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Telecommunications technology transfer and the development of institutional infrastructure: the case of Cuba

Ann C. Séror[a,*], Juan Miguel Fach Arteaga[b]

[a]*Department of Management, Faculty of Administrative Sciences, Université Laval, Ste.-Foy, Qué., Canada G1K 7P4*
[b]*Fundación Redes y Desarrollo (FUNREDES), Santo Domingo, Dominican Republic*

Abstract

The objective of this study is to describe the institutional infrastructure for the adaptation and transfer of telecommunications and other information technologies in Cuba. The origins and evolution of Cuban science and technology policy are reviewed. Institutional and managerial aspects of the Cuban telecommunications infrastructure are identified and the authors formulate suggestions for future telecommunications policy research on regional integration.

Keywords: Cuba; Science and technology policy; Regional integration; Technology transfer

1. Introduction

The Cuban Strategy for an Information Society begins with a quotation by Ernesto "Che" Guevara dated March, 1962. Although the source of this quotation remains unknown, the visionary inspiration conveyed in Guevara's words is unmistakable:

> 'El mundo camina hacia la era electrónica … Todo indica que esta ciencia se constituirá en algo así como una medida del desarrollo; quien la domine será un país de vanguardia. Vamos a volcar nuestros esfuerzos en este sentido con audacia revolucionaria …'[1]

The Cuban strategy recognizes a new industrial revolution driven by information technology defined as the integration and convergence of computing, micro-electronics, telecommunications and data processing. The fundamental premise of the Cuban information society is controlled universal access to information and telecommunications technologies. Analysis of telecommunications

* Tel.: + 1-418-656-2131; fax: + 1-418-656-2624.
E-mail address: ann.seror@mng.ulaval.ca (A. C. Séror).

[1] Ministerio de la Industria Sideromecánica y Electrónica et al., 1997, p. 1.

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in the developed world focuses on the identity between the individual user and the technology, while in the developing world universal service is defined with respect to collective social units, and necessary distance or travel time to reach points of access to such service. For example, the Cuban strategy defines the standard for telephone service as availability in all villages and communities of more than 500 inhabitants (International Telecommunication Union, 1998; Ministerio de la Industria Sideromecánica y Electrónica et al., 1997). This distinction raises the important debate between universal service and universal access.

The strategy for a Cuban information society further recognizes information technology and knowledge industries as of critical strategic national importance for a variety of reasons. These are the fastest growing industries of the global economy, including developing countries where policies are being formulated to create the necessary supporting infrastructures. These industries generate key technologies for development, including organization reengineering. They also constitute an infrastructure to facilitate organizational information processing and transmission, knowledge sharing, and productivity improvement. Telecommunications and information infrastructures also provide a powerful vehicle for social and economic globalization with associated paradoxes: risks of cultural colonization; and opportunities to preserve patrimonial values as well as national and regional cultural identity.

The Cuban experience raises these and many other issues related to development, information technology transfer, regional integration, and the future of ideological diversity in a democratic world order. This paper is an attempt to address these concerns in a Cuban perspective. First, a model of national development is presented and information technology infrastructure is defined within this model. The Cuban case is then introduced with a discussion of the Caribbean context. The Cuban innovation system is then presented in the framework of a national development model focusing on management of enterprise linkages with educational and research institutions, investment and financial incentives for innovation, and information services with particular emphasis on telecommunications networks and infrastructures. The distinctive aspects of telecommunications management and control in the Cuban context are identified. In conclusion, the authors formulate some recommendations for future policy-making and research on national development and regional integration.

2. Information technology infrastructure and national development

A national development model serves as the foundation for analysis and evaluation for Cuban technology infrastructure. This theoretical model identifies the entrepreneurial roles of government with respect to indigenous and foreign companies as well as other national institutions on the following strategic policy dimensions: (1) creation of national research centers and institutes and development of linkages between these institutions and business enterprises; (2) development of incentives and financial support to promote investments in R&D; and (3) development of information services and networks (Tang & Yeo, 1995; Correa, 1995).

The functions of public research centers and institutes included development of specialized education and training programs in information systems, R&D focused on pre-competitive technologies, design of specialized services for information technology users, and technology transfer to industry and other sectors of economic activity. The linkage between research institu-

tions and business enterprises has been promoted in Latin America through a variety of mechanisms including mandatory enterprise contributions to finance scientific and industrial complexes, the establishment of foundations and other special entities to support research–enterprise linkages, and the creation of technology parks or poles to co-locate research, innovation and enterprise activities (Correa, 1995). These policies promote formation of competitive industry clusters integrating both foreign and indigenous companies by encouraging strong linkages among firms within such clusters and location of activities such as R&D within national boundaries to increase the value added by the indigenous workforce.

The most important research themes related to implementation of this model in Cuba are identification of appropriate technologies, evaluation of their effects on society, and their transfer for application in all sectors of economic activity. Institutional innovation networks contribute to the process of technology transfer motivated by market dynamics; this motivation may be based on the creation of a new product or process (*push*), or the emergence of a new technological requirement in the market (*pull*). In the context of the technological market, network institutions influence or control the transfer process through a variety of roles (King, Gurbaxani, Mcfarlan, Raman & Yap, 1994). These roles include the processes of research and development, knowledge diffusion, creation of archives and data banks, resource allocation to technology transfer projects, public information, education and training, definition of technological norms and standards, and the use of administrative policies and directives to foster creation or adoption of innovations identified as policy priorities.

Of pivotal concern in analysis of the Cuban case are the ideological assumptions, particularly social welfare priorities, upon which telecommunications technologies and their infrastructures are founded. These assumptions affect the social pattern of interaction between telecommunications technologies and institutional choices within the society. Social behavior shapes technological development by a process reinforcing institutional structures as well as organizational adaptation. Telecommunications infrastructure regulatory policy "should be focused on accentuating those attributes of digital information technology that make it a potential vehicle for achieving a broad distribution of access to and participation in the social processes of knowledge production" (Benkler, 1998, p. 184). The Cuban strategy recognizes this proposition and attempts to identify key choices in this respect (Ministerio de la Industria Sideromecánica y Electrónica et al., 1997). The broad objectives of the strategy are to benefit Cuban society in ways consistent with its socialist ideology:

- Improvement of the efficiency of manufacturing and service sectors by increasing their quality and decreasing resource and energy consumption;
- Improvement of public and private managerial decision-making effectiveness;
- Development of software and other knowledge industries for exportation;
- Improvement of public services in education, healthcare and social security;
- External access to information on the Internet and through other media concerning the Cuban revolutionary process, political, social and economic realities, as well as scientific and cultural development and investment opportunities;
- Management of organized and controlled internal access to the Internet and other information media for professionals, researchers, students, educators, and government workers through their institutional affiliations.

The control functions of such a system differentiate democratic from socialist or communist national development. Cuban national control over telecommunications focuses on selection of

actors allowed to participate in technology markets as content suppliers or users, as well as control over content itself exercised by brokers. These control processes are shaped by ideological assumptions as well as by dramatic resource constraints and the conflictual relation between Cuba and the United States. The next sections of this paper discuss the role of Cuba in the political economy of the region as well as the evolution of Cuban science and technology policy.

3. Cuba and the Caribbean region

The Marxist–Leninist revolution launched in 1959 marked the end of capitalism in Cuba, and for four decades, Cuba has been politically and economically isolated from the Caribbean region and the rest of the world by the United States embargo preventing free trade and other forms of international exchange and collaboration. With the disintegration of the Soviet Union, Cuba suffered severe economic consequences, and the Cuban Liberty and Solidarity Act of 1996 has more recently deepened the Cuban economic crisis (Vilarino, 1997; Laffita, Oceguera & Herrera, 1997; Perez-Lopez, 1997a, b; U.S.–Cuba Trade and Economic Council, 1998). The North American Free Trade Agreement, the loss of Caribbean status as a favored region with respect to US foreign policy, and the strengthening of the European Economic Community have weakened Caribbean ties with Mexico and Spain. This evolution has reinforced the Caribbean Community and Common Market (CARICOM) and its initiatives to integrate Cuba in the economic and cultural activities of the region (Nunez, 1997). At the 11th summit of CARICOM in 1990 it was decided that cooperative projects would be undertaken with the creation in 1992 of a joint Cuban–CARICOM Cooperation Commission. Cuba was also accepted as a founding member in the Association of Caribbean States established by 25 Caribbean Basin nations in 1994 (CARICOM, 1998a, b; ACS, 1998).

Potential Cuban influence in Caribbean regional development is significant in several areas. Recent demographic data show Cuba's comparatively favorable position in health care and education measured in life expectancy at birth (75.2 yr), infant mortality (8.9 deaths per 1000 live births), literacy (95.7%), and fertility rate (1.54 children born per woman) (U.S. Central Intelligence Agency, 1997). Areas of shared interest among Caribbean nations include migration, illegal drug and arms control, environmental protection, and science and technology policy (Nunez, 1997; Payne, 1998). Science and technology policy is a particularly important area of common Cuban and Caribbean concern in the light of the emergence of new industrial and information technologies, and the ongoing devaluation of primary exports. Particularly in the areas of information technologies and telecommunications, the Caribbean nations and Cuba are at risk of falling further behind the developed world and increasing the gap in ability to acquire, adapt and use such new technologies (CARICOM, 1998a; Payne, 1998).

Demand for telecommunications technologies, especially the Internet is growing rapidly in the Caribbean and throughout Central and South America,[2] even though telephone penetration is low at less than 10% throughout the region (Connolly & Hernandez, 1997). Tables 1 and 2 show

[2] For presentations of the historical evolution of the Internet see the web site of the Internet Society, 1998.

Table 1
Country profiles — telecommunications indicators I[a]

Country	Main telephone lines (total (k)/ per 100 inhabitants) (1996)	% Digital telephone lines (1996)	Public telephones as % of main lines (1996)	Cellular mobile subscribers (k) (1996)	Telex subscribers/ fascimile machines (est.) (k) (1996)[b]	Television receivers per 100 inhabitants (1996)
Cuba	356.2/3.23	11.0	1.74	2.4	3.5/n.a.	20.0
Dominican Republic	665.0/8.26	46.0	0.71	64.2	0.2/2.3	8.4
Haiti	60.0/.84	94.0	0.03	n.a.	0.2/n.a.	0.5
Jamaica	353.0/14.17	100.0	0.59	54.6	0.4/n.a.	32.6

[a]Source: International Telecommunication Union (1998).
[b]It should be noted that the number of telex subscribers is decreasing in both the country categories of low income (Haiti) and lower middle income (Cuba, Dominican Republic, and Jamaica). The rate of decrease in number of subscribers is negatively associated with country income category.

telecommunications indicators for Cuba, the Dominican Republic, Haiti, and Jamaica. These data show the relatively strong position of Cuba with respect to the largest nations of the Caribbean region. Although technologies in use in Cuba (e.g. analogical telephone lines and telex communications) may be obsolete and scarce in absolute terms, availability of such technologies to the population is relatively high through management of collective public access. For example, although the number of main telephone lines per 100 inhabitants is relatively low, the number of public telephones as the percentage of main lines is the highest of the four largest nations of the Caribbean region (Table 2). It is also of interest to note that the number of telecommunications network nodes per 1000 inhabitants is high when the number of internet users is taken into account (Table 2). This feature of the data may be attributed to severely restricted access to the Internet with respect to much broader user access to extensive Cuban national telecommunications networks.

Among the four largest nations of the Caribbean, some emerging competition in telecommunications industries is apparent. The Dominican Republic has two carriers while Jamaica's carriers, Telecommunications of Jamaica and Jamaica Digiport International (Cable and Wireless Operating Companies: Jamaica, 1998) are both substantially controlled by Cable and Wireless. Cuba's ETECSA benefits from its partnership with the Italian telecommunications firm STET, and Haiti's carrier is a national monopoly firm. The development of the Internet in this context at an average annual rate of 50% between 1997 and 2000 is serving as a vehicle for both enterprise privatization and regulatory liberalization throughout Latin America. Enterprise privatization is driven by the capital requirements for deployment of new information and telecommunications technologies, while regulatory liberalization results from de facto competition between private service providers and public networks (Connolly & Hernandez, 1997).

Table 2
Country profiles — telecommunications indicators II

Country	Internet users per 10 k inhabitants (1996)[a]	Hosts (total/ per 1000 inhabitants) (1995 Census)[b]	WWW Servers (1998)[b]	Dominions/ % unattributed (1998)[c]	Carriers[c]	
Cuba	3.17	218/0.02	72	34/23%	ETECSA	29.9% ownership by STET
Dominican Republic	7.70	48/0.006	16	82/78%	Codetel	Local PTT
					Tricom	Cellular provider — 40% ownership by Motorola
Haiti	n.a.	0/0.00	0	0	Télécommunications d'Haïti S.A.M. (TELECO)	Local PTT
Jamaica	59.01	595/0.23	83	177/43%	Telecommunications of Jamaica Ltd (TOJ)	79% ownership by C&W. Local PTT
					Jamaica Digiport International Ltd	International carrier, uses Intelsat satellite network

[a]Source: International Telecommunication Union (1998).
[b]Source: Unidad de Redes, University of Costa Rica (1998).
[c]Source: Primus (1998).

4. Origins and evolution of Cuban technology policy

Cuban technology policy since the Revolution has been marked by efforts to create a system for social evaluation of new technology and development of national solutions to technological problems. Efforts to integrate national research and development policies have resulted in a three-state process of development: (1) creation of a science base and infrastructure (1962–1976); (2) elaboration of a centralized management model (1977–1989); (3) horizontal integration and adjustments after the collapse of the Communist bloc (1990–present) (Capote, 1996). The first stage of development was motivated by recognition of the need to promote technology transfer from external sources in order to create national productive capacity. The ability to receive and adapt new technology required a national capability for research and engineering supported by an institutional infrastructure. After 15 years of efforts dedicated to creation of a research and development sector with the necessary critical mass of resources, it became necessary to develop national mechanisms for coordination and management of the emerging institutional system. The objectives of intervention in technology transfer included the improvement of commercial conditions of technology transfer agreements such as supplier pricing, the elimination of certain restrictions as to technology transfer and adaptation to specific needs, the unbundling of the

components of new technologies and the control of intra-firm accounting and management practices of transnational corporations (Correa, 1995).

The second stage of the development process (1977–1989) began with institutional efforts to manage the use of results generated in R&D. This was accomplished by designation of research institutes and identification of research problems reflecting national priorities. In the second half of the 1980s, scientific and technical program structures were introduced to better integrate technology producers and users as well as other agents in the transfer process. A system for the transfer of research results was introduced in 1987 to complement program structures with a mechanism for technological innovation. However, enterprises specialized in technological change were operating in a closed market without exposure to a demanding international clientele, and in these conditions the presumed national leaders in technology adoption did not assume the leadership role necessary for the successful diffusion of research and development results.

Starting in 1986, difficulties in the effectiveness of centralized planning were diagnosed, and a process of 'rectification' indicated the beginning of a third evolutionary stage (1990–present). In organizational terms, the integration of networks for collaboration in activities of science and production, the creation of the National Forum for Science and Technology, and the development of expertise in technology management characterized the third phase of science and technology policy. During this period, technico-scientific programs emerged in project management structures with refereed evaluation for project selection. Ecological considerations began to influence science and technology policy, and national production was profoundly affected by changes in international markets and the disintegration of the Soviet Bloc (Richards, 1998). These changes produced a national debate on the topic of Cuban competitive strategy that extended to the foundations of social and political organizations, including municipalities, people's councils (consejos populares), and new forms of union organizations. Technological innovation has thus emerged since as a very broad social and political concern in Cuba.

5. Education and research: enterprise linkages

In this evolving economic environment, technological innovation is considered one of the most important tools for the protection and the development of the Cuban social project. Policymakers are aware that the center of gravity within social structures is now moving away from the mechanisms of central planning and closer to production or manufacturing units (Villanueva, 1998). The evolution of science and technology policy has required a new focus on innovation within productive units of society, and creation of cooperative networks linking the actors of the national innovation system, including public, private, joint venture, local and foreign entities. Cooperative networks are designed to integrate diverse institutional roles among *technology producers, consumers, and facilitators* with respect to *regulators*. Included in the first category are R&D centers, universities, producers of goods and services, engineering and consulting groups specialized in technology management and transfer as well as finance, units specialized in testing and quality control, measurement and information, and lastly professional, technical, and workers' organizations. The most important producers of technology, R&D centers and universities, include state-supported research centers dedicated to science and technology priorities such as health and information, large specialized research institutes with networks of affiliates, and the network of

centers for higher education with priority research tasks in every discipline. The second category, *technology regulators*, includes the National People's Assembly and provincial assemblies, Cuban national ministries, the State Central Administration, territorial and municipal governments. These actors develop linkages with existing networks such as the National Science and Technology Forum and the network of provincial science and industry 'poles' (co-located clusters of research and industrial organizations) within a regulatory institutional structure implementing fiscal, investment, commercial, intellectual property, quality control and other policies (Capote, 1996; Negrin, 1996).

Particularly critical to national technology strategy is the competitive Science and Technology Forum integrating innovative ideas generated in all social sectors. The Forum is an ongoing activity including a bi-annual competition to give recognition to those who produce the most useful ideas, and to make those ideas available on a national scale (Agencia Informativa Latinoamericana, 1997). Although required institutional participation is competitive and some of entries could be eligible for patent, the primary motives of those who participate appear to be social recognition and opportunity to validate individual initiatives. The organization of the Science and Technology Forum is the responsibility of a network of provincial centers for technology management whose general mission is to promote more efficient integration of research and development with the production of goods and services (Bejerano, 1996). The network stimulates the generation of services and products for other entities and consultation pertinent to universities, research centers, and the technical concerns of a variety of enterprises and organizations.

Provincial information centers share a number of characteristics. They are affiliated with the Ministry of Science, Technology and the Environment and share specialized personnel from the Ministry, its agencies and territorial offices. Their clientele is comprised primarily of enterprises or smaller entities seeking integrated, modular products and services for the management of new technology, including production, financial administration, human resources, marketing, commercialization, and environmental protection. The nature of the relationship among the centers is cooperative, and each creates its own network within its provincial territory (Negrin, 1996). These regional networks are designed to facilitate integration of technological market dynamics and reduction of related market uncertainties. They play a key role, with the network of university centers, in the process of information technology transfer and management of the linkage among education, research and industry.

The foregoing strategies are considered critical to the national priority for software industry development as well as the creation of the Cuban information society. The national objective for the period 1997–2000 according to the Cuban Strategy for an Information Society is the structuring of technological research and development as part of registered research programs under regular funding mechanisms. The Ministries of Science, Technology and the Environment as well as Communication have presented such projects integrated in larger research programs on information science and system development. In general, information technologies have been viewed mainly as tools for the development of research and applications in other areas. However, it is recognized that research programs must be developed with the specific objectives of information technology creation, transfer and assimilation (Ministerio de la Industria Sideromecánica y Electrónica et al., 1997, p. 58). This action requires creation of decentralized co-ordination and exchange mechanisms and a tightly focused linkage between R&D and industry demand expressed in local or regional technological markets.

6. Investment and financial incentives for innovation

Financing and investment to create the Cuban information society vary with different sectors of economic activity. The government strategic plan suggests that in the business enterprise sector, most of the investment should be financed by income from operations, although this objective appears unrealistic generally. For example, according to the strategic plan, the computing industry with related R&D should be auto-financed after an initial period of state support. ETECSA is expected to finance the development of communications infrastructure through foreign investment from joint venture partners. The public sector including the ministries of higher education and justice is seeking financial support from international agencies to address their requirements in new information technologies and infrastructure.

Another important strategy to encourage investments in technology transfer and innovation is the privatization of Cuban state-owned enterprises (Travieso-Diaz & Ferraté, 1997). The goal of these policies is to improve efficiency and productivity of the economy and to create a platform for national development, regional integration, and foreign investment. Several important considerations affect the management of this strategy. Although rapid privatization methods attract investors to foster emergence of a domestic enterprise sector, such methods may create significant unemployment and inflation and they may be hampered by lack of adequate external financing. Another consideration is the choice between internal and external privatization strategies. Major state-owned enterprises may more appropriately be privatized by foreign investors with the necessary capital, technology and knowledge resources, while medium-sized and small enterprises may be transferred to local participation. The formation of the Cuban telecommunications joint venture, ETECSA, is a very pertinent illustration of the concern for creating a balance between political expediency an economic efficiency.[3]

Cuban state-owned enterprises include joint ventures between the state and a foreign investor, cooperatively held property or enterprises subject to time-defined rights to exploit a particular resource such as agricultural land, and wholly state-owned and operated enterprises. The most common vehicle for foreign investment is the joint venture under Law No. 77 promulgated in 1995 (Ministry of Foreign Investment and Economic Cooperation, 1995; Werlau, 1997). This law maintains business organizations already recognized by Cuban legislation including joint ventures, production agreements and joint accounts. It further creates a new entity: the enterprise structured

[3] Considerable economic and political difficulties have hampered foreign investors seeking to particiapte in this joint venture with the Cuban government because of penalties threatened by the United States government. In Havana in 1994, Grupo Domos, a Mexican conglomerate which had been the largest foreign investor in Cuba, announced an agreement which included minority partnership in a 750 million US$ joint venture in the Cuban telephone monopoly. In June, 1997 due to American economic sanctions and other financial difficulties, Domos withdrew from the agreement. The Helms-Burton legislation was enacted in 1996 to intensify the US economic embargo after Cuba shot down two American registered civilian light planes over international waters. At the same time as Domos began experiencing financial problems, the Cuban government began seeking other investors, and the Italian communications company STET entered the partnership. The Cuban telephone system owned by ITT Corporation was confiscated by the Cuban government in 1960, resulting in 130 million US$ in outstanding expropriation claims. In spite of the US law, STET expressed determination to remain in the joint venture and successfully reached a compensation agreement with ITT (Rohter, 1997).

with wholly foreign capital. Such a business entity may be formed by registration of the foreign investor or firm with the Chamber of Commerce of Cuba, or by creation of a wholly owned Cuban corporation as a subsidiary of the foreign entity.[4]

While privatization strategies are extremely important, the influence and purchasing power of state-owned enterprises within the socialist Cuban economy should not be overlooked. Several factors explain why this power has often not been effectively mobilized to contribute to national innovation and industrialization efforts. These include risk aversion, lack of competitive support for local suppliers, and lack of long-term purchasing programs. In the future, an important consideration in the Cuban national innovation system will be the management of a balance between State-owned enterprise, privatization and public investments.

7. Telecommunications networks: management and control

Cuban telecommunications policy recognizes that national productivity and R&D capability in all economic sectors of activity depend upon the effectiveness of telecommunications networks. In recent years, convergence among computing, telecommunications, and television based on digital technologies has reduced costs associated with information infrastructures. Fortunately, convergence among these technologies means that additional investments in telephony and related infrastructure will serve telecommunications networks for computing and information. Cuban policy provides for digitalization of the telephone systems in Havana, all the provincial capitals, tourist and industrial centers within a planning horizon of four years, and to make available within the same time frame higher speeds of digital data transmission in the majority of national and secondary systems.

There are a number of major public telecommunications networks in Cuba with international connectivity serving a significant number of interconnected national subnets and institutional intranets.[5] These have been developed mainly since 1990, despite extreme economic hardship experienced in the same period of time. The most important of these, the Center for Automated Exchange of Information (CENIAI), was initiated in 1982 and has operated with UUCP connectivity to the Internet since 1991. Networks with IP connectivity to CENIAI include

[4] It remains very difficult to obtain accurate information on internationl joint venturing with Cuban firms as well as foreign investment in the Cuban economy; the US–Cuba Trade and Economic Council have published data estimating the total amount of committed or delivered foreign investment to be about US$ 1.8 billion. The most important foreign investors are Canada ($600 million), Mexico ($450 millon), Italy ($387 millon), and Spain ($100 million) (U.S.–Cuba Trade and Economic Council, 1998). While Law No. 77 offers new opportunities for foreign investment, much progress still needs to be made in establishing its interpretation in Cuban courts. Other areas also require legislation to complete the necessary legal framework for foreign investment (Travieso-Diaz and Ferraté, 1997): (1) the legal foundations of a privatization program including constitutional law, property rights and resolution of expropriation claims; (2) laws governing the conduct of the privatization program; (3) laws relating to privatization such as foreign investment and bankruptcy; and (4) laws defining financial benefits and penalties accuring to ownership of an interest in a privatized firm, such as taxation and environmental protection.

[5] See Press (1996a, b), for discussions of these networks. Data for this discussion were also drawn from analysis of Cuban networks cited below.

CENIAI Internet, InfoMed, TinoRed, and RENACYT networks, and the ministries of culture, communication, and the interior. There remains a high degree of uncertainty regarding this development of more widely available IP connectivity.

Teledatos network is a division of the Group for Electronics and Tourism (GET) responsible for networking and integrating telecommunications and computer equipment in the tourist industry (Teledatos, 1998). This X.25 network topology connects nodes in Havana, Varadero, Cienfuegos, Holguin, Santiago de Cuba, Cayo Largo, and Madrid, Spain. Its activities include administration and maintenance of a national X.25 (packet switching) data transmission network for the tourism sector, communication hardware and software installation for network users, computer system development, national and international email service, facsimile services, and Webpage design and installation on an international server. Teledatos has also launched IntraWEB, a service offering mainly foreign businesses an access to the Cuban economy.

RENACYT, the National Science and Technology Network, serves primarily to connect other academic networks including CENIAI and InfoMed on X.25 links with only UUCP connections; and it connects the institutional system of provincial centers for technology management responsible for the Science and Technology Forum.

InfoMed, the network of the National System of Health Information of the Cuban Ministry of Health, was founded in 1992 with central operations in Havana. This organization is developing a distributed network serving Cuban medical schools with support from the Pan American Health Organization and UNESCO (InfoMed, 1998).

There is also X.25 connectivity for interactive applications and exchange of UUCP traffic between networks. In addition to the larger networks providing international connectivity, several significant intranets or national networks connect to CENIAI or RENACYT. These networks have developed in a context of serious technical and economic constraints including poor connectivity between local area networks throughout Cuba and no direct connection to the Internet, dial-up or X.25 based UUCP for computer communication, and use of low-cost, unlicensed, or public-domain software.

CIGB Intranet serves the Center for Genetic Engineering and Biotechnology. This institution is dedicated to scientific research, production, and commercialization of biotechnology products with locations in Havana, and two provincial capitals, Camagüey, and Sancti Spiritus. The network is made up of the interconnected computing and networking equipment of CIGB and networked information services made available to specialists, researchers and other users with access to more than 210 computers though fiber-optic and coaxial backbones and 10 subnetworks. CIGB Intranet also exchanges TCP/IP-based services with other academic institutions though RENACYT (CIGB Intranet, 1997).

TinoRed is operated by the Cuban Youth Computer Clubs in all 169 Cuban municipalities with walk-in computer centers offering training and services, email accounts and modem connections.[6] This network was established with support from Castro himself as well as the Cuban Communist Party. It plays an important educational role in information technology, offering training courses

[6] This network formerly served Red David, a network offering services to more than 30 nongovernmental organizations in 1996 (Press, 1996a). Red David has been dismantled due to the perceived vulnerability of such nongovernmental organizations to subversive influences.

in use of computers and software as well as access to computing laboratories for children and young people.

In addition to these national networks, other bank and tourism school networks provide specialized information services to their respective sectors. It is apparent that development of telecommunications networks and infrastructures in Cuba has progressed rapidly in the last four years. Several very distinctive features distinguish this development from the free enterprise development model in both technological and managerial choices (Dunn & Noguera, 1995). These choices in turn create unique technological market dynamics. Of particular interest is the nature of such market dynamics at the interface between democratic free enterprise systems and the centrally managed and controlled Cuban system. In the case of Cuban telecommunications systems and markets, a dual model is designed to clearly differentiate national from international telecommunications, and to carefully control the linkage between the two systems.[7] In this context, the objective of the general policy for access to telecommunications technologies is not the greatest freedom for market actors and correction of market failure, but rather limited and managed access subject to resource constraints and the imperative of information control. Somewhat paradoxically, competition in free technological markets may suggest policies for unbundling of a single firm's activities at different levels of the telecommunications system, while in a centralized model, such unbundling of international services may reduce redundancy and waste while improving control, evaluation, and adaptation of telecommunications and other information technologies to managed markets.

The institutional duality in response to centralized US Internet control is apparent in the general lack of connection of national networks to the Internet and the careful selection process which determines which individuals and institutional affiliations may gain such access. Such determinations are based as much on political evaluation criteria as on other considerations. The control of access relies to a significant degree on the personal 'trustworthiness' of selected users in positions of authority. The strategic plan for a Cuban information society stipulates that computers containing classified information will not be connected to international networks and designates network administrators as key actors to allocate appropriate resources and to protect the integrity of network functions. User control is reinforced by collective modes of use, where individuals with appropriate institutional affiliations share access to limited computing equipment. The lack of privacy associated with access to computers and networks strengthens group and institutional norms controlling usage and strongly discourages deviant or nonconformist behavior on the part

[7] Reasons for such duality reside in the long-standing enmity between the US and Cuba, and the fact that the Internet and the Internet Assigned Numbers Authority (IANA) were created by the Defense Advanced Research Projects agency (DARPA). At a recent meeting of the VII Foro Permanente de Redes de América Latina y el Caribe, the president of Reacciun proposed the creation of a coordination structure (NICALyC: Coordinación Internacional de Redes de América Latina y el Caribe) for Latin America and the Caribbean. This proposal was based on the perceived need for an independent administration and a priority accorded to information in Spanish language (CENIAI, 1998a). Although a self-regulatory Internet oversight corporation has been created, the Internet Corporation for Assigned Names and Numbers (ICANN), these efforts have not as yet significantly affected US control over the Internet. Governance is a critical technical and political issue, since lack of coordination may cause serious malfunction, while at the same time diverse stakeholders in the Internet require representation in regulatory decision-making. The new corporation, ICANN, is organized to insure governance with international representation, but these concerns continue to be weighted against the need for expertise currently residing in the US to guarantee coordination of a coherent Internet system (See IANA, 1998; ICANN, 1999).

of individual users. The Cuban principle of universal access to telecommunications technology is predicated upon institutional affiliation and collective use. Thus there is a distinctive coherence between access, managerial control processes and resource constraints. These principles guide computer usage, for example, at InfoMed where the office headquarters in Havana are being designed according to this model. These arrangements are also apparent among the TinoRed youth clubs set up throughout Cuba to facilitate young people's access to computers and training programs on technology use.[8]

National and international exchange mechanisms also contribute to management and control of telecommunications networks. The Cuban strategy specifies extension of the scientific community as well as access to information in science and technology beyond Cuban boundaries. With respect to these objectives the plan suggests analysis of Cuban publications and their potential national and international scientific impact, the use of electronic publication as an exchange mechanism, development of scientific seminars and conferences with international and national participation, and development of information services to promote revenues in foreign currency. For example, Teledatos network offers electronic catalogue services and data transmission across Cuban markets to external enterprises visiting its Web Site (Teledatos, 1998). The catalogue package for product or service information creates a market *pull* dynamic outside Cuba and within Cuban markets favors a *push* dynamic. Another example of this articulation of internal with external markets occurs in scientific electronic publishing (CENIAI, 1998b). Publications in science and technology, primarily in medicine under the auspices of InfoMed, are offered in Spanish on Web sites linked to the CENIAI Web site. A number of these electronic journals offer full text articles, and solicit submissions to an editorial email address. In this way, Cuban research on science and technology is distributed to external markets, while the electronic journals present a vehicle for edited distribution of foreign content to internal Cuban markets. These unique control mechanisms facilitate national and international information exchange while maintaining the integrity of national networks.

Patterns of control in the Cuban context show how collective culture, ideological differences and resource constraints affect the management of a dual telecommunications system. Examples illustrate how institutional infrastructures serve to reduce technological market uncertainties, to manage the interface between internal and external telecommunications systems and technological markets, and to bring together in a tightly controlled system appropriate information suppliers, brokers and users. The objectives of these infrastructures appear to be the most effective use of limited resources and management of the interaction between technological markets with differing ideological foundations.

8. Conclusions and future research directions

Analysis of the Cuban case reveals the limited success of policies to promote innovation. One of the reasons for this lack of success is the Cuban policy emphasis on technological market supply and failures in efforts to promote the important activities necessary for technology transfer and diffusion. Related to this important concern is the question of long-term effects of economic liberalization on innovation and technology transfer in Cuba and the Caribbean region. Such

[8] These observations are based on a guided tours of the InfoMed offices on May 25, 1998, and TinoRed headquarters in Havana on May 27, 1998.

liberalization would theoretically lead to higher rates of innovation, but it is not clear that fragile Latin American economies will have the managerial, technical or financial resources to support the new dynamics of technological markets. Where resources are inadequate, the result may rather be the further erosion of industrial bases existing in the region and the widening of the gap between the developed and the less developed nations (Correa, 1995).

The Cuban strategy for an information society proposes a model for integration of Cuba in the regional and global economy. Analysis of the Caribbean region shows the comparative performance of the Cuban model in health care and education, despite the adverse political and economic effects of the US embargo, Helms-Burton legislation, and the collapse of the Soviet Bloc. These achievements as well as trends in the formation of the North American Free Trade Agreement and the European Union suggest that Cuba, the largest nation of the Caribbean, may play a critical role in the future integration of the Caribbean region.

The origins and evolution of Cuban science and technology policy since 1959 demonstrate three major phases of evolution: (1) creation of a science base; (2) elaboration of a centralized management model; and (3) institutional decentralization with horizontal integration (Capote, 1996). While the Cuban blueprint for an information society promotes collective social welfare priorities, science and technology policy is also convergent with the strategies of the national development model (Correa, 1995; Tang & Yeo, 1995).

- *Creation of national research centers and university institutes with business enterprise linkages.* Institutional networks of such specialized centers and institutes offer training and development programs in information technology available to Cuban enterprises. The linkage between learning and business institutions contributes to creation of technological demand (Edquist & Hommen, 1999). The National Science and Technology Forum managed by the network of provincial centers for scientific and technical information affiliated with the Ministry of Science, Technology and the Environment, further creates linkages among social institutions and business enterprises at all levels of society for problem solving and innovation. This competitive forum stimulates broad public interest in innovation at all levels of Cuban society and contributes to the integration of supply and demand in the unique dynamics of managed Cuban technological markets.
- *Development of incentives and financial support to promote investments in R&D, primarily through the Foreign Investment Act* (*Law No.* 77) *ratified in* 1995. The uncertainty of the legal environment in Cuba, particularly with respect to private investment and enterprise ownership, continues to hamper investment initiatives such as privatization of state-owned enterprises. However, some efforts to secure foreign investment necessary for telecommunications infrastructure development have produced promising results in spite of significant obstacles including United States economic sanctions. Such efforts appear most frequently to take the form of international techno-scientific collaborations among universities, research centers, or national and multinational firms of the public and private sectors.[9] The most notable example of such effort is the

[9] See Archibugi and Iammarino (1999) for a discussion of global innovation strategies including entrepreneurship for international exploitation of nationally produced innovations, global generation of innovations by multinational firms, and by international techno-scientific collaboration among universities, public research centers, national and multinational firms. See also Rivera (1998, p. 110) for a discussion of the effectiveness of a transnational elite network and joint venturing in the Cuban telecommunications system.

joint venture, ETECSA, between the Cuban national telecommunications enterprise and the Italian firm, STET.

- *Development of telecommunications networks and infrastructure with related services including CENIAInternet and national networks linking institutions in the areas of healthcare (InfoMed) and biotechnology (CIGBnet).* Much progress has been made in recent years in this area, although the Cuban strategy for development and control of telecommunications technologies has favored elaboration of national networks, frequently without regard for technical integration of these systems with external networks and the Internet (Press, 1996a, b). Modernization of Cuban telecommunications systems includes finding ways to integrate certain obsolete technologies such as analogue telephony in order to allocate effectively very scarce resources, and to extend services as much as possible throughout the country. Convergence among computing, telecommunications and television based on digital technologies has reduced costs associated with modernization efforts such as digitalization and expansion of telephone and telecommunications networks by ETECSA.

The Cuban experience in each of these three areas demonstrates the unique coherence between socialist ideological values and management systems under severe resource constraints. Consistent with social welfare priorities, Cuban telecommunications infrastructures have benefited education, healthcare and other knowledge-intensive public sectors of activity as well as banking and tourism where controlled access to external information is of strategic importance.

Some convergence between socialist and democratic discourse on the information society has been identified. First, although definitions and management approaches vary, the information society is founded upon the principle of universal access to telecommunication technologies. In the Cuban model, access is defined as a function of institutional affiliation according to social priorities such as education and healthcare, while in developed democracies, such access is measured by workplace penetration as well as individual or household ownership of the technology. Second, both models favor technological unbundling; in the case of the Cuban model, the objective is to minimize redundancy and facilitate adaptation of new technologies to social and cultural priorities, while in democratic free-market economies, the objective is to maximize technological market decentralization and efficiency. Third, in both patterns of discourse, there is an emphasis on *democratic* participation in the information society.[10]

Within the Caribbean regional context, the Cuban case offers alternative strategies for reduction of ever-increasing social inequities which have not adequately been addressed through existing institutional infrastructures. Options for management of change at the regional and national levels need to be considered in the light of the issues of access to networks and digital gateways in an environment of converging telecommunications and information technologies, protection of cultural content and ideological diversity, investment under highly uncertain demand, and

[10] Interestingly, Chapter Two, Article 13 of Regulations for organizations of the Cuban Communist Party states: "In their functioning, centers (cells) are governed by the principles of centralized democracy, an essential condition for ideological and political cohesion and unity of action" (Partido Communista de Cuba, 1999). According to this text, democratic centralization refers to collective subordination to the criteria of the majority through rigorous exercise of collective governance and individual leadership. See also Amaro (1996) for a discussion of decentralization, local government and citizen participation in Cuba.

management of the requirements of regional and national regulatory environments (OECD, 1998a, b). Regulatory principles in such an environment, while assuring global coordination and integration, must be founded to a very significant degree on self-regulation by institutional, organizational and individual actors in technological markets (European Commission, 1997; OECD, 1998b; Mansell, 1999).[11] This is particularly important in the context of cultural and ideological diversity where the dynamics of technological markets and paths to creation of the information society vary. While arguments for technological determinism may prevail (Carlisle & Manning, 1999), the economic and social transformations of the information society are shaped by ideology and culture as well as economic and technological considerations (Mansell, 1999; Melody, 1999).

This case study has raised important issues of concern to future telecommunications policy modeling and implementation in Cuba and the developing world:

- Transferability of the Cuban model to other economic and political environments, and the lessons learned for other nations of the developing world.
  - Management of universal access to information and telecommunications technology under severe resource constraints.
  - Definition and measurement of R&D where new and obsolete technologies are integrated to optimize resource allocation and support sustainable development.
  - Significance of the Cuban Science and Technology Forum to development of national technological markets.
- Elaboration of alternative scenarios describing the roles of the Caribbean Community and Common Market (CARICOM), the Association of Caribbean States (ACS) and other regional or international organizations in the regional integration process.
- Internationalization of Internet and telecommunications governance and its consequences for management of cultural and ideological diversity in telecommunications systems as illustrated in the Cuban case.

Research on the above agenda will contribute to a broader understanding of the unique Cuban case and its significance for national and regional development models as well as global telecommunications policy implementation.

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[11] See also Mansell (1999) for a discussion of English language dominance and host location in the industrialized countries and how these factors affect the ability of researchers and policy makers in the developing countries to learn about themselves, their needs, and shared solutions to common problems. The proposition here is that self-organization requires a process of 'self-learning'.

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