, we'll consider France's investment in its telecommunications industry over the past 10 years, looking in detail at the two primary telecommunications media, satellites and cables.

We saw in the sections above how France linked its future economic prosperity to investment in high technology. The nation's industrial policy emphasizes training the French workforce in scientific and engineering disciplines, leading to strong research and development capabilities. The result: France developed modern industries such as nuclear power, biotechnology, an active space program, and telecommunications which meets domestic requirements and earns export income. Chief among France's telecommunications successes are developing an ultramodern network and services, including ISDN, packet switching, and Minitel; and increasing fiber optics production and usage.

These advances result from the growing importance of the services sector of the world economy which France competes in. Sauvant (1986) points to the "quiet and almost unnoticed revolution" over the last twenty years when "services have become the single largest economic sector" in the world economy (p. 282). In 1979, 59% of the developed world's GDP came from trade in services (Sauvant, 1986, p. 292). By 1986, estimates for the annual world market in services exceed US$600 billion (Feketekuty, 1986, p. 590). In Europe in the early 1980's, 60% of the EEC's GDP resulted from services (Sauvant, 1986, p. 282), with growth continuing in the 1990's. Toffler and Toffler (1988, p. 48) cite an EC study that predicts Europe's entire GNP will increase by 5% as a result of "Project 1992."

Telecommunications services in particular loom large for Europe after 1992: One 1985 US Department of Commerce study put the total world market for telecommunications trade and data services at US$300 billion in 1984, estimating it to rise to US$560 billion by 1990 (Robinson, 1985, p. 311). In 1988, total spending on network improvements by the world's telecommunications operators reached US$112.9 billion, and will increase 4% to US$118 billion during 1989. Of that, US$43.9 billion, or 37.3% of the world total, will be spent by Europe operators, a rise of 7.8% over 1988 (Anderson and Inan, 1989, p. 20). This supports Ungerer's (1988) claim that telecommunications will be one of Europe's largest industrial sectors by the early 1990's. Whereas today about 3% of the EC's GDP derives from telecommunications, by the year 2000 it may be 7% (Ungerer, 1988, p. 98). Hence, Europe's post-1992 economy will have a "telecommunications engine" running on trade in data services as fuel. Ungerer (1988) sums up the situation:

> Telecommunications will thus be a determining factor for Europe's future role in the world's expanding services market. (p. 92)

Where does France stand in face of this enormous growth? We will look next at France's telecommunications sector investments, highlighting its satellite and cable segments further on. To begin, telecommunications and telematics investment in France increased significantly after the publication of the Nora and Minc report in 1978. Its proposals for a national policy to computerize French society were taken up by the government's telecommunications administration. By 1981, then PTT Minister Louis Mexandeau reported "determined efforts...to digitize the network" with "special emphasis...on France's telematics projects" (1981, p. 2). That year the PTT budgeted 27 billion francs (almost US$5 billion) for network modernization (Mexandeau, 1981, p. 2). The telecommunications investment policy continued with PTT efforts at forging "an efficient industrial tool...allowing French firms to offer competitive products adapted to the needs of both the domestic and foreign markets" (Grenier, 1982, p. 2). The following years saw continued strong investment in the telecommunications infrastructure, leading to numerous innovations:

* **in 1979, the Transpac public packet switched data network;**

* **in 1982, the Teletel videotex (Minitel) system;**

* **in 1984, the Telecom-1 satellite digital business network;**

* **in 1985, nationwide 64 kb/s all-digital connectivity;**

* **in 1986, interactive TV and videocom over optical fibers;**

* **in 1987, ISDN service offerings opened in Brittany;**
* **in 1988, the TAT-8 transatlantic fiber optic cable;**
* **in 1990, nationwide ISDN will be available; and**
* **in 1991, the TAT-9 fiber cable will be operational.**

What is the scale of investment to realize these kinds of innovation? Telecommunications is today one of France's largest industrial sectors--and expenses. One of France Telecom's recent long-term modernization programs alone will invest 33 billion francs (US$5.27 billion), according to Director General Roulet (Anderson and Inan, 1989, p. 29). We look next at France's past investment in its two transatlanic telecommunications media, satellites and undersea cables. We begin with the satellites of Intelsat's global network. France joined Intelsat in 1973 and has thereafter maintained steady ties, becoming its third leading investor behind the US and the UK (Rapport d'Activite, 1987, p. 44), holding a 5.64% share (Pelton and Howkins, 1988, p. 180). In 1987, France upgraded its access to Intelsat satellites by improving its antennae and access facilities. France uses Intelsat for three primary international functions: extra-European telephony, TV broadcasting, and digital data transmissions.

The second medium of French investment is transatlantic undersea cables. Before employing satellite technology, France invested in--and relied on--undersea cables. Three previous direct telecommunications links from French territory to North America were analog coax cables: TAT-2 (48 circuits) in 1959; TAT-4 (138 circuits) in 1965; and TAT-6 in 1976 (4200 circuits) (Rowbotham, 1987, p. 11). In December 1988, the TAT-8 fiber cable began operation with 40,000 digital circuits: TAT-9, the next generation, will provide 80,000 more by the end of 1991.

All these cable systems are joint ventures funded by international consortia of telecommunications operators. As it has in the past as an active investor, France Telecom pursues these systems for several reasons. First, undersea cables augment France's transatlantic telecommunications capacity (principally with the US) and provide backup security in the event of a satellite outage. Second, in 1982 France undertook its S-280 submarine optical fiber development program to compete for the coming all-digital transatlantic fiber cable projects then being formed ("Cables blaze," 1981, p. 14). Third, France stood to profit from undersea cables' enormous construction contracts through the expertise of its Submarcom cable-laying subsidiary ("TAT-8: fibre optics," 1989, p. 22). The following table shows France's investments in the most recent cable systems:

Table 2

French Investment in Recent Transatlantic Cable Systems

Cable	Circuit Capacity	Construction Cost, US$Mil	France's ownership
TAT-7	4,246	190	5.60%
TAT-8	40,000	360	9.80%
TAT-9	80,000	420 (est.)	6.25%

Why is France spending so heavily on cables over more Intelsat satellite capacity? The primary reason stems from technical and cost considerations. The main technical drawback, as discussed in that previous section, is the time delay of satellite transmission. The central cost issue is that, to date, cable circuits have been about 1/3 less expensive than Intelsat's circuits due to the latter's cross-subsidization policy ("TAT-8: fibre," 1989, p. 22). This becomes increasingly important in view of fast-rising traffic levels across the Atlantic. In 1986, telephony to North America represented 7% of France's international traffic; of this, 86% or a total of 66.7 million chargeable minutes went to the United States. These figures rose 20% in 1987 alone ("TAT-8: fibre," 1989, p. 21).

Besides providing capacity for mounting traffic levels, the new fiber cables will have significant impacts in the near future on France's use of satellites for delivering transatlantic voice and data telecommunications. At the end of 1987, France used only 2059 circuits, with 25% carried by coax cable. But, reports France Telecom,

> by...October 1988, [it] was using 10,330 intercontinental circuits, of which 52.8% on average passed via a submarine cable and 47.2% via satellite. ("TAT-8: fibre," 1989, p. 21)

By 1992, estimates France Telecom, undersea cables--especially optical fiber cables--will carry 65% of its US traffic ("TAT-8: fibre," 1989, p. 21). The growing importance of these impacts is already evident to the French economy: in 1988, France Telecom realized revenues of 10 billion francs (US$1.6 billion) from its international activities--10% of its total revenues and up 19.6% over 1987 (Performance Data 1988, 1989, p. 6). Where is France Telecom headed in this expanding international scene? The answer seems to be "to the top," as France has put its money into fiber optics to achieve its long-range goal of leading Europe in telecommunications development. The TAT-9 cable, for example, will terminate in Brittany when it comes ashore, but its digital circuits will be routed overland through the French networks and then onward via an undersea link to Sicily for connection to EMOS-1 (the Eastern Mediterranean Optical System cable number one) in 1990. France's Submarcom will construct most of the US$90 million EMOS-1, which will extend 2852 km from Sicily to Greece, Turkey, and Israel, providing these countries 40,000 digital circuits ("TAT-8: fibre, 1989, p. 26). France Telecom also recently bought into the HA4/TPC3 transpacific fiber cable initially linking California, Hawaii, and Japan. This 11,500 km-long undersea system will cost an estimated US$633 million (Johnson, 1987, p. 282). So important are the "PacRim" countries to future world commerce that France felt compelled to invest in HA4/TPC3 even though it will be built by three Asian operators with no Submarcom help.

This global strategy will leave France in a position of strength when these cable projects finally come on line. France will be strategically placed at the European center of an end-to-end digital fiber optic system extending from Tokyo to Tel Aviv, connecting the Far East with the US, Europe, and the Middle East. The countries concerned will be linked up with France, home of the Continent's most modern telecommunications network. Small wonder then that its economic investments further France Telecom's goal of achieving European leadership through what Director General Roulet calls "technical innovation combined with commercial inventiveness" (Roulet, 1987, p. 8). Indeed, France is well on its way of becoming the third center of global information commerce.

CHAPTER V

Summary and Conclusions

The rapid changes underway in the global, European, and French telecommunication arenas provide the background for this ~~this.~~ study. We've seen how data services are replacing manufacturing as the largest world economic sector and how national industries and private corporations are competing more for market shares in telematics than in heavy industries in recent years. With these trends taking precedence in the global economy, the European Community is unifying its twelve diverse members into one large economic and political union that can better compete with the US and Japan for future telecommunications and telematics markets, and hence, for economic security.

In this context, we have shown how France successfully confronts the challenges of the changing international telecommunications marketplace. A combination of external and internal factors contribute to these challenges. Externally, the major factors are the evolving predominance of global trade in data services and the technical benefits of fiber optics for transatlantic telecommunications. Internally, France today reflects its historic tradition of dirigisme, state intervention and planning, by responding with a concerted effort to lead its EC neighbors in the formation of the world's third economic center, the Europe of 1992.

France continues this leadership role by improving and expanding its own telecommunications sector. One principal example is given by

France's capitalizing on the benefits of fiber optics and the subsequent shift to larger French investments in fiber technology for both terrestrial and undersea applications. France Telecom invests heavily in fiber optics research, development, and utilization for three reasons. First, to modernize its telecommunication networks; second, to increase its international connections; and third, to profit from the worldwide shift from satellites to transoceanic fiber cables through its long experience in laying undersea cable systems. We therefore find that as France increases its investment in fiber cables, it decreases its reliance on satellite connections to the US for carrying voice and data traffic.

In sum, use of fiber optics in undersea cables offers operational and economic advantages that directly impacts on the Intelsat consortium, especially with its ongoing problem of excess capacity of satellite transponders. This could ultimately affect the financial stability of Intelsat which may have to realign its pricing policies in view of this new competition.

Observers of international telecommunications predict two major scenarios resulting from the impacts of undersea fiber optic cables on satellites linking France to the US. One is that, as more fiber cables are laid across the Atlantic,they will attract increasingpercentages of telecommunications traffic due to their low cost and inherent high capacity, end-to-end digital technology and lack of propogation delay. Significantly, since France has developed a competitive undersea fiber system and is geographically situated between most other European countries and the US and Japan, it is in a pivotal position to benefit financially from the success of fiber technology in carrying increasing traffic volumes.

The second scenario is that Intelsat's satellites will evolve into the favored international broadcast medium due to their high levels of reliability, transponder circuit availability, plus their point-to-multipoint and multipoint-to-point distribution characteristics. This evolution will not preclude Intelsat from carrying a certain (as yet undetermined) amount of future transatlantic traffic. This bodes well for France Telecom since it requires an alternate medium for backup security in the event of disruption of service to current and planned undersea cable systems.

One important implication of these scenarios is that fiber cables will continually challenge Intelsat for users since it is dedicated to providing cost-averaged charges to all its members. This results in higher Intelsat user charges on heavy routes, precisely those that fiber cables creamskim. That translates into a migration to less-expensive fiber cables by many current Intelsat customers on both sides of the Atlantic.

Another implication is that since fiber can also carry TV circuits, Intelsat's emergence as the broadcast carrier of choice may also be threatened since undersea cables are constructed with excess capacity for future traffic growth and could transmit TV signals at competitive costs to fill this capacity. This secondary challenge may be the impetus that induces Intelsat to adjust its averaged-cost policy in the near term. If it does change this policy, that would negatively impact on developing countries which rely on Intelsat for national and international telecommunications. For a wealthy country like France, however, this would not affect its transatlantic traffic significantly, especially as France owns a percentage of the fiber cables already.

These trends raise several possibilites for future research. On the global scale, one study could evaluate Intelsat's strategies in face of the efforts by the operators of fiber cables to creamskim profits from heavy international routes. This would require an analysis of Intelsat's pricing policies as it faces the 1990's weakened and still burdened by enormous excess transponder capacity. Another study might compare the rise of international telematics in developed countries to the displacement of labor-intensive manufacturing to developing nations. This could identify the basic factors related to the global shift from trade in goods to trade in data services.

At the European level, a future study of the post-1992 telecommunications sector could examine the unified market and how well major European telecommunications companies compete with their American and Japanese counterparts. Such a study could also evaluate the impacts of any "Fortress Europe" protectionist trade barriers some analysts predict may be erected to deflect the same American and Japanese rivals. Another study could compare the growth of TAT-8 traffic between the main landing sites, the US, France, and the UK. This would offer insight into which of these leading European countries is gaining the most "switchover" transatlantic traffic via its fiber cable investment. That might tell if the UK is an effective competitor with France for attracting profitable international telematics traffic.

Finally, a follow-up study investigating France's efforts at leading Europe in telecommunication products and services development could determine if its long-range strategies have proven successful. The results would tell whether France does indeed attract the significant telecommunications traffic flows it seeks for its advanced internal networks and eventually becomes the "third hub of the international telecommunications triad."

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APPENDIX

APPENDIX

Glossary of Terms as Used in this Study

Term	Meaning
Atlas	French X.400 electronic messaging system
BER	bit error rate
bp/s	bits per second
broadband	communication links employing over 2 Mhz bandwidth
CCIR	International Radio Consultative Committee
CCITT	International Telephone and Telegraph Consultative Committee
CEPT	European Conference of Posts and Telecommunications Administrations
CNET	Centre National d'Etudes des Telecommunications (National Telecommunications Research Center)
COST	European program for Scientific and Technical Cooperation
DGT	Direction General des Telecommunications (recently renamed **France Telecom**)
EC	European Commission
EDI	Electronic Data Interchange

EEC	European Economic Community
EMI	electro-magnetic interference
EMOS-1	EasternMediterraneanOpticalcable System#1
ESPRIT	European Strategic Research Program in Information Technology
ETSI	European Telecommunications Standards Institute
Europe 1992	post-1992 single unified European market structure
Eutelsat	European Telecommunications Satellite Organization
FOTS	fiber optic transmission system
FTI	France Telecom International
GATT	General Agreement on Tariffs and Trade
Gbit/s	billions of bits per second
gigabits	billions of bits
GSO	geostationary orbit
Inmarsat	International Maritime Satellite Organization
Intelsat	International Telecommunications Satellite Organization
ISDN	Integrated Services Digital Network
ITU	International Telecommunications Union
Mbit/s	millions of bits per second

megabits	millions of bits
Mhz	millions of cycles per second
MTBF	mean time between failures
NUMERIS	French commercial ISDN products and services
OECD	Organization for Economic Cooperation and Development
ONA	Open Network Architecture
ONP	Open Network Provision
OSI	Open Systems Interconnections
PABX	private area branch exchange
PTAT-1	Private transatlantic cable #1
PTE	Ministre des Postes, Telecommunications, et Espace (Ministry of Posts, Telecommunications, and Space)
PTT	Ministre des Postes, Telephones, et Telegraphes (Ministry of Posts, Telephones, and Telegraphs
R & D	research and development
RACE	Research for Advanced Communications in Europe
RFI	radio-frequency interference
TAT-1 to 7	Transatlantic cables #1 to #7
TAT-8	Transatlantic cable #8

TAT-9	Transatlantic cable #9
TAT-10	Transatlantic cable #10
TDM	time division multiplexing
TDMA	time division multiple access
TRANSCOM	French 64 kbit/s digital switched telephone system
TRANSDYN	French satellite-switched flexible digital network
TRANSPAC	French X.25 public packet switched data network
VANS	value added network services