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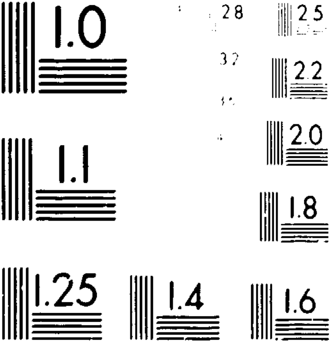

MICROCOPY RESOLUTION TEST CHART

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THE BRAZILIAN TELECOMMUNICATION INDUSTRY:

Accumulation of microelectronic technology in the manufacturing and service sectors *

Prepared by

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INTRODUCTION

It is now becoming widely recognised that an efficient and modern Telecomms infrastructure is a vital prerequisite for economic development and participation in many modern economic activities. Researchers in the area of Communications, and more recently Development Economics, have demonstrated the need for society at any level of economic development to have a correspondingly well-developed communications infrastructure.[I] Furthermore it is now almost common policy practise among OECD Governments to give large investment and technological support to their National Telecomms equipment supply industry - not only as a means of augmenting the industrial and technological[2] capacity of the economy as a whole, but also as a strategic means of establishing a base in the highly competitive international Information Technology markets. Indeed, the strategic role of the Telecomms industry as the "cutting edge" of microelectronic-based Information Technology is by now a well recognised fact by policy makers in the Developed Market Economies.[3]

As far as the Developing Countries (DC's) are concerned the rapid diffusion of microelectronic digital technology throughout the Telecomms industry over the '70s has far reaching implications. On one hand the impact of digital technology has radically changed the international market structure in Telecomms, and also the prospects for DC's to acquire the products and technologies which form the basis of Telecomms infrastructure. On the other hand microelectronic innovation has also dramatically altered the nature and the functioning of the equipment itself. Digital semiconductor technology has greatly expanded the range of systems available and also introduced far greater capacity and flexibility than previously possible with mechanical and electromechanical technologies.

I) For a Communications literature survey see Hudson et al (I98I). For a narrowly economic discussion refer to Leff (I980).

2) Bell and Hoffman (I98I) explain the important distinction between industrial and technological capacity, and the considerable economic benefits to be gained from local technological capability.

3) OECD (I98I) and (I98I[a]) demonstrate the pervasion and importance of Information Technology to the world economy.

It therefore comes as no surprise that no less than 60 DC's have established Government departments to deal with immediate and longer-term policy issues[1] such as: a) how to assess and acquire an appropriate level of industrial and technological capacity; b) how to go about planning and expanding an efficient Telecomms network suited to current domestic needs and future demands of information technology; c) how to ensure that the major MNC suppliers comply with the wider development objectives of the economy.

One of the major problems DC's face in assessing these policy questions is the newness of microelectronic technology, and the consequent lack of empirical examples to contribute to decision making and help avoid costly mistakes. With this in mind the case of Brazil is unique among the DC's. Since the mid '70s Brazil has invested heavily in establishing a modern micro-electronic based Telecomms infrastructure. Furthermore the Brazilian Government decided to eliminate as far as possible, reliance on foreign technology sources in order to develop its own local industrial and technological base from scratch. Brazil's performance in achieving these two objectives clearly provides an excellent case for study.

The aim of this paper is therefore to assess Brazil's progress in establishing an efficient Telecomms infrastructure, together with a strong local industrial and technological base in digital technology. Hopefully this will not only contribute to current policy decisions in Brazil but also provide evidence which other DC's will find useful in their own Telecomms planning.

Given the low level of economic research in this area Part 2 attempts to establish at the outset Brazil's overall progress, both in terms of infrastructural growth and industrial and technological developments. From the aggregated evidence it is clear that Brazil's achievements have indeed been remarkable, and that Brazil currently leads the Third World in developing Telecomms technology.

In an effort to understand exactly how Brazil formulated

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1) Spero (1982)

and implemented its Telecomms strategy Part 3 examines: a) the successive steps taken by the Government in terms of finance, administration and legislation - especially in relation to regulating the activities of the MNC's operating within Brazil's national boundaries; b) some of the main achievements in digital Telecomms systems produced by the Government R&D centre at Campinas. It is hoped that this substantive evidence of Brazil's accumulation of microelectronic technology will prove useful to other major industrialising countries wishing to follow a similar path.

Finally Part 4 focusses on current difficulties facing the industry, in particular, the impact of the current economic crisis on infrastructural and technological progress. Again an attempt is made to illustrate issues of general interest to other DC's including: problems in rural Telecomms, the importance of small scale local industry, and Brazil's success to date in adapting digital technology to suit local conditions. Policy proposals and important areas of further research are detailed at the end of the relevant sub-sections of Parts 3 and 4. A glossary is also provided to explain necessary technical terms.

PART I THE INTERNATIONAL CONTEXT OF MICROELECTRONIC CHANGE

Before analysing the Brazilian case it is first necessary to briefly outline how digital technology has affected the Telecomms industry, and the implications for DC's. It is usual to analyse the Telecomms market in terms of two sectors. First the carrier network or service sector which represents the basic communications infrastructure of the country; services are normally provided by operating companies either owned, or strictly regulated by the state. Second, the equipment supply sector - internationally this industry is dominated by I2 major corporations who account for around 80% of equipment, needed to provide all instantaneous, two-way communications - mainly telephone, telex and telegraph.[I]

It is also helpful to analyse the equipment supply sector in terms of three distinct subsectors: I) exchange or switching systems which account for roughly 3I% of world sales; 2) transmission equipment, appx. 30% of world sales, and 3) peripheral equipment which accounts for the balance.[2] Technologically, exchange equipment represents the "heart" of a Telecomms system performing the central function of connecting and switching electronic signals within and between networks. Transmission systems are used to carry the signals from one geographical location to another. Traditional coaxial cable transmission links are gradually being replaced by more efficient digital satellite and fibre optic systems. The remaining peripheral subsector is assuming increasing importance with the recent spate of microelectronic innovations, and includes all the equipment needed to support the overall system such as telephone handsets and input/output devices including modem and codec equipment; recent digital innovations include such products as portable telephones, video display units and mobile digital radio.

The rapid diffusion of microelectronic technology during the '70s has transformed what was once a stable oligopolistic market, into a highly competitive, rapidly changing and uncertain one. The merger of computer and Telecomms technology made possible

I) OECD (I983)
2) ibid

by the digital integrated circuit has allowed market entry to new competitors from the computer, office equipment and aerospace industries. This intense competition in what was previously a well-defined market is gradually breaking down the barriers to entry especially in the areas of peripheral and transmission equipment. While the traditional suppliers still dominate the major exchange equipment markets digital technological change has led to intense rivalry and competition. Huge R&D investments in developing large scale public exchanges by the MNC's, often financially backed by domestic Governments, has been the principal means of competition.[I]

There are four important reasons why these changes brought about by digital technology may in fact prove beneficial to DC's. First, many of the MNC manufacturers justify their R&D investments on relatively small uncommitted export markets, mainly in Third World countries.[2] In order to gain new markets the MNC's are often prepared to sell systems at lower prices than payed by the Telecomms administrations in the advanced countries. In addition assistance in terms of cheap loans and "aid for trade" arrangements are becoming a common means of market entry. Furthermore, the purchase, installation and operating costs of all three categories of digital equipment are far lower than in comparable electromechanical systems. For example, installing I million telephone lines today costs three to five times less than the now-advanced economies payed 30-40 years ago.[3]

A second possible benefit for DC's currently expanding their basic Telecomms infrastructure is the potential advantage of "leap-frogging" older, more expensive electromechanical technologies and installing what are now well established, and more flexible microelectronic networks. A third potential advantage also concerned with the product technology is the substantially greater capacity and efficiency of digital over previous technologies. Essentially the introduction of Stored

I) Muller (I982) describes the large MNC investments in public digital exchanges. See Hoffman (I98I) for general discussion of Government support for technology based competition in the OECD.

2) Section 3.3.3 below provides more details.

3) The term "line" includes all the necessary telephone equipment needed to install one telephone line. Information from Jequier (I977) p2I7.

Program Controlled (SPC) technology has dramatically reduced the cost of manipulating and transmitting information from one location to another.[1]

A fourth possible benefit to DC's concerns the "modular" design of digital technology in Telecomms. In contrast to older technologies microelectronic systems are designed to be modular which means that a network can be built up gradually from a range of basic modules.[2] At the same time the skills and technology needed to develop and produce the technology can also be gradually acquired. Unlike pre-microelectronic technology, digital systems require a relatively small range of high level design skills coupled with a wider range of low level skills - especially in the assembly, installation and maintenance stages. This skill configuration may well be more suited to the existing endowments in especially the larger DC's. In comparison with digital exchanges the older Strowger and Crossbar systems required a thoroughgoing technological capacity all the way through from design to maintenance.

However in order to realise these potential advantages an adequate level of local knowhow and skill is needed not only to efficiently operate and maintain the network, but also to actually choose and bargain for the most appropriate system. In terms of local manufacture of digital Telecomms a substantial level of local knowhow is required to aquire and adapt the technology to suit local circumstances. Again, the prospects for larger DC's attempting to gain local technological capacity from foreign sources appears favourable. In fact, where sales of equipment are linked to sales of technology and manufacturing capacity in the recipient country, the competition for orders between the MNC's is even more intense than with straight product sales.[3]

Potentially therefore there are considerable benefits to be gained from the shift to microelectronic technology. Again the case of Brazil is especially interesting given its large internal market and its primary objectives of reducing dependence on foreign technology, developing local capabilites, and providing digital products and technologies to suit local conditions.

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1) Muller (1982) provides a detailed analysis of the greater capacity and reliability of digital Telecomms equipment.

2) See POEU (1979) for technical details.

3) This point is confirmed by the competition for the recent Chinese and Indian contracts. See section 3.3.3 below for details.

PART 2 AGGREGATE INDICATORS OF BRAZILIAN PROGRESS IN TELECOMMS POST '74.

2.I Position before '74

Before the major policy initiative which began in I974 Brazil's Telecomms infrastructure was largely unplanned, inefficient and fragmented. In the mid '60s total telephone coverage amounted to less than I.3 million serving a population of around 74m; up to I970 telephone coverage remained extremely low with an average of less than 2 telephones per I00 population.[I] Similarly national Telex coverage was very poor with appx. I000 terminals to support the whole of Brazil's industrial and domestic needs.

Until the late '60s one major foreign owned corporation CTB[2] was responsible for appx. 68% of installed telephones, with a staggering 300 or so other small companies supplying the balance of Brazil's telephone services. As a consequence tariffs varied widely across regions and most of the operating firms lacked any significant financial, managerial or technological resources.

With very little long-term investment taking place the transmission network was also wholly inadequate to meet the demands of a rapidly growing economy. Modern microwave links only extended to 4 of the major cities, Rio de Janeiro, São Paulo, Belo Horizonte and Brasília. Where other cities and towns were integrated at all into the national network they were forced to rely on inefficient and low capacity systems. It is hardly surprising that the Telecomms network overall was frequently subject to system conjestions and breakdowns.

The poor state of Telecomms services was compouned by an equipment supply sector heavily dependent on imports of equipment and technology. Four major MNC's, Ericsson do Brasil (EDB), Standard Electric (SESA) a subsidiary of ITT, Siemens, and Nippon Electric (NEC) almost totally owned and controlled the domestic supply industry. Up to the early '70s these MNC subsidiaries had developed very little in the way of exchange and transmission technology and played only a passive role in technology transfer from the parent companies.

I) The following information is from SSI (I982)

2) A Canadian company, Companhia Telefonica Brasileira.

Furthermore before '74 Brazil as yet had no significant Government involvement in R&D in communications technology. Except for poorly financed and disorganised research activities, mainly in the various universities, the country was devoid of any local scientific and technological capacity. In short, Brazil entered the '70s with a wholly inadequate Telecomms infrastructure, virtually no local Brazilian industry, no R&D capacity and no significant technological base.

2.2 Indicators of Service Sector and Infrastructural Achievements

Following the change of Government in 1974 the poor overall state of the Telecomms sector improved dramatically. The new Geisel Government, sensitive to criticisms of dependence on foreign capital and technology, adopted a strongly interventionist approach to Telecomms based on a well defined industrial and technological strategy. Through the Ministry of Communicatons (MINICOM) the government committed itself to three main objectives in Telecomms: 1) to accelerate the expansion of a dependable, efficient and comprehensive Telecomms infrastructure; 2) to gain ownership and control of the MNC subsidiaries operating within the country, and 3) to build a Government R&D centre in Telecomms capable of providing an independent base in the latest digital technology, thereby reducing dependence on foreign technology sources.

Table I overleaf presents the historical growth of Telecomms coverage from 1948. After the relatively stagnatory levels of coverage up until 1974, Brazil experienced a remarkable excelleration in telephone coverage from only 2.9m in 1974 to 9.3m today. This raised the number of telephones per 100 population from only 2.7 in 1974 to 7.8 in 1983. Brazil's telephone density currently compares well with most other DC's, and is well above the average for Latin America, Africa and Asia.[1] By the end of the '80s Brazil intends to increase the present level to around 20m.[2]

Telex coverage witnessed a similarly rapid expansion. By the end of 1980 Brazil had installed a fully automatic public

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1) Average DC density is barely 1 telephone per 100 population Pelton (1981) p208. For detailed international comparisons see SSI (1982) p39.

2) Pelton (1981) p222.

Table I Number and Density of Telephones in Brazil - Selected Years 1948 to 1983.

Year	Number of Telephones (Thousands)	Number of Telephones per 100 population
1948	484	1.30
1964	1283	1.55
1968	1660	1.88
1970	1980	2.15
1972	2380	2.42
1974	2917	2.70
1976	4036	3.50
1978	5552	4.90
1980	7535	6.20
1981	8085	6.80
1983	9300	7.80

Sources: Compiled from Maculan (1981) pp193-194, SSI (1982) p197 Mattos (1983) p6, and Telebrasil (1981)Nov-Dec, p6.

telex network serving 535 main localities with 53 domestic exchanges.[1] The number of telex terminals increased from the low level of around 1000 in the late '60s to over 43,000 in 1982.

This extremely rapid growth in telephone and telex coverage facilitated a large increase in the volume of Telecomms traffic both nationally and internationally. The volume of international telephone calls rose from 4m in 1969 to over 340m in 1980, with an average growth of over 20% per annum over the 1975 to 1980 period. Today Brazil is connected with direct dialing facilities to 56 other nations. The expansion of overall Telecommunications facilities both paralelled and supported Brazil's economic growth in recent years and substantially improved the communications capacity of the country.

In order to support this expansion of Telecomms services it was necessary for Brazil to invest heavily in the network. Table 2 shows the magnitude of total investments by TELEBRAS (the overall Telecomms operating company) over the 1976-1983 period. Although these figures are extremely sensitive to exchange

1) The following details are from SSI(1982).

Table 2 Investments by the TELEBRAS System, I976-I983

(Millions of Dollars)

Year	Value
I976	I790
I977	I540
I978	I340
I979	I280
I980	890
I98I	950
I982	I090
I983	I2I0

Sources: I976-I98I SSI (I982)p52 (Exchange rate of December I98I, $I=CrI27.8)
I982-I983 Calculated from Telebrasil (I983) Jan/Feb.p55 (Exchange rate of $I=Cr242 as per Ministry of Communications).

rate conversions (the official cruzeiro/dollar exchange rate rose from I30 in Jan.'82 to 979 in Dec.'83 over which period the cruzeiro was devalued 93 times) they do indicate the large dimensions of total investments, amounting to around $I0 billion over the 8 year period.

However, it would be wrong to suppose that these investments represented a great resource drain to the country. On the contrary, operating data from TELEBRAS clearly show that Brazilian Telecomms services are largely self-financing, highly profitable, and a constant contributor to Government resource raising. A brief review of some of the main economic parameters of TELEBRAS helps to illustrate the contribution of Telecomms to the economy.

Since TELEBRAS was established in I972 it has grown to become the I8th largest corporation in Brazil in terms of sales, and now ranks as the second largest profit maker (in absolute terms) in the country.[I] Over the '70s TELEBRAS has largely financed its own expansion through operating revenues, mainly from the more profitable international and interurban services.[2] Indeed since I977 TELEBRAS has been almost completely self-sufficient with autofinancing never falling below 94%. This is, in

I) Visão (I983)

2) Full details for the period I973-I98I are given by Revista Telebrás (I98I) September, p77.

itself, an unusual achievement among Telecomms operating companies internationally who normally expect to raise approximately an equivalent of one third of annual turnover in the form of fresh capital, to keep pace with an average annual growth of I0%. (In fact Brazil's Telecomms growth was way above this rate averaging around I8% p.a. over the 1977-I98I period).[I] Today operational costs currently run at only 48% of gross operational receipts, with a further 39% of receipts covering interest payments and amortization on loans.[2]

In addition to financing its own expansion, since I974 TELEBRAS has been used as a constant source of Government revenue for other activities. Central Government has consistently diverted resources from the National Telecomms Fund (set up to finance Telecomms investments) to other Government projects. In I983 of the Cr225b (appx. $370m) received by the fund from operating revenues 77% was diverted to activities outside the Telecomms sector. In I984 only I0% of the estimated Fund receipts of Cr520b (appx. $460m) is forecast to be used for Telecomms purposes.[3] In spite of this large resource drain TELEBRAS has maintained an impressive rate of Telecomms expansion almost wholly from operational receipts.

Furthermore the high levels of growth, investment and profit under TELEBRAS have not been at the expense of the consumer in terms of high prices. Since I974 increases in Telecomms tariffs have remained consistently and substantially below the average rate of inflation. In I983 local tariffs were 25 times higher than they had been in I973, with inter-urban 35 times, while the general price index over the same period increased 89 times. In the context of these extremely high rates of inflation relative price increases become very important. In comparison with all the major public services and products over the I973-I983 period Telecomms charges experienced the lowest rates of inflation with for example,

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I) I0% is the average DC Telecomms growth rate, Pelton (I980)p2I0 The demand for external capital is due to the extremely "heavy" nature of Telecomms services where the ratio of fixed capital requirements to gross annual income is usually about 3/I - appx. 9 times greater than normal manufacturing capital/output ratios which average around I/3.Chapius (I975)p6I5

2) Information from Telebrasil (I983) Nov/Dec. p4.

3) Exchange rates for I983, average of Cr606 = $I; for I984 current rate of CrII28 = $I.

coffee and bread prices rising 140 times, water rates increasing 46 times, electricity 120 times, gasoline 118 times and minimum wages 87 times.[1]

Alongside high profitability and relatively low price inflation TELEBRAS has also been a constant source of employment throughout the recessionary period beginning in 1974. Over the period 1974 to 1976 the number of TELEBRAS employees increased from 78,000 to over 84,000 and today employment stands at around 97,000.[2]

In short the large investments in Telecomms since the mid '70s have more than realised their return. Today TELEBRAS occupies an almost unique position among state enterprises in Brazil with low debt, falling imports, no contribution to inflation, and rising levels of employment.

Returning to actual infrastructural improvements, much of the investment described in Table 2 above was directed to expanding and modernising the basic Telecomms transmission network. The updating of the technologically backward transmission systems was vital not only to integrate the country within one Telecomms network, but also to lay the foundations for Brazil to "digitalise" the whole Telecomms network and thereby meet the demands of so-called "information society".[3]

Briefly, the predominant form of domestic transmission is microwave line-of-sight relays which integrate all the states and most cities, and are now used to connect Brazil directly with Argentina and Paraguay using high capacity linkages. Where Brazil's environmental conditions do not permit access by land other modern means of transmission are used. Satellite transponders currently leased from INTELSAT cover the massive Central East Amazon region, while troposcatter systems cover the remote North/North East regions. In addition satellite and

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1) Telebrasil (1983) Nov/Dec p7. The "squeeze" this has imposed on the Telecomms sector as a result of relatively low tariff increases and rising input costs is discussed in Part 4 below.

2) Sources: Maculan (1981) p196, Wajnberg (1982) p5, Lu(1978)p75.

3) Based on digital information technology, this sector includes Telecomms, Telematics and Informatics, and is recognised to be the largest dynamic source of employment and economic growth in the OECD countries. See OECD (1981[a]) especially pages 72 and 73. Also see glossary for explanation of these and other technical terms in this section.

short wave radio systems now provide a full coastal Telecomms service.[1]

After microwave relays satellite is the second largest form of domestic transmission. Brazil is now one of the largest Third World leasers of INTELSAT satellite transponders. However, a wholly Brazilian developed satellite is due to be launched next year to begin replacing the relatively expensive and inflexible INTELSAT services.[2] Local satellite development is also geared towards the planned digitalisation of the entire Telecomms network.

Satellite transmission has played an increasingly important role in integrating Brazilian Telecomms both nationally and internationally since 1974. Currently, satellites provide local Telecomms links to Boa Vista, Macaro, Manaus, Porto Velho, Rio Branco and Tangua (near Rio de Janeiro); this coverage is to be expanded substantially over the next five years. Internationally satellite links are centered around two major earth stations at Tangua which connect Brazil directly with over forty other countries. The current capacity of around 700 international circuits is planned to increase to 3500 by 1993.

Although the use of satellites has grown considerably the principal means of international transmission remain the coaxial networks, again developed extensively after 1974. Over the last 10 years Brazil has installed 2 major underwater coaxial systems. The first, "Bracan I" was developed jointly with the International Telephone Company of Spain and since 1973 has provided 160 telephone voice circuits to Europe. The second, "BRUS" with 1640 voice circuits began operating in 1980 to provide transmission to the United States. BRUS was developed together with a group of corporations led by AT&T. A further high capacity coaxial system called ATLANTIS began operating in 1982 to expand Brazil's telephone and telex transmission links with the continents of Africa and Europe. ATLANTIS has two major submarine cable sections, the first with a capacity of 1380 voice circuits and the second with 2580 circuits.

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1) Full details of the technological upgrading of Brazil's transmission network are given by SSI (1982).

2) Jornal do Brasil (9/1/84)

It is also important to note the impressive progress made in providing an informatics transmission base. Essentially Brazil's aim is to keep apace with the increasing economic demands for rapid transmission, manipulation and storage of digital data in various forms through the national Telecomms network. Regarding public data communications facilities, EMBRATEL, the operating company responsible, introduced a comprehensive data communications service in 1980 called Transdata. This system employs the most up-to-date Time Division Switching and Multiplexing technology and now covers 300 localities with over 4000 terminal points. The principal aim of Transdata is to allow firms, institutions and private individuals to send large quantities of data in digital form at great speed and low cost from one location to another.

A further public data communications system, SICRAM, is also provided by EMBRATEL for the automatic storage and retransmission of data. SICRAM is also open for public use and data is processed in digital form through the national telex networkand controlled by a central computer in Rio de Janeiro. Internationally data transmission is now provided by the INTERDATA service. An additional international system exclusively for banking use is also currently being commissioned and due to be installed soon.[1]

Together with the now comprehensive data communications network Brazil is also developing and introducing various Telematics systems at the very frontier of information technology.[2] A public Videotext system which transmits data in digital form through the telephone network and displays information on television screens is currently being installed in São Paulo. A further project Teletext is also underway; this system transmits digital information via television signals and again uses the TV screen to display information to the user.

A public international electronic mail system is already operating in Rio de Janeiro and São Paulo and shortly to be extended to other major cities. The Ministry of Communications

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1) Comprehensive digital systems for Maritime and Air Traffic control are also now operating through the Telecomms network SSI (1982)

2) Again see SSI (1982) for full technical details.

is presently deciding which national corporations will supply the hardware and software for the international electronic mail service and the planned domestic electronic mail network. Finally, it was very recently announced that from March this year each household in the capital city Brasília will be linked by telephone to a central computer information centre, to provide a wide range of public information services. All the software for the network is being developed locally together with some of the hardware, including the modems which allow the telephone direct access to the central computer.[1]

In short, since 1974 Brazil has not only greatly improved and expanded its conventional Telecomms infrastructure but also layed the foundations for meeting the increasingly important demands of information technology.

2.3 Indicators of Industrial and Technological Achievements

2.3.1 Private Sector Progress:

While details of how Brazil planned and executed its Telecomms strategy are discussed in Part 3 below it is useful here to present in general terms the progress to date in establishing a viable national equipment supply sector. In terms of ownership and national integration of the MNC subsidiaries the new policy introduced by the Ministry of Communications after 1974, achieved three major objectives vital to technological accumulation within the country. First, the majority of voting capital of the MNC's has now been transferred to Brazilian financial groups. Although in itself ownership transfer is not a sufficient condition to ensure local technological development, this was a vital step in gaining national control over the industrial and technological activities of the MNC's.

Second, all the Telecomms equipment purchases were centralised under TELEBRAS under the new industrial policy. This new monopsony purchasing power enabled TELEBRAS to insist that the MNC's reduce their imports of components and equipment, and use locally produced inputs and technology. In other words

1) Jornal do Brasil (1984) 23/1/84 p12.

the MNC subsidiaries were forced to increase the level of integration of their activities within the industrial structure of the country. Table 3 illustrates the degree of success of this policy over the 1975 to 1982 period, with imports falling from $249m in 1975 to around $80m in 1982.

Table 3 Commercial Balance of the Telecomms Equipment Supply Sector 1975-1982 (millions of dollars, current prices).

	1975	1976	1977	1978	1979	1980	1981	1982
Imports	249	161	177	68.8	68.5	78.1*	88.9*	79.7
Exports	-	1.5	30.7	24.7	33.4	36.9	38.7	21.6
Commercial Balance (negative)	249	159.5	146.3	44.1	35.1	41.2	50.2	58.1

Source: Wajnberg (1983)p22
*Increase due to introduction of SDS-SPC technology.

A modest level of exports also helped improve the overall trade balance of the manufacturing sector from -$249m to around -$50m over the last 3 years. Evidence from GEICOM (the agency responsible for regulating Telecomms imports) shows an even higher degree of success in reducing imports of the state operating companies under TELEBRAS, with imports falling from over $100m in 1975-1976 to only $19m in 1981.[1]

By reducing the import value per unit of output the indices of nationalisation increased from around 80% in 1975-1976 to appx. 90% today.[2] This means simply that for every dollar of imports Brazil produces 10 dollars of local output. Although this is a very crude measure, the Telecomms ratio of 1:10 is easily the most successful within the electronics sector overall in Brazil, with the consumer goods sector standing at 1:6.6 and the informatics sector at only 1:3. New rules to reduce imports still further were issued by CACEX (the department of foreign trade of the Bank of Brazil) in 1983, with an extension of the list of prohibited Telecomms imports. Latest estimates indicate a reduction of imports of 22% in 1983 in

1) Wajnberg (1982) p6.
2) Calculated from Wajnberg (1982) and (1983).

relation to 1982.[1]

The third major achievement of Telecomms policy after 1974 is the substantial degree of local technological development by the MNC's within Brazil's national boundaries.[2] This occurred a) as a direct consequence of the rules regarding the "Brazilianisation" of technololgy imposed by TELEBRAS (combined with the competition between the MNC's for new orders), and b) as an indirect result of the import reductions imposed on the MNC's which necessitated a degree of local technological development to substitute domestic inputs for previously imported ones.

In fact the post '74 policy gave rise to a further important phenomenon - the rapid growth and participation of small scale firms of Brazilian origin supplying equipment, components, and materials for the Telecomms network. By 1982 the number of small and medium scale Brazilian firms had reached 120, supplying appx. 17% of total equipment supply needs. The vital technological role played by these firms is analysed in Part 4.3, suffice to mention here that some of the larger units have already moved up the scale of technological complexity and are now actively involved in developing digital exchange technology in conjunction with TELEBRAS.

2.3.2 Government Sector Investments:

Together with directing the activities of the private sector Brazilian state enterprise has also successfully embarked upon an ambitious programme of local technological development, principally under the major new R&D centre in Campinas (CPqD). Since 1976 CPqD has been engaged in developing digital technology right the way through from basic design research, to transferring technology to local industry. Through these state R&D activities Brazil has succeeded in mastering microelectronic technology in all three areas of exchange, transmission and peripheral equipment.[2]

Table 4 below shows TELEBRAS's investments in R&D over the period 1977 to 1983; again it is important to note the

1) Telebrasil (1983) March/April p21 presents the response by the supply industry who believe this to be unfair treatment.

2) Again detailed below Part 3.3

extreme sensitivity of exchange rate conversions especially for 1982 and 1983.

Table 4 Investments in R&D by TELEBRAS, 1977 to 1983 (millions of dollars, current prices)[a]

Year	Investments R&D Expenditure	Fixed Assets[b]
1977	20.1	5.4
1978	22.0	6.7
1979	31.3	25.0
1980	32.1	22.1
1981	30.8	21.4
1982	28.3	n/a
1983	13.7	n/a

Sources: 1977 to 1981 SSI (1982)p53
1982 Telebrasil (1982) Nov/Dec p78.
1983 Telebrasil (1983) Nov/Dec p4.

a/ Exchange rates for 1977 to 1981 as per TELEBRAS, rate of Jan. 1981 Cr65.5 per dollar. Exchange rates for 1982 and 1983 calculated as an average from official Central Bank Statistics, 1982 Cr183.6 per dollar, 1983 Cr606.5 per dollar.

b/ Includes land, construction of buildings and acquisition of real estate and equipment.

The main point to note is the relatively low levels of R&D investment in relation to total investments by TELEBRAS (appx. 3%), and in relation to gross operating revenues of TELEBRAS.[1] TELEBRAS policy is to invest around 1% of operational receipts in R&D - far lower for example than the major MNC's expect to invest in R&D internationally.[2] If we compare the R&D investments say for 1983 (Cr8.3b) with resources diverted from the National Telecomms Fund for other purposes (Cr150b)[3] - finances diverted amount to 18 times TELEBRAS's total investment in R&D. In other words, establishing a local technological

1) Calculated as a yearly average from Tables 2 and 4 above.

2) Estimates vary between 5% and 10% depending on the Corporation See Muller (1982) for discussion.

3) Telebrasil (1983) Nov/Dec. p3.

"backbone" in digital Telecomms in no way amounted to an insupportable resource burden for either the Telecomm sector or the economy as a whole.

Despite these comparatively low levels of investment TELEBRAS has built up a large and successful centre for developing microelectronic technology. CPqD now has around 900 regular employees, 700 of whom are directly involved in research. To date CPqD has developed virtually from scratch a range of digital exchange systems designed not only to suit Brazil's tropical climate, but also the particular types of telephone traffic conditions found in the various regions. CPqD's close relations with industry has enabled technology transfer and joint development with local firms in exchange, transmission and peripheral Telecomms technology.[1]

Also worth noting here is CPqD's development of a complete fibre optic transmission system using the most sophisticated digital multiplexor and laser technology. This technology has been transferred to local industry for production and field tests are also currently underway in Rio - making Brazil the first Third World nation to successfully design, develop and install an integrated optical fibre system. CPqD is also responsible for the development of the indigenous satellite to be launched next year which will play a vital role in providing Brazil's remote regions with telephone and TV facilities.

From CPqD's creation in 1976 it has become established as a successful high level R&D institution well integrated into the industrial and technological structure of the country. Government estimates show that systems developed by CPqD already supply apnx.15% of Brazil's total Telecomms market, and 50% of all future TELEBRAS orders have been reserved by law for CPqD.[2]

2.3.3 Summary:

There can be little doubt that in the areas of industrial and technological progress in digital Telecomms Brazil now leads the Third World, largely as a result of the policies

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1) Again detailed below Part 3.3

2) SSI (1982), and Brundenius and Goransson (1982)p23.

adopted after 1974.[1] Brazil's Government R&D centre has played a central role in coordinating technological progress in Telecomms, and ensuring that a "technology gap" does not occur between Brazil and the developed market economies as a result of the diffusion of microelectronic technology. From a technologically backward and wholly inadequate Telecomms infrastructure Brazil has achieved a massive improvement in the coverage and quality of Telecomms services and provided the foundations for meeting the demands of modern information technology. Brazil's shift from a position of acute technological dependency to dynamic technological progress may well hold lessons for other larger DC's which hold national autonomy in Telecomms technology as a high priority. What follows is therefore a detailed assessment of how this progress was made in such a short period of time.

I) For the relative technological backwardness of other major DC's see for example the cases of India (Hobday 1982) and Mexico (Tigre 1983).

PART 3 THE STRATEGY OF TECHNOLOGICAL ACCUMULATION

The aim of this section is to illustrate exactly how Brazil established its base in Telecomms technology and to describe in detail some of the major technological achievements to date. Section 3.I begins by examining the uncompromising policy objectives after I974 and goes on to discuss the legislative, administrative, and financial steps taken to ensure these aims were met. Section 3.2 focusses on Brazil's efforts to direct the industrial activities of the MNC's to ensure local technological developments began at the level of the firm. Finally Section 3.3 analyses the means by which direct Government investment in the R&D centre CPqD, was used to develop a strong autonomous base in digital Telecomms technology. From the overall evidence it is clear that Brazil's shift from a position of severe technological dependency to substantial technological accumulation was the result of the innovative and offensive technology strategy adopted after I974.

3.I Planning Objectives, Legislation, Administration and Finance.

Two equally important and complementary areas of policy were defined and legislated for in the post '74 period. The first concerned the service sector and establishing a modern and efficient Telecomms infrastructure. The notions of National Security and the integrated Nation State were fundamental not only in the initial high priority given to Telecomms, but also in the subsequent decision to begin installing the most sophisticated microelectronic-based technological systems. Brazil's infrastructural objectives therefore involved, on the one hand detailed planning to integrate the various diverse regions of the country, and on the other a detailed strategy towards implementing the very new and rapidly changing digital systems.

The second policy objective, not only closely linked but fundamental to the first, was to establish a strong autonomous industrial and technological base in order to supply the necessary equipment and components for the infrastructural expansion. This objective involved a two part strategy of: I) indirect Government intervention to establish ownership and control over the activities of the MNC's within the country to ensure local technological development, and 2) direct Government intervention in building from scratch a major State R&D centre to dominate the main areas of digital Telecomms technology.

Furthermore a conscious decision was taken in 1976 to begin the "digitalisation" of the Telecomms network. By building a major industrial and infrastructural base in digital technology the advantages of "leapfrogging" the older, less flexible, and more expensive electromechanical technologies could be gained. These early decisions provided the groundwork for later policy regarding the Informatics sector and especially the control of data processing within Brazil's national boundaries.[1] However, at the time the immediate motivation was to reduce the high level of dependence on foreign imports of equipment, components and technology. Policy towards Telecomms therefore followed the general shift in economic policy towards greater import substitution and local technological development of key infrastructural and capital goods industries, adopted by the new Geisel Government in 1974.[2]

3.1.1 Infrastructural Planning, Administration, and Sources of Finance:

Although the rapid expansion of the Telecomms network began after 1974, efforts to organise and finance the service sector had already begun in the late '60s. Under the new Ministry of Communications (MINICOM) established in 1967, CTB, the Canadian owned operating company which provided the bulk of Telecomms services was nationalised. In order to provide finance for the network, MINICOM introduced a novel "self-capitalising" scheme whereby potential telephone customers

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1) SSI (1982).

2) These principles are expressed in Brazil's Second National Plan and Second Basic Plan for Scientific and Technological Development for the period 1975 to 1979.

were obliged to "subscribe" to the telephone company in order to receive a telephone.[1] Given the large existing demand for telephone installations this served the dual purpose of registering current demand for planning purposes, and raising resources for investment.

In 1972 TELEBRAS was created and granted complete monopoly power over Telecomms services under the constitution. TELEBRAS was also given jurisdiction over EMBRATEL, the Brazilian operating company responsible for international and interurban Telecomms traffic established earlier in 1965. TELEBRAS immediately began centralising and reorganising the fragmented service sector by setting up one operating company for each State. By 1973 twenty five regional comanies were established and operating under the central authority of TELEBRAS. Tariffs were standardised across regions and the rapid growth of the overall network was planned.

Two further means of finance raising were introduced by TELEBRAS - again both from internal sources. First, EMBRATEL was obliged to transfer appx. 80% of international Telecomms profit to the Brazilian Telecomms Fund. Second, TELEBRAS allowed the operating companies capital earnings of up to 12% (ie over and above operating and capital costs).[2]

By centralising the organisation and financing of Telecomms nationally, TELEBRAS was also able to plan for the integration of the various regions and rural areas lacking sufficient infrastructure. Areas of low profit, mainly the remote and rural areas were to be subsidised by the more profitable international and interurban traffic. At the same time regional cross-subsidisation became possible, and high profit and high productivity regional companies were obliged to contribute to the infrastructural development of the less profitable regions.[3]

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1) See Pelton (1981) p218.

2) Details from SSI (1982).

3) Section 4.2 below describes the problems encountered in this area due to the economic crisis and subsequent investment restrictions imposed on the sector.

3.1.2 Legislating for Local Industrial and Technological Development:

Comprehensive legislation was introduced both to strengthen the new administration under MINICOM and to translate the broader Telecomms objectives into policy rules for action.[1] Within the extensive and detailed legislation of the post '74 period it is possible to identify three main laws which expressed and defined Brazil's industrial and technological policy. The first of these laws, No 102 of Jan. 1975 defined the TELEBRAS philosophy regarding increasing local technological capacity and reducing dependence on foreign sources of technology. In addition Law 102 gave MINICOM the authority to begin identifying and deploying the available technological resources within the country, principally in the universities but also in other R&D institutes and private industry. Thus even before CPqD was created, TELEBRAS was able to begin marshalling local technological resources in the areas of Telecomms materials, components, and equipment inputs.

Shortly afterwards in August of the same year the second major Law, No 661, was passed to establish exactly how the Brazilian takeover of the market was to proceed. On the one hand this involved defining the choice of technology to be developed under CPqD, and on the other how the activities of the MNC's were to be subordinated to Brazil's National Telecomms policy. Under Law 661 TELEBRAS was to use its newly granted monopsony purchasing power as a means to establish control over equipment production and technology. By concentrating purchasing power previously decentralised, TELEBRAS was able to insist that the major MNC subsidiaries transferred majority ownership to Brazilian capital, and most importantly begin developing technology locally. The MNC's were only permitted to continue manufacturing electromechanical systems in the short term, and in order to compete for the large new orders on offer had to begin immediately developing SDS-SPC digital exchange technology, according to standardised specifications issued by

1) See SSI appendices (1982) for full details, for analysis also see Assis (1978).

TELEBRAS.

Law 66I also gave TELEBRAS the mandate to set up CPqD to develop digital systems from the basic research stage through to prototype development, and transfer of technology to local industry. 40% of the local market was reserved for technology developed at CPqD (later increased to 50% under a further Law No.2I5). Again this was a deliberate measure to strengthen the overall economic and technological bargaining position of TELEBRAS in relation to the 4 major MNC's.

The third major Law No.622 of June I978 complemented and updated the first 2 Laws. Law 622 reaffirmed the rules for nationalisation of inputs to the sector. GEICOM, the institution created in I975 under MINICOM, was given the power to coordinate the reduction of Telecomms imports and to ensure the progressive nationalisation of equipment, raw materials and component inputs.[I] Law 622 also contained more specific measures to assist local capital towards technological self-sufficiency and provided facilities for developing human capital resources.

To sum up, under MINICOM Brazil set about identifying, planning, and allocating local technological resources to ensure the development of a national Telecomms industry. In terms of investment resources the expansion of Brazil's Telecomms network was designed to be self-financing from the outset. By adopting a well defined and offensive technology strategy Brazil was in a position to begin directing the activities of the MNC subsidiaries and also build its own local base in digital Telecomms technology. Alongside the planning and legislation introduced after I974 the principal means by which Brazil intended to bargain with the MNC's was by strengthening the State institutions responsible for executing Telecomms policy - thus, through the purchasing power of TELEBRAS Brazil could insist that technological activities were actually located within the country.

I) Part 2 above described the overall success of GEICOM in this area.

3.2 Technological Development and the MNC's

In order to understand the extent of industrial and technological integration of the MNC's in Brazil it is important to view progress in this area in historical terms. Indeed, control over the MNC's must be seen as a long-term process of bargaining for industrial and technological transfer with achievements and setbacks, continuing up to the present day.

Unlike State enterprise in Telecomms, the MNC's have been supplying equipment in Brazil for over over 80 years. As Table 5 shows, except for NEC, the MNC's began their operations before or just after the turn of the century with the establishing of simple sales offices:

Table 5: Principal Activities of Telecomms MNC's in Brazil-Starting Dates:

Firm Name	Sales Offices	Import Subsidiaries	Assembly	Manufacturing
Siemens	1895	1905	1958	end of the 1960s
Ericsson	before 1900	1924	1955	1955
Philips*	1920	1925	1949	-
SESA/ITT	before 1908	1926	1942	1965
NEC	-	1966	-	1969

Source: R.S.Newfarmer, in Maculan (1981) p116.
*Philips were to drop out of the major equipment market during the 1970's.

As the internal market began to grow the sales and distribution offices were expanded and greater commercial representation introduced by the parent companies, in their competition to supply the local equipment market.[1] At this time the main buyer

1) For details see Maculan (1981) pp116-117

CTB was licensed by the Government to purchase imported equipment necessary for the Telecomms network.

This situation persisted up to the 1950s when the Vargas Government cut CTB's import quotas and placed general restrictions on imports. In the general climate of import-substitution at this time the MNC's were forced to begin locating assembly facilities in Brazil to remain in the market. Later on in the 1950s a special Government Commission into Telecomms also insisted that the MNC's should use locally produced inputs wherever possible.

Led by Ericsson, the MNC's responded by locating manufacturing facilities in Brazil, beginning with simple peripheral equipment and then moving into the production of transmission systems. By 1957 Ericsson had already begun to locally manufacture Crossbar exchanges to gain a competitive advantage over Siemens and SESA.[1]

Even during this early period it is therefore possible to identify the role of Government policy in directing the activities of the MNC's - at this stage principally through fostering competition amongst them. Nevertheless it is also important to recognise that the core technology necessary for the design and manufacture of exchange systems remained exclusively with the parent companies abroad. The Government played no active role in local development in Telecomms but was solely concerned with reducing imports under the general programme of import-substitution.

The next phase of Telecomms development began after the military takeover of 1964. Again led by Ericsson the Telecomms sector followed the general "economic miracle" pattern of rapid unchecked expansion of MNC investment. Over the 1967 to 1973 period of economic boom the MNC's greatly expanded their local manufacturing activities to meet the increased demand for Telecomms equipment.[2] Again technology was transferred only when needed to support the manufacture of the electromechanical Crossbar systems but very little in

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1) Brundenius and Goransson (1982)

2) ibid for details.

the way of local development took place.

By 1974 at the end of the boom period, like many other industries in Brazil the Telecomms sector entered a period of crisis of overcapacity, falling demand, growing financial debt and redundancies. To make matters worse the laissez-faire policy towards the MNC's had resulted in acute technological dependency. The local subsidiaries lacked any substantial capacity in R&D or product modification technology. The equipment sector was almost totally owned and controlled by the four major MNC's, Ericsson, Siemens, SESA and NEC. Indeed the concentration of foreign capital in this sector (over 90% of total sales) was even more pronounced than in the overall Electrical and Electronic sector where MNC's accounted for appx. 77% of total sales.[1]

It is within this context that MINICOM formulated its industrial and technological strategy after 1974. Initially the "Brazilianisation" rules contained in Law 661 of 1975 were resisted by the MNC's who continued with the production of electromechanical exchange equipment.[2] In order to overcome the reluctance of the MNC's to transfer SPS-SPC exchange technology, TELEBRAS eventually threatened to cancel outstanding orders. By 1977 the MNC's had begun to comply with the ownership and technology transfer directives in order to win the new orders on offer.

In terms of ownership a progressive transfer of voting capital from the MNC subsidiaries to large Brazilian financial groups began. Ericsson with a 40% market share pursuaded two financial groups, Monteiro-Aranha and Atlantica Boavista, to form a holding company MATEL to take over the majority of Ericsson's voting capital.[3] This deal was eventually approved in July 1979 and as a result Ericsson won the largest order on offer and agreed to transfer their AXE-10 SPS system technology to Brazil. Siemens with roughly 14% of the market sold a majority share to Hering, another Brazilian holding group,

1) See Newfarmer (1979) and Epstein and Mirrow (1977).

2) Earp (1982) p118.

3) Brundenius and Goransson (1982) provide full details of the Ericsson case.

forming a new company Equitel - again to compete for the new digital exchange orders. SESA and NEC with 38% and 5% market shares respectively, both sold a majority of voting capital to BRASILINVEST.

Clearly the new monopsony purchasing power granted to TELEBRAS was instrumental in pursuading the MNC's to transfer company ownership to Brazilian capital. This process of bargaining and manoevering over the 1975 to 1979 period also applied to the transfer of technology to the subsidiaries.

Detailed research by Brundenius and Goransson (1982) shows clearly that in order to gain market shares in Brazil Ericsson (also called EDB - Ericsson do Brasil), reorganised their management structure and negociated a new agreement with their parent company for the transfer of digital SPS technology. In order to compete with the SESA Metaconta, NEC's D-10, and Siemens EDS system, Ericsson set up a new technology directorate to organise the transfer and local development of digital SPS technology in Brazil. Alongside these developments in exchange technology Ericsson also set up departments to develop component and material inputs as well as an informatics sub-division.

At the time of the ownership negotiations Ericsson bargained for a new technology agreement with its parent company LMF in Sweden. The negotiations were complex and involved Ericsson do Brasil, LMF, TELEBRAS and MATEL. Unlike previous technology contracts this agreement involved a substantial transfer of the core technological elements of the central exchange system. TELEBRAS used the opportunity of a large new order of 800,000 lines to supply São Paulo over the 1982 to 1986 period, to insist that the AXE-10 SPS technology was in fact developed in Brazil. The contract covered exchange, transmission, and some peripheral equipment and included: a) full technical specifications and design information, b) extensive training in design, engineering, manufacture and installation, and c) other information essential to financing, marketing and purchasing, including details of components and machine tool suppliers together with necessary information on marketing channels.

Interestingly, the terms of this thoroughgoing technology contract were far superior to former agreements. Not only was the overall cost substantially lower, but two important clauses - patent rights and trade mark rights - were granted completely free.

The negotiations under TELEBRAS succeeded in acquiring all the necessary software and hardware technology vital for research, design and development of microelectronic SDS technology. Training for Ericsson employees in Brazil constituted the largest cost component of the contract, followed by direct technical assistance for production start-up, and disembodied technology in the form of specifications and documents. The clear superiority of this contract reflected the direct involvement of TELEBRAS in the negotiations and the application of their own technical and managerial knowhow to the bargaining process.

In 1980 however a major policy change occurred. It became evident that the SDS (space division switching) technology was rapidly becoming obsolete. TELEBRAS therefore suspended all outstanding orders, except for Ericsson's São Paulo contract, and began negotiations for the transfer of the new,higher capacity, TDS (time division switching) technology. ITT/SESA, formally with a large share of the market supplying Rio de Janeiro, showed no interest in developing TDS technology locally. In September 1981 ITT allowed BRASILINVEST to buy the total of their capital and in effect dropped out of the market - leaving the competition for the other 3 MNC's, Ericsson, Siemens/Equitel, and NEC.

Siemens/Equitel took this opportunity to attempt to regain a greater share of the market. Having previously lost ground to Ericsson and been relegated to the much smaller regional market of Curitiba (south of São Paulo) Siemens (now called Equitel) also began following a technology based strategy to gain an increased market share.

Although the evidence for Equitel is far less conclusive than Ericsson, there are strong indications here too of local technological progress in response to the Brazilianisation rules both before 1980 and after.[1] After 1976 Equitel (then Siemens) began introducing technology to adapt private and public exchanges developed by Siemens in Munich and succeeded in developing a series of products not in the parent company range. Also in response to the Brazilianisation rules, Siemens began a systematic replacement of imported for locally produced inputs, involving substantial technology training from Germany. This involved extensive product redevelopment as simple substitution of imports was rarely possible. Today appx. 93% of public exchange and 98% of private branch exchange equipment is of national origin.[2]

After the local technology training programme a large proportion of the German engineers returned home and were replaced by Brazilian engineers. Currently, only 5 engineers at Equitel are German with none at directorate level. As far as local product development is concerned Equitel participated in a consortium with 4 other Brazilian based companies (ABC-Teletra, Sitelta, Induco, and Siecom) to develop small central exchanges for Brazil's rural areas. Some of the new products developed by Equitel are now being exported to other Latin American countries.

Following the shift to TDS technology, Equitel embarked upon a new major technology-based strategy to gain a larger share of the future exchange market. Again this involved a programme of joint technology development, this time headed by the largest national Telecomms firm Elebra. In January 1983 the two parties signed an agreement authorised by MINICOM for the joint development of medium scale public TDS exchanges in conjunction with CPqD.[3] Clearly, from the point of view of Equitel this strategy is designed to regain a larger share of the major Brazilian exchange market.

This process of technology bargaining and competition for market shares therefore continues. At present it appears

1) Industry interviews and Telebrasil, various issues.

2) Calculated as per GEICOM nationalisation indices. Telebrasil Nov/Dec (1983) p48.

3) Companhia Docas de Santos (1982) Annual Report.

that the three major corporations Ericsson, Siemens and NEC will remain in the competition for the major exchange segment of the market.[1] By 1985 Brazil plans to introduce its own TDS technology and intends to supply 50% of the local market, as allocated by Law 215 of June 1981. Whether or not the new technology strategy adopted by Siemens will lead to a restructuring of market shares remains to be seen.

3.2.1 Implications: Bargaining for Local Technological Capabilities.

Historically there can be no doubt that the MNC's in the Brazilian Telecomms market have progressively become more and more integrated into the industrial and technological structure of the economy. From simple sales offices, through to assembly units, the subsidiaries are currently developing technology within Brazil - in some cases in cooperation with State enterprise and new firms of Brazilian origin.

The latest phase of MNC integration illustrates the difficult and complex process of bargaining involving setbacks and successes, with resistance by the MNC's on one hand and various forms of Government pressure on the other. The international diffusion of microelectronic technology during the '70s and the subsequent increase in MNC competition for Third World markets, placed Brazil in a better position to bargain for genuine technology transfer. At the same time the strengthening of MINICOM's own administration and their insistence on transfer of ownership and technology as a prerequisite for remaining in the market, gave further momentum to local technological progress within Brazil's national boundaries.

In response to the dual pressure of intensified international competition and the TELEBRAS Brazilianisation rules, local technological development is currently being employed as a means of Multinational corporate competition. This strategy is clearly illustrated by the willingness of the

1) Interviews suggest that the other major, NEC, has not yet joined in this type of technology-based competition but only appears to wish to assemble equipment in Brazil.

subsidiaries to: a) restructure their organisations to produce technology locally, and b) collaborate with State enterprise and national firms to develop the highest level TDS digital exchange technology. In short, the Brazilian Telecomms industry illustrates an important new phenomenon in DC industrial technology studies - the use of local technological development as a means of corporate competition.

3.3 Government Direct Investments in Technology.

Alongside the strategy of technological aquisition through the MNC's the Government also embarked upon a long-term investment programme in its own R&D centre at Campinas (CPqD). The level of investment and the general size and scope of of CPqD were outlined in Part 2. However to appreciate the fundamental long-term role of CPqD in organising, choosing, and developing technological resources it is helpful here to examine a) how CPqD functions as the centre of local technological accumulation in Telecomms, and b) some of the major achievements in digital technology since its creation in I976.

3.3.I CPqD as the Centre of Local Technological Accumulation in Telecomms:

The overall aim of State investments in Telecomms was to reduce dependence on foreign sources of technology and to establish Brazil as a major producer of digital electronic systems. CPqD was to be the principal means by which TELEBRAS could identify and deploy Brazil's existing technological resources at the outset. In the planning stage over the period I972 to I976, TELEBRAS conducted a series of meetings and established formal agreements with the universities and other institutions involved in Telecomms related research.[I] The aim was not only to define existing activities being carried out, but also to officially set up and fund various research projects

I) For a full discussion of the institutions involved see Albuquerque and Waldman (I980)pp44-62; for a listing in English see Galli (I982) pp35-38. Tania discusses the early meetings conducted (I983).

and begin planning for the human capital resources needed to master the technology. In 1976 CPqD took over this coordinating role, and in addition the main responsibility of developing the new digital systems through from the basic research and design stages to the development and transfer of technology to industry.

Table 6 describes the distribution of R&D activities as originally planned by CPqD and TELEBRAS:

Table 6: Distribution of R&D Activities in Telecomms According to the CPqD/TELEBRAS Plan.

R&D Activities	Groups Responsible
Basic Research	Universities and Centres of Research
Applied Research	Universities, CPqD, and other Centres of R&D
Prototype Development	CPqD, other Centres of R&D
Product Development	Industry (eventually CPqD and other Centres of R&D)
Adaptive Development	CPqD, other Centres of R&D, and Industry

Source: Albuquerque and Waldman (1980) p3.

Essentially, basic research was to continue within the Universities but under the coordination and financial umbrella of TELEBRAS. Applied research and prototype development was to be conducted by CPqD, with the option of contracting out work to other institutions if necessary. Under the new authority of TELEBRAS, CPqD could also choose which firms were to collaborate in the design and eventual manufacture of the products - an extremely important task, given that 50% of the future market was allocated by law to systems developed by CPqD.

From the early philosophy of CPqD the vital role of the Government sector is clear. Under TELEBRAS, CPqD was the means by which local technological activities were to be identified, organised, financed and expanded. By integrating CPqD into the industrial structure of the country TELEBRAS could begin exercising control over the equipment supply sector and fulfil its mandate of supporting the growth of local firms. At the same time CPqD was to function to feed back the infrastructural demands for products and technology, through to the universities and R&D institutes for basic and applied research. By subjecting the universities and R&D institutes to CPqD's overall technology planning, Brazil could also begin taking over the important "choice of technology" decision, previously under the sole direction of the MNC's.

Initially CPqD's choice of technology was determined by the Government's aim of gaining self-sufficiency in micro-electronic systems, thereby bi-passing intermediate technologies. The idea later crystallised, that by absorbing the most advanced digital technology Brazil could effectively prevent any "technology gap" from developing between itself and the advanced economies due to the diffusion of information technologies. In effect CPqD was to be Brazil's leading edge in absorbing digital technology and "catching up" in the field of micro-electronic technology.

At the start however, CPqD's main aim was to dominate all three areas of digital Telecomms technology - exchange, transmission, and peripheral systems. By mastering the technology in these areas Brazil could locally supply the knowhow and personnel needed for digitalising the whole of the domestic Telecomms network.

Besides these strategic plans for dominating micro-electronic technology, CPqD would also function in response to day to day requests from the State operating companies. Currently, requests for special product development are chanelled to CPqD for development or contracting out, providing the technology is approved. In this way CPqD is geared to respond to the specific technological needs of the local Telecomms network.

After a product is developed and reaches the industrial prototype stage the technology is transferred to industry for production. Normally the choice of firms is decided before the manufacturing stage as it is necessary for the chosen company to be actively engaged in the R&D especially in the later stages of development. Patents belonging to TELEBRAS are then registered and royalties are received, normally from the operating companies.

In short CPqD is not simply an R&D centre but actually represents a system for the National accumulation of technology. All the various research groups, firms, institutions and personnel involved are organised to respond to: a) the strategic Government objectives towards Telecomms and microelectronic technology, and b) the specific technological demands of the State operating companies. Through its authority under TELEBRAS, CPqD is also able to choose which firms are to develop and manufacture particular products. In addition CPqD's coordinating and financial role enables control to be exercised over the basic research activities throughout the country, mainly in the universities. Thus, from the outset CPqD was designed to be a system of technological aquisition and coordination to meet Brazil's overall digital Telecomms objectives and the specific regional needs of all the various operating companies.[I]

3.3.2 Digital Technological Developments under CPqD:

While a case study of CPqD's achievements is outside the scope of this paper it is possible here to outline the main programmes underway, and to present progress to date in the technological "heart" of Telecommunications - exchange systems. Table 7 presents all the major projects currently under development together with the institutions and firms involved. As can be seen the major areas of digital exchange, transmission and peripheral technology are covered, involving a large number of research institutions and firms.

I) Part 4.4 below describes some of the successes in producing and adapting microelectronic technology to meet local needs.

Table 7: Major Programmes and Projects under CPqD

Programmes and Projects	Institutions and Firms Involved
1) Digital Exchange Technology - Tropico C - Tropico R - Tropico L - Tropico T	CPqD, EMBRACOM*, Elebra* and PSD Sistemas Eletrônicas*
2) Programme of Digital Transmission	
- MCP 120/480 (PCM 120/480 channels)	CPqD, UNICAMP (University of Campinas), Elebra*, Ampere Volt Eletrônica Ltda*
- Radi-834 (Digital Radio)	CPqD, UNICAMP, CETUC (Centre of Telecomms Studies, Catholic University - Rio) and LME (Laboratory of Microelectronics University of São Paulo)
3) Programme of Data Communications	
- REXPAX (Experimental packet switching network)	CPqD, EDP (Division of EMBRATEL) and EDTE.
4) Programme of Optical Communications	
- ELO-34 (Optic fibre system)	CPqD and UNICAMP.
- Laser and semiconductors	CPqD and LPD (R&D Lab.of UNICAMP)
- Fibre optics	CPqD, LPD and X-Tal*
5) Satellite Communications Programme	
- ETP (Public Telephone Station)	CPqD, EBT, IGB-Control*, AVIBRAS CETUC and LME.
- ERTV (TV receiving station)	CPqD, EBT, IGB-Contol*, CETUC, LME AVIBRAS (Indústria Aerospacial S/A).
- LCS (Laboratory of Satellite Communications)	CPqD and EBT.
- Other Projects including: Satellite Interference, and signal processing and transmission.	CPqD, EBT and CETUC.
6) Telecomms Systems Programme	
- Interference between terrestial systems	CPqD, EBT and CETUC.
- Radio-electric systems	CPqD, TELEBRAS Operations Directorate, and CETUC.
7) Components and Materials Programme	
- Laser and semiconductor	CPqD and LPD.
- Fibre optics	CPqD and X-Tal*
- Hybrid Circuits, thick and thin film	CPqD, CETUC, LME, Laboratory of Electronic Devices (University of São Paulo-LED), Elebra* and Gradiente*
- Integrated ciruits	CPqD, LED, and LME.
- Electronic grade materials	CPqD and UNICAMP.

Compiled from various sources including CPqD, TELEBRAS, Assis (1978) pp20-21, Company Reports and Interviews.

*indicates private company.

Brazil is the only country in the Third World to have successfully developed and installed an integrated optical fibre system using multiplexor and laser technology (the ECO-I). The ECO-I was developed from several of the projects listed above, and all the necessary technology including industrial grade silicon material for manufacturing optical fibres, is being transferred to local industry for production this year. CPqD's satellite programme is also well advanced and has succeeded in producing low-cost digital receiving stations, together with all the necessary components and equipment for the Brazilian communications satellite to be launched next year. Various integrated circuits are already under production by CPqD, and a pilot line line with a capacity of 100,000 hybrid circuits per year, for use in central public exchanges is now being developed in conjunction with 2 local Brazilian firms.

By far the largest programme under CPqD is the Tropico exchange technology project which absorbs around 30% to 40% of total CPqD investments.[1] Tropico is a family of digital stored program controlled exchanges based on the most advanced time division switching technology. The main objective of Tropico is to design and develop totally in Brazil, digital exchanges not only of the highest quality but also more suited to the particular climatic and telephone traffic conditions found in Brazil. From 1985 50% of Brazil's internal market is to be supplied by CPqD's technology. Over the longer-term it is intended that Brazilian exchange technology should be able to compete with products available on the international market.

The R&D philosophy adopted by CPqD was to begin by developing low capacity exchanges and gradually build up to medium and large scale systems. Even a brief analysis demonstrates the considerable success to date in developing and manufacturing these systems.

The initial project Tropico C (originally called SISCOM 3) entailed the development of a line concentrator with a capacity of 100 and 200 terminals. Essentially a line concentrator is equipment linked to a central exchange which allows a given number of subscribers to be "concentrated" through far fewer

1) Telebrasil (1982) Nov/Dec p78.

lines than otherwise necessary. Line concentrators are especially important given Brazil's need for low-cost expansion of existing exchange capacity. To date CPqD has completed the design and development of Tropico C using PCM multiplexing techniques to transmit the signals, together with a digital-analogue converter at subscriber level. Field tests began in 1982 in Rio de Janeiro and the system is ready to be industrialised and used in the TELEBRAS network.

Using much of the same design knowhow, the next project Tropico R involved the development of a small, low-capacity public exchange with a capacity of 1000 terminals. Again a TDS system wholly produced in Brazil, Tropico R was especially designed for low-density urban and rural use. This project too has successfully reached the field test stage and is now ready for production.[1] It is interesting to note that the 3 private companies involved in the later development stages (see Table 7) are all new wholly Brazilian firms. This not only illustrates CPqD's role in developing local technological resouces but also in transfering the know-how to local industry.

Building on the experience of Tropico R, the next project Tropico L was a medium scale local and tandem public exchange with a capacity of 60,000 lines. Although some of the hardware from Tropico R was used in the development of this exchange, far more sohisticated upgrading of the system design was necessary. Again Tropico L is a fully digital TDS exchange developed completely in Brazil. CPqD began first prototype tests in May 1981 and field tests at the end of 1983; the system is planned for manufacture and installation this year. In January '83 MINICOM authorised a consortium headed by the largest Brazilian firm Elebra to begin negotiations over the development and manufacture of this system with CPqD and TELEBRAS. As noted earlier, the willingness of a major MNC, Equitel/Siemens,to participate in this consortium indicates the tendency towards the increasing technological integration of the MNC's.[2]

1) In July '82 Elebra was authorised by MINICOM to begin manufacture, Docas Annual Report (1982) pII.

2) The final project, Tropico T, is discussed at the end of this section.

3.3.3 Further Research Recommendations:

A) Technological "Learning" at CPqD

Since 1976 CPqD has accumulated sufficient experience and technology to master the frontier areas of digital Telecomms technology. A detailed analysis of the technological "learning"[1] experience at the level of CPqD, to illustrate the channels and mechanisms by which this technology was acquired could be of considerable interest to other DC's wishing to acquire a national base in digital Telecomms technology. An examination of CPqD's successful role as a system of national technological accumulation, both at the coordinating managerial level, and at the micro/engineering level, could also add to our very limited knowledge of how information-based microelectronic technology can be acquired. (As opposed to mechanical and electromechanical technology for which there now exists substantial evidence). Furthermore, a detailed investigation of this type could also have a wider bearing on the potential impact of microelectronic diffusion on the Third World - if indeed other DC's are also in a position to effectively "leap-frog" intermediate technologies and prevent a further widening of the technology gap between Developed and Developing Countries.

B) Should Brazil Develop Large Scale TDS exchanges?

Of more immediate interest to Brazil is the question of whether the country should begin the development of large scale public exchange systems. Tropico T, the final project in CPqD's exchange series is a proposal for a large-scale central exchange. Until now this project has not been clearly defined, but there are strong reasons to doubt whether the production of Tropico T is the best strategy for Brazil to follow. To compete in design and quality with existing international systems would require a huge increase in financial and technological resources to establish the critical mass necessary to successfully develop this type of system.

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1) For exact definition and benefits of "learning" see Bell and Hoffman (1981).

Internationally the central exchange market is both oversubscribed and fiercely competitive with soaring R&D costs. There are currently I6 major Telecomms exchange systems developed at a cost of over $6b competing for uncommitted export markets of only $2b to $3b per annum. Market analysis shows that it is highly probable that many of these systems will not realise any profit at all.[I]

To win export orders it is now becoming almost obligatory for the MNC suppliers, or their domestic Governments, to offer extremely cheap credit. For example, to win the recent Indian order the French Government had to step in to support CIT-Alcatel to guarantee a cheap loan "aid for trade" arrangement, while ITT are currently offering China 25 years credit at only I% p.a. to compete with the French.[2]

Rapidly rising R&D costs also make entry into the large scale TDS exchange markets prohibitive. ITT for example have spent between $300m and $500m developing their I240 system.[3] After investing over $I00m in development the Swiss appear to have pulled out of the competition. The British System X, now finally developed over many years at a huge investment cost, appears unlikely to win any major export markets after loosing the recent Indian contract to the better established French CIT-Alcatel system. If we compare the magnitudes of exchange development costs, averaging roughly $375m for each system, with Brazil's total investments in Telecomms R&D of around $20m to $30m per year it is obvious that an immediate and massive increase in investment would be a necessary prerequisite for market entry.

In short, the extremely high risk and cost of entering the international export market in exchange systems means that all alternative avenues to developing large scale TDS technology in Brazil should be explored. Research is therefore requied into alternative means of gaining technological capabilities to meet Brazil's needs. Given the unlikelyhood of Brazil successfully

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I) Muller (I982) pI06. See also OECD (I983).

2) Details Electronics Weekly (I983) May 4 pII, and Electronic Times (I982) May 20 pI and pI0.

competing in head on competition with the MNC's for export markets, research is also required into whether Brazil's domestic market could support such a huge investment programme, especially in view of Brazil's current internal and external financial debt.

PART 4 EFFECTS OF THE ECONOMIC CRISIS[1], POLICY PROBLEMS AND PROPOSALS.

Progress in Brazilian Telecomms has without doubt been impressive, however it would be wrong to suggest that the sector does not face serious difficulties. The purpose of this section is to examine the major infrastructural and industrial problems caused both by the current economic crisis and policy failures, and thereby arrive at policy recommendations. Section 4.I briefly outlines the extent and impact of Government imposed investment restrictions as a result of the crisis. Section 4.2 examines the severe problems encountered in the rural sector due to the economic recession and the overall low priority accorded to regional and rural Telecomms. Section 4.3 describes the important technological role of the growing small-scale sector and the serious threat to continued technological accumulation posed by the crisis. Finally section 4.4 assesses Brazil's success to date in adapting digital technology to suit local conditions and argues that Brazil could become an important alternative source of microelectronic products and technology for other Developing Countries (in areas other than central exchange technology).

4.I Investment Restrictions and the Fall in Potential Telecomms Growth.

As a result of mounting Government debt and balance of payments problems following the economic "miracle" period the original Second Plan expansion of Telecomms was cut back substantially,[2] and considerable financial resources were diverted from Telecomms to other sectors of the economy. In 1975 SEPLAN, the overall Govenment planning authority began placing investment restrictions on the Telecomms sector; as a consequence the level of investments fell from a peak of around $I.8b in 1976 to $I.3b in 1979, stabilising at just under $Ib from 1980 onwards.[3]

I) In Brazil the term "crisis" refers generally to the recessionary period following the oil and commodity price increases of 1973 and 1974, characterised by balance of payments problems, accelerating inflation, rising unemployment and extremely low rates of economic growth in relation to the previous boom period of 1967 to 1973. For analysis and causation see Wells (1979) and Balassa (1979). "Crisis" and "recession" are used interchangeably

2) See Earp (1982) ppI05 to I08.

3) See Table 2 above.

In terms of the equipment supply sector the imposed cuts reduced the size of the market considerably, from appx. $I.2b in 1975 to a level of around $800m since 1978:

Table 8: Brazil's Telecomms Equipment Supply Market 1975-83.
(Billions of Dollars - Current Prices)

1975	I.2
1976	N/A
1977	I.0
1978	0.82
1979	0.89
1980	0.76
1981	0.78
1982	0.83
1983	0.80

Sources: Wajnberg (1982) and (1983).

The market reductions illustrated in value terms in Table 8 represent a very substantial fall in the actual number of physical lines contracted out by TELEBRAS for manufacture. In terms of lines the market shrank from around Im in 1973 to 1974 to the low level of under 400,000 up to 1982. In 1983 latest estimates show a modest increase in market size to about 500,000 lines due to the slight increase in investment in 1982 over the 1980 and 1981 levels.[I]

These heavy reductions in demand for equipment following the rapid expansion of MNC investment over the period 1967 to 1973, resulted in a severe and continuing problem of overcapacity since 1975. Production output over the second half of the 1970s averaged only 55% of installed capacity,(reaching 65% for cable manufactures)[2]. The increased output last year meant a relatively good performance with capacity utilisation overall of appx. 70%.

As a direct result of overcapacity and investment restrictions total employment in the supply sector fell by roughly one half.[3] Plessey and Philips withdrew from the market,

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I) Sources: Revista Telebrãs (Various Issues) and Wajnberg (1983).

2) Wajnberg (1982) p6.

3) It should be noted that the equipment supply sector represents only a small proportion of total Telecomms employment in Brazil as elsewhere.

while Ericsson and the other MNC's were forced into redundancies and factory closures.

Alongside the enforced investment cutbacks by SEPLAN two further means have been used to restrict the potential rate of growth of Telecomms, and divert resources to other sectors. The first relates to the tariff levels imposed by Government. While Telecomms tariffs remained well below the rate of inflation over the period 1973 to 1983, input prices to the sector experienced no such restrictions. Over the 1972 to 1980 period tariffs increased 12 times over, while Telecomms input prices grew 21.6 times. Since 1980 this "squeeze" has continued with the average rate of tariff increase less than the overall rate of price inflation.[1]

The second method used to divert resources is the direct appropriation of finance from the Brazilian Telecomms Fund (FNT). Appx. 30% of the price of each telephone call is chanelled to the FNT set up originally in 1973 as a source of central investment funding for Telecomms. The aim of centralising these resources under MINICOM was to enable the rapid expansion of services into the less profitable regions, effectively cross-subsidised by the more profitable States. In terms of overall importance to Telecomms investment the FNT (in spite of heavy resource appropriations) provided an average of around 24% p.a. of TELEBRAS's total investments over the 1973 to 1981 period.[2]

Since 1975 a large percentage of FNT resources has been diverted to the National Development Fund to finance other Government activities. Between 1975 and 1980 total resources appropriated reached the huge accumulated figure of Cr43b (appx. $813m).[3] By 1980 the percentage of resources chanelled away from the FNT reached 50%. Since 1980 this position has worsened still. In 1983 of Cr225b FNT receipts only Cr75b (or 33%) were returned for Telecomms investments. In 1984 only 10% of fund receipts are planned to be reinvested in Telecomms (Cr52b

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1) Telebrasil (1983) Nov/Dec.p7. and Revista Telebrás (1981) Sept.p72

2) Calculated from Telebrasil (1981) Sept.p76.

3) Telebrasil (1983) Nov/Dec.p3.

from a total of Cr520b).[1]

The long-term wisdom of these considerable restrictions in potential investment and expansion of the Telecomms network is not an issue that can be dealt with in a sectoral case study but a matter for overall resource allocation and development planning. Indeed, it may be that other more urgent social and economic needs justify this resource diversion. It should also be remembered that despite the cutbacks Telecomms services have continued to grow extremely rapidly and profitably - an additional indicator of the sector's overall performance. Within the Telecomms sector however it is possible to analyse the effects of the recession and imposed investment restrictions - the most badly effected area being rural Telecommunications.

4.2 Rural and Regional[2] Telecomms- the Problem of Low Priority.

In terms of infrastructural expansion the cutbacks imposed by SEPLAN after 1975 seriously reduced the intended rate of rural and regional Telecomms expansion. The decision to divert resources from Telecomms to other Government activities led to a restructuring of Telecomms investment priorities based on profitability. This meant that areas of social investment and low return on capital, notably regional and rural Telecomms, fell to the lowest level of priority after international, inter-state, inter-urban and urban investment. As a result the rate of growth of rural Telecomms proceeded at an extremely low level in relation to the major cities and urban areas.

According to the census of 1980 the total number of terminals in the rural sector amounted to only 75,000. Today this figure stands at little more than 90,000, or put another way, only 1% of rural households in Brazil possess a telephone.[3]

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1) Telebrasil (1983) Nov/Dec. p3.

2) In Brazil it is necessary to analyse Telecomms in Regional as well as Rural terms due to the geographical and economic diversity of the various States of the country.

3) Source, Minister of Agriculture, Telebrasil (1983) July/Aug. Although these figures refer to the strictest definition of "rural", this is still an extremely low figure, especially when one considers that 7.8% of the population overall possess a telephone.

This extremely poor level of telephone coverage reflects on one hand the investment restrictions imposed by SEPLAN due to the economic crisis, and on the other the much deeper poverty of many of the rural areas in relation to the main industrial centres. Overall this must be considered a very grave long-term problem given the vital need for social overhead investments in the poorer areas, and given the threat to the continuing efficiency of agriculture posed by a weak and sparse Telecomms coverage.

In terms of regional Telecomms, in spite of the absence of any systematic and detailed research, it is possibleto illustrate the effects of the cutbacks using information from the various regional operating companies.[I] On the whole this data shows that throughout the poorer regions of Brazil the crisis and investment cuts have resulted in frozen investment projects, low Telecomms growth and unsatisfied demand.

Evidence from Telepar, responsible for providing services to Paranã in the South of Brazil, shows that as a consequence of investment restrictions the growth of telephone coverage is insufficient to meet local demand. At the same time, plant utilisation has not reached its target level of 90%. More fortunate in the Southern region, Telesc for Santa Catarina report continued progress regardless of the crisis with the approval of a CrIb investment budget for 1983.

In the generally poorer regions of the North East severe problems, intensified by the recession, are reported by most of the operating companies. In Pernambuco several major rural projects have been frozen since the mid '70s due to investment restrictions; as a consequence telephone coverage still only amounts to 2.6 per 100 people, while the inadequate transmission coverage often results in inter-urban conjestion. A similar situation exists in Rio Grande de Norte where investment cuts have prevented the full communications integration of the State. Also in the North East Telebahia of Bahia report a continued inability to meet current demand for Telecomms services due to

I) Sources: Interviews with MINICOM and various issues of Telebrasil and Revista Telebrãs.

lack of investment resources.

Serious problems are also evident in the Northern region of the Amazon, where Teleamazon are unable to provide further infrastructural expansion to many of the interior regions due to investment cuts. Despite the progress made in extending satellite communications to many parts of the Amazon the coverage of the interior is still very poor. Restrictions on operating expenditures also mean that the maintenance of the system (often needing boats and planes) has become a very severe problem for the operating company.

In the Central Eastern region of Goiás, Telegoiás reports increasing debt, again especially due to the maintenance of existing services. In addition the company is unable to expand infrastructure to meet the currently unsatisfied demand in the region, due to the low priority accorded to regional projects.

Other operating companies report similar problems to lesser or greater extents. Overall it is clear that as a direct result of the crisis and subsequent investment restrictions, rural and regional Telecomms have not progressed to anywhere near the same level of coverage and quality as the major industrial centres or the capital Brasília. Research by the Banco Nacional Crédito Cooperativo shows that from a sample of 100 of Brazil's rural cooperatives their exists an unattended demand of 26,000 terminals. This study suggests that in each of Brazil's 2140 rural production and electrification coops there is similar unsatisfied demand. In spite of this large demand the service companies are forced to restrain their regional programmes due to Government imposed investment cuts. In short, by concentrating investment in the relatively high profit areas, regional and rural Telecomms have been forced to bear the brunt of the post '74 Brazilian economic crisis within the Telecomms sector.

4.2.1 Policy Proposals:

Currently the Ministry of Agriculture together with MINICOM are attempting to resolve the problem of lack of investment by raising finance via the existing agricultural cooperatives. However, given the extent of the problem this can only be a partial solution. It should be recognised that in relation to the industrial areas rural and regional Telecomms are severely underdeveloped. For both socioeconomic reasons and for reasons of continuing agricultural productivity it is therefore vital that a) far greater priority is given to rural Telecomms within the Telecomms sector, and b) if possible the National Telecomms Fund should be used to support the expansion of infrastructure into the poorest regions as originally planned.[1]

4.3 Recession and the Threat to Brazilian Small-Scale Industry and Technology.

The general effects of the crisis in terms of unemployment, overcapacity and investment restrictions were outlined in Section 4.I. However, within the industrial sector the economic position of the MNC subsidiaries is far stronger than that of local Brazilian firms for the following reasons. First, the far greater operating scale of the MNC's allows not only significant cost advantages in production, but also greater access to lower cost financial resources; consequently, the MNC's are in a better position to withstand both short and longer term liquidity problems, order cutbacks and the general financial constraints intensified by the recession. Second, the size of the MNC's and their access to foreign technology allows easier diversification into other product areas. For example, since I975 ITT/SESA have moved into the production of photographic and computer equipment. Ericsson is now manufacturing components for IBM computers and also photographic equipment for Kodak. NEC has deversified into microwave transmission equipment and is also producing parts for mainframe computers.

A third major advantage of the MNC's is that the type of equipment they produce, mainly large-scale exchange equipment, is not subject to the same degree of demand fluctuation and uncertainty as the relatively, lower-level technology produced by the small-scale Brazilian firms.[2] The longer cycle time

1) This would also permit the wider use of the many new digital product innovations developed especially for rural areas by Brazilian enterprise (see Section 4.4 below).

2) Described below.

of exchange equipment allows greater time and flexibility for planning and organising production output. The fourth advantage of MNC's over local firms relates to longer-term investment cutbacks forced upon firms by the recession. If cuts are imposed upon technological investments by the local MNC's, access to parent company technology is always available. This is not the case for technological investments by national firms who depend on their ability to produce technology locally.

This final point is extremely important in terms of the continuing role of Brazilian industry in upgrading and adding to the overall technological capacity of the country. As one of the directors of a local Brazilian company put it, in order for local firms to remain in the market, it is necessary to develop technology locally as part of their very survival strategy. Without a continuous upgrading of the technological capacity of these firms they cannot hope to compete in the highly sophisticated and rapidly changing microelectronic Telecomms market. In other words dynamic local technological accumulation is a necessary condition for the survival of the new Brazilian firms - this is not the case for the MNC's, who as discussed earlier, develop technology as a strategic means of market competition and not as a condition for survival.

Turning to the actual participation and role of local Brazilian capital in the market, Table 9 lists the 2I largest Telecomms enterprises as of I98I by sales. The 7 largest firms are all of foreign origin occupying just over 83% of the market. In the public exchange equipment market the MNC concentration is even more pronounced with around 98% of sales.[I] However, since I974 when there were virtually no local firms in the market, there has been a consistent and rapid growth of small and now medium scale Telecomms companies. By I976 following the introduction of import restrictions, local firms occupied around 2% of the market. By I980 this figure had increased to I0%, and at the end of I98I local Brazilian firms supplied I6.7% of total Telecomms equipment.[2]

I) Wajnberg (I982) pII.

2) ibid and Maculan (I98I) pI59.

Table 9: Major Firms in the Brazilian Telecomms Equipment Supply Industry (I98I Sales, in Millions of Cruzeiros).

Firm Name	Sales (total equipment)
Ericsson do Brasil*	I7,96I
NEC do Brasil*	8,877
Standard Electric(SESA)*	8,87I
GTE do Brasil*	5,644
Telettra*	3,306
Telefunken(Siteltra)*	2,392
Equitel/Siemens*	4,784
Elebra S/A	863
E.E.Equip.Eletrônicos	75I
Daruma	I,I80
Embracom	773
Splice	938
Icatel	389
Autel	507
IGB-Control	428
Telequipo	307
Redentor	393
Schause	269
Tecnasa	692
Microlab	I,624
Unitel	I,275

Source: Wajnberg (I982) pII.
*signifies firms of foreign capital origin.

Today there are appx I20 local firms supplying inputs for the TELEBRAS system, representing about I4% of total fixed capital investment of the Telecomms industry.[I] These firms currently represent around I0% to I5% of annual Telecomms investment in the supply industry. In terms of employment the participation of Brazilian capital is becoming extremely important. In I982 with roughly I4% of capital investment the new medium and small scale firms absorbed around 30% of the labour force. Overall it is estimated that these firms have the capacity to generate 3 times the employment per unit of investment than the major MNC's.

Alongside the proliferation of local firms there has been a consistent upgrading of the technological capacity of this segment of the industrial sector. In I975 local firms were mainly engaged in producing relatively simple equipment and technology for HF and VHF radio equipment used in transmission. By I980 local capital had progressed through to more sophisticated

I) The following information is from Telebrasil (I983) Jan/Feb. p54, and Telebrasil (I983) Sept/Oct.pp4-5.

areas of transmission equipment together with terminals for telephones and telegraph.

Today local Brazilian firms play a very important role as an alternative source of products and technology for TELEBRAS. Some of the larger Brazilian firms are actively engaged in technological investments and have built up their own R&D departments. For example the largest company Elebra invested Cr350m (around $2m) in R&D in 1982, and now employs 140 full time electronics engineers. Other larger firms are also presently involved in joint technological developments with CPqD for the TELEBRAS system.

The following products developed jointly with CPqD illustrate the dynamic technological progress of local Brazilian capital since 1974. First, Tropico C, a line concentrator, is now developed and currently in production. Second, Tropico R the TDS exchange system is also developed and ready for manufacture. In transmission technology, the MCP-30, a digital multiplexor is already in production by local firms, together with the MDT-101, a telegraph and data communications multiplexor. Also in transmission a terminal device for digital laser communication, the ELO-34 has been manufactured, and optical fibres for use in laser transmission are due to be manufactured this year using silicon material also developed locally. In addition many other products in the Satellite programme, together with various materials, components and peripheral devices are currently under production. Currently between 10% and 15% of the TELEBRAS budget is destined for orders for small and medium scale Brazilian firms.

Although local firms have experienced a successful period of growth over the last 10 years or so, the prolonged effects of the economic crisis and Governments cuts are especially severe on local firms given their inherent economic and technological disadvantages in relation to the MNC's. Unlike the MNC's Brazilian firms have very little definition of medium and long-term contracts to help plan production. Orders from TELEBRAS are subject to far greater amendment and uncertainty. The financial weakness of local firms in relation to the MNC's is also aggravated as a result of the recession. With small firms investment cutbacks actually threaten continuity in local technological progress (whereas the MNC's usually have access to technology from the parent companies). Much shorter lead times can prevent adequate production, financial and technological planning, while order cutbacks and the inability to diversify production can mean severe financial problems and bankruptcy.[1]

4.3.1 Implications and Policy Proposals:

Since 1974 a large number of small and now medium scale Brazilian firms have developed and grown to play an important role in local technological progress in digital Telecomms. The entry of many small scale firms into what was a rigidly MNC dominated, oligopolistic market up to 1974 was the result of: a) import restrictions imposed upon the MNC's and the operating companies, b) deliberate Government policy support for local capital, and c) the "modular" nature of digital technology itself which permitted the entry of small scale suppliers and the gradual upgrading of technological capabilities.[2] The possibility of market entry and local technological progress in this manner is extremely important, and encouraging, to other DC's wishing to manufacture and develop digital technology.

In terms of Brazilian Government policy, it is important that more recognition is given to local industry, both as a dynamic source of national technological accumulation, and as a present and future alternative source of Telecomms equipment. As discussed above, technological aquisition through the MNC's is a constant and difficult bargaining process - the existence of an alternative Brazilian production base in microelectronic technology substantially strengthens TELEBRAS's overall position in relation to the major equipment suppliers.

More specifically it is recommended that a policy distinction is made between the MNC subsidiaries and the new firms of wholly Brazilian origin. At present no such distinction is made; current policy is to consider any firm of majority voting shares in the hands of Brazilian capital, as equal for

1) The industry point of view is given by Telebrasil (1983) Nov/Dec.

2) In economic terms this indicates a greater degree of capital divisibility in digital technology over electromechanical technology (see Part 2 above).

the purposes of policy. This means that the MNC's (now all majority owned by Brazilian capital) have a built-in competitive advantage over local firms. Given the important technological role of firms of local capital origin, policy discrimination is needed in favour of local companies to help them toward a more equal competitive position with the MNC's.

Specific measures could potentially be introduced to: a) guarantee at least equal order continuity for local firms, b) financially support the smaller firms especially in the area of technological investments, c) increase the quota of orders allocated to Brazilian firms, and d) expand the existing technological cooperation between CPqD and local capital. A clarification and reaffirmation of policy support for local Brazilian firms would be of great benefit to Brazil's overall progress in digital Telecommunications.

4.4 Brazil as Exporter of Telecomms Products and Technologies.

A final issue of policy importance, especially in the context of the current Government and IMF pressures to increase exports as a solution to the crisis, is the potential role of Brazil as an exporter of Telecomms products and technologies. Section 3.3.3 above explained why competing in the major exchange markets internationally cannot be considered a viable proposition, at least in the short and medium term. Together with the financial and technological reasons already discussed there is an important scale consideration which puts Brazil at a severe disadvantage in relation to the major MNC Telecomms equipment suppliers. Internationally 5 of the majors produce over I million lines p.a. while most of the others produce 800,000 or more each year.[I] This gives the individual MNC's a huge economy of scale advantage over Brazil where currently the annual output of around 400,000 is shared between four major companies. The prospects for Brazil to enter the main international exchange markets must therefore be considered very poor.

I) Telebrasil (I983) Sept/Oct.

However, there is good reason to believe that Brazil could become, in the very short term, a major Third World supplier of other areas of Telecomms technology as a result of the experience to date in planning, aquiring and adapting digital technology to suit local conditions. Two of the main problems facing DC's in the expansion and improvement of their Telecomms networks are: I) the need to rely on the MNC's who supply the products for advice and expertise, and 2) the product technologies themselves, which are normally designed to suit the climatic,economic and telephone traffic conditions of the advanced economies not the DC's. Brazil's successful experience in planning, legislating and financing a modern Telecomms network, as well as bargaining with the MNC's to begin local technological developments, could be of considerable assistance to other DC's with similar,or even less ambitious objectives. Potentially there is scope for Brazil to supply consultancy expertise in all these vital areas of Telecomms planning and implenentation - and therefore provide for other DC's an alternative to reliance upon the MNC's and other agencies from the advanced countries who lack this direct experience.

In addition Brazil has to date developed a considerable range of product innovations based on the greater flexibility of digital over electromechanical technology. Brazil's experience in adapting microelectronic technology to suit local economic, climatic and telephone traffic conditions could well be a source of technology-based competitive advantage over the major international suppliers. While an appropriate export strategy would require detailed analysis and investigation, it is possible here to briefly present some of Brazil's achievements in producing microelectronic technologies more suited to DC conditions.

Beginning with exchange technology, Telebahia, the operating company for Bahia, has developed and is currently using low-cost, simplified automatic exchanges (known as CTAS's), designed especially for small towns and rural areas. The CTAS costs only I/I0 of a central exchange system, with only I/5 of the installation costs. As a low cost means of expanding network capacity, this is ideally suited not only to Bahia where around 80% of the population live outside the major cities, but also other regions within Brazil and indeed to other DC's looking for a low-cost solution to Telecomms expansion.

To help increase access to public telephones, Brazil has developed a number of systems centred around the concept of Community Telephone Services - all made possible by the flexibility of digital technology. For example, Telpe of Pernambuco responding to the heavy concentration of reverse charge calls, has installed a system developed by Telesc (of Santa Catarina) which allows automatic collect[I] calls via public telephones. A similar system developed for use in the Amazon region allows public telephone calls without coins. Other variations on community telephone services include public telephones especially designated for receiving calls and making collect calls. Inter-urban automatic reverse charge systems are also currently in operation; by using a special dialing code a recorded voice asks the telephone subscriber whether he or she is willing to accept a reverse charge call, and at the same time gives information as to the caller and city. These types of systems are particularly important in DC's where public telephones are relied upon far more than in the developed countries.

In order to maximise the use of public telephone lines MINICOM has recently approved various "line-sharing" systems using Brazilian PCM technology. These allow more than one person to use the same telephone line, with seperate telephone extensions. A light indicates when the line is being utilised and one user cannot hear the other; seperate numbers and accounts are also maintained. A variation on the line-sharing idea is already in use by Telecearà in the North East which allows I line to be shared by IO seperate callers. Again, these types of systems could prove very relevant to other DC's looking for sensible and inexpensive methods of expanding urban and rural Telecommunications.

I) In England "reverse charge" calls

A number of new digital transmission systems have also been designed and introduced in Brazil to help overcome the very high cost per line of installing rural Telecomms. Embracon, one of the new Brazilian firms has developed a digital system (currently awaiting approval by TELEBRAS),which utilises existing electrical cables to transmit telephone signals. This system uses FDM techniques and enables up to 8 telephones to operate simultaneously with one pair of existing electrical cables. Using existing infrastructure in this manner is extremely important for remote regions and expanding rural Telecomms to improve agricultural efficiency.

Also in transmission, CPqD has developed a low-cost satellite communications system for low and medium capacity telephone traffic. This was designed especially for extending transmission to small towns and rural areas. All the necessary digital equipment including amplifiers, transmitters and receivers was developed in Brazil, and EMBRATEL has already contracted out 220 units for manufacture.

To cope with the more inaccessible and remote regions of low density where it is not feasible to use satellite communications, portable digital radio telephones have been designed. These were developed especially for use in areas divided by islands and rivers. Teletet of São Paulo has developed and is currently manufacturing digital telephones for use by Teleamazon in the Amazon region. This particular system is not designed to receive calls but only to make outgoing calls which are reverse-charged automatically. This is an extremely low cost method of providing urgent Telecomms services up to a distance of 70kms with both urban and inter-urban dialing.[1]

At present the World Bank is funding an experimental project of installing 17 digital radio telephones to serve 15 small rural villages, thereby avoiding the high expense of laying transmission infrastructure. If the project is successful TELEBRAS intends to extend this method of communication to the whole of the Amazon region.

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1) The cost is around Cr200,000 for each telephone (appx.$1100 - 1982 prices).

4.4.I Implications and Policy Proposals:

Since 1975 Brazil has succeeded in producing an abundance of digital technological innovations to meet the needs of the local Telecomms network. The range of innovations already developed demonstrate the comparative flexibility of microelectronic over previous technologies. Digital technology has made feasible low cost satellite communications, small inexpensive exchange systems, simple methods of line sharing and several methods of low-cost transmission suitable for DC's.[I]

For other DC's, Brazil's successful exploitation of digital technology should prove both instructive and useful. Clearly there is potential for other DC's to adapt digital Telecomms technology to suit local needs.

Regarding Brazil's role as a potential exporter of technology, it is recommended that further research is conducted into: a) further areas of digital technological innovations, b) potential technology export markets in other DC's, and c) an appropriate strategy for Brazil's entry into technology exports in Telecomms.

Brazil's potential role as an alternative source to the major MNC suppliers, could take the form of intra Third World technology cooperation or technology sharing.[2] Awareness raising could be conducted at inter-Governmental level, particularly in international Telecomms forums such as the ITU (the International Telecommunications Union). Methods of organising trade could possibly take the form of soft currency trade, or exchange for other imports vital for Brazil such as oil and other raw materials; bilateral trade of this nature would avoid the need for raising hard currency and generally assist in balance of payments difficulties.

While proposals of this kind are by definition speculative, Brazil's substantial experience in both planning and acquiring digital technology strongly suggest the possibility of a technology-based competitive advantage over exis ing Developed C nty suppliers. However, a detailed planning and research programme would be a prerequisite for success in this area.

I) It should also be noted that the whole of CPqD's research is geared towards meeting the specific needs of Brazil.

2) The recent speech by the Minister of Communications officially confirms Brazil's desire to engage in such cooperation(Mattos 1983)

Conclusion: Relevance to Other Developing Countries.

Since 1974 the Brazilian Telecomms industry has progressed from a situation of deep technological dependency to one of substantial and dynamic progress in modern digital Telecomms. At the same time the domestic Telecomms infrastructure has been modernised and expanded and is now in a good position to meet the forthcoming demands of information technology. Brazil's remarkable industrial, technological and infrastructural achievements were primarily the result of forceful and forward-looking Government policy intervention in a sector formerly owned and controlled by foreign enterprise.

While it must be remembered that Brazil is in many respects a special case among DC's, given it's size and technological and industrial infrastructure, there are many points of direct relevance and interest to other DC's. Indeed, the Brazilian example illuminates several issues regarding: a) the accumulation of microelectronic technology, b) the benefits of developing a strong local Telecomms industry, and c) the role of Government policy. These issues are important not only for other large industrialising counties, but also for smaller DC's wishing to expand their basic Telecomms infrastructure. It is helpful to consider these three points in turn.

Virtually from scratch, with little experience in microelectronic technology and even less local industry, Brazil aquired a strong base in Telecomms technology in an extremely short period of time. In fact it was precisely the diffusion of digital technology during the '70s which provided the opportunity for Brazil to enter what was previously a closed and rigidly defined market. On the one hand Brazil was able to exploit the intense MNC competition for Third World markets, by insisting that manufacturing and technological activities were located within the national boundaries. On the other hand, the characteristics of digital technology itself, in terms of skill requirements, modularity and flexibility, allowed Government enterprise to rapidly accumulate substantial experience and knowhow in Telecomms - beginning with relatively simple digital technologies and gradually moving up the scale of complexity to medium scale public exchanges, satellite systems, and high capacity optical fibre transmission. At the same time it was the arrival of digital technology which permitted the rapid growth and participation of small scale local enterprise, now supplying almost 20% of the domestic market.

The potential for local technological development demonstrated by Brazil is clearly relevant to other larger DC's such as India and Mexico, currently attempting to develop industrial and technological capacity to supply their own local markets. In addition, the possibility of domestic small scale industry entering the production of microelectronic equipment may well be of relevance to smaller DC's with less ambitious objectives towards overall industrial and technological capacity. Brazil's experience in progressing from lower level peripheral and transmission equipment through to sophisticated TDS exchange technology is both relevant and encouraging to other DC's.

The second issue of considerable interest to other DC's concerns the economic benefits gained by Brazil's progress in Telecomms. While it was not possible here to conduct a formal cost-benefit analysis, several major indicators demonstrate beyond any doubt, the substantial benefits gained as a direct result of Brazil's nationalisation of its domestic Telecomms network, and local development of technology. Far from being a drain on the country's resources the Telecomms sector overall is largely self-financing and also an important source of revenue for other Government activities. In addition total investments in technology were extremely low in terms of gross operating receipts, and indeed amounted to only a fraction of the resources diverted from Telecomms to other sectors. In fact, the overall operating company TELEBRAS occupies an almost unique position among Brazilian State enterprises, with very high profit, very low debt, falling imports, continuously increasing employment and price increases below the average rate of inflation.

Besides these direct and measurable benefits, the vital economic and social gains from establishing a modern, well-functioning communications infrastructure should not be forgotten. Brazil's success since 1974 in building a comprehensive Telecomms infrastructure served the dual purpose of meeting the conventional industrial and domestic demand for efficient communications, and also layed the foundations for meeting the future demands of information technology. Brazil's accumulation of digital technology through its Telecomms infrastructure and supply industry is an important component of the overall strategy of preventing any possibility of a technology gap developing between Brazil and the advanced economies, due to the diffusion of microelectronic technology. Local enterprise has not only succeeded in aquiring this technology but in fact has already produced a whole range of digital innovations designed to suit local environmental and economic conditions. The potential for other DC's to use the Telecomms sector as a strategic means of accumulating a national base in digital technology is clearly an important matter for policy consideration. At the same time the possibility of adapting microelectronic technology to suit local needs may also prove useful to other countries.

The third issue of general relevance is the role of Government policy in ensuring domestic progress in Telecomms. Rather than being the result of the invisible hand of the market Brazil's progress was the direct consequence of the very "visible hand" of Government policy intervention. Through a carefully planned strategy of strengthening local enterprise and legislation Brazil was able to ensure that the activities of the MNC's fitted in with the overall Telecomms planning goals. This was achieved mainly by centralising Telecomms purchasing power with TELEBRAS who were then able to insist that technological activities were located within the country. The other main function of Government policy was to set up a major R&D centre in Telecomms to ensure, directly, an independent base in digital Telecomms technology. In addition, Government policy was instrumental in encouraging the growth of the large number of new national firms currently developing and manufacturing equipment for TELEBRAS.

Brazil's technological and infrastructural gains were clearly the direct result of a well-orchestrated and vigorous Government policy, translated into economic reality by legislation and administration. Although this experience cannot be transplanted to other DC's, the Brazilian case does emphasise the need for planning and organising local technological capacity to meet specific infrastructural and industrial needs. In fact, probably the most important lesson from the Brazilian experience in Telecomms, for large and small DC's alike, is the need for an informed and well-planned Government policy.

GLOSSARY OF TECHNICAL TERMS

ANALOGUE Electro-magnetic wave form used in transmission. Analogous to a continuously variable physical quantity such as temperature. Digital transmission on the other hand is transmitted in discrete, separate pulses using Pulse Code Modulation (PCM).

COAXIAL CABLE A cable used for trunk transmission. The coaxial outer sheath and central coil are both electrical conductors, separated from each other by an insulating material. Expensive to install in relation to alternative systems such as microwave relays, optical fibres and satellites.

CROSSBAR Near obsolete, electromechanical switching system, used as an intermediate technology between Strowger and Electronic exchanges.

DIGITAL A discrete or discontinuous signal transmitted in intervals. Most modern computer and Telecommunications technology is now based on digital data transmission because of its advantages over analogue, in terms of speed and low cost per bit of information. The terms "digital" and "microelectronic" and sometimes "PCM" are used interchangeably to decribe digital Telecomms systems, now converging technologically with computers.

EARTH STATION Used to receive and transmit signals in Satellite transmission systems.

ELECTROMECHANICAL Semi-electronic, incorporating moving parts unlike "solid-state" microelectronic systems.

ELECTRONIC MAIL Service providing data storage to a subscriber to store messages received through a Telecomms network.

EXCHANGE EQUIPMENT Also known as switching equipment - represents the heart of the Telecomms system, performing the central operating function of connecting calls within and between networks.

HARDWARE The physical equipment and components required to build a Telecomms, or any electronic, system.

INFORMATICS Automated digital data processing systems incorporating harware and software, involving one or more computers. Based on digital technology, the transmission of data is normally processed using PCM techniques.

INFORMATION TECHNOLOGY The range of Telecomms, Telematics and Informatics technologies, centred around microelectronic devices which permit the storage, transmission and manipulation of data in digital form, at low cost and great speed.

INTELSAT The International Telecomms Satellite Organisation responsible for providing over 60% of the world's overseas Telecomms traffic.

LASER TRANSMISSION Transmits signals through a modulated laser, either through optical fibres or space.

LINE CONCENTRATOR A concentrator enables the signals from a given number of telephones to be sent over one pair of wires simultaneously - used in local telephone loops to achieve substantial cost reductions.

LINE-OF-SIGHT Microwave transmission system in which a set of receivers are located in a line to receive microwave signals, without obstacles.

MICROELECTRONIC A digital, solid-state semiconductor component.

MICROWAVE Very short electromagnetic radio wave, within the overall wavelength spectrum of long, medium, short, infrared, ultraviolet, X-ray and gamma ray.

MODEM Equipment for modulation and demodulation of Telecomms. In other words it takes an analogue electrical signal and converts it into a digital one, for rapid low-cost transmission.

MULTIPLEXOR A device which interfaces with a central exchange and converts analogue into digital signals, then transmits them using PCM techniques. Many telephone conversations and other signals can be simultaneously transmitted by "interleaving" samples of each signal, thereby increasing the capacity of existing coaxial or microwave networks. Also the different types of signal can be "multiplexed" together without interfering with each other, unlike analogue.

OPTICAL FIBRES Used in PCM transmission, made of silica which is much cheaper and more readily available than copper which is used in conventional cables. Advantages over coaxial cables are: larger capacity, resistance to corrosion but not to transmission signals (therefore less signal regenerators or "boosters" needed). In addition optical fibres can be installed with existing infrastructure such as coaxial ducts or railway lines.

PCM (PULSE CODE MODULATION) Digital transmission of information by modulation of a pulse according to a code. (See analogue and digital).

PACKET SWITCHING Used in data communications systems. Information is stored in binary digits until line capacity is available for transmission (the resulting data stream is termed "packet") Has been called an "electrical post office".

SATELLITE "A microwave relay in the sky" (Martin,1977 p2II). Receives microwave signals and retransmits them to another location. Satellites are used especially for intercontinental transmission, and can handle large amounts of traffic with no cables or boosters and send signals almost anywhere on earth.

SDS-SPC Space Division Switching - Stored Programme Contolled (see TDS-SPC)

SOLID-STATE No moving parts, fully digital or electronic as opposed to electromechanical.

SPC (STORED PROGRAMME CONTROLLED) A switching system whose internal control is performed by a computer. (See TDS-SPC).

STROWGER Electromechanical telephone exchange invented in Kansas in 1889, based on banks of rotary switches connected in series - slow, inflexible and costly in comparison with solid-state electronic exchanges.

SWITCHING EQUIPMENT See exchange equipment.

TDS-SPC (TIME DIVISION SWITCHING-STORED PROGRAMME CONTROLLED) TDS-SPC is the most recent digital switching process by which signals are transferred from one point to another by sending samples down different paths, depending on their desired destination, at exactly the right time, so that a particular "gate" opens allowing the signals down a specific path. By changing the times at which the gate opens,different signals can be accepted. TDS is more economical than conventional "space division switching" (SDS-SPC) where the physical path is permanently connected.

TELEMATICS Also known as Teleinformatics (sometimes Comp-communications).Telematics is the fusion of Telecomms and Computer technologies made possible by digital electronics. Data in digital form is stored, manipulated and transmitted between computers using public Telcomms transmission networks.

TRANSMISSION EQUIPMENT Includes microwave, satellite, coaxial and more recently,fibre optic systems. Transmission equipment is used to carry signals between terminals and includes local network "loops" and long-haul or trunk systems.

TRANSPONDER Rented from INTELSAT, transponders accept signals in a given frequency band and then retransmit them at different frequencies so as not to interfere with weak incoming signals.

TROPOSCATTER A system of microwave transmission which utilises the troposphere (the lower part of the Earth's atmosphere) to link up receiving earth stations separated by larger distances than allowed by line-of-sight transmission (infrequently used).

VIDEOTEXT TV sets are used as data terminals which are connected to the public Telecomms network to receive various kinds of information.

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