Satellite Communications for the Pacific Islands

Second Year Final Project Report

December 1982

Prepared by
the Public Service Satellite Consortium

NASA
National Aeronautics and Space Administration

PUBLIC SERVICE SATELLITE CONSORTIUM

SATELLITE COMMUNICATIONS
FOR THE
PACIFIC ISLANDS

SECOND YEAR

FINAL PROJECT REPORT

prepared by the

Public Service Satellite Consortium

for the

National Aeronautics & Space Administration

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SATELLITE COMMUNICATIONS
FOR THE
PACIFIC ISLANDS

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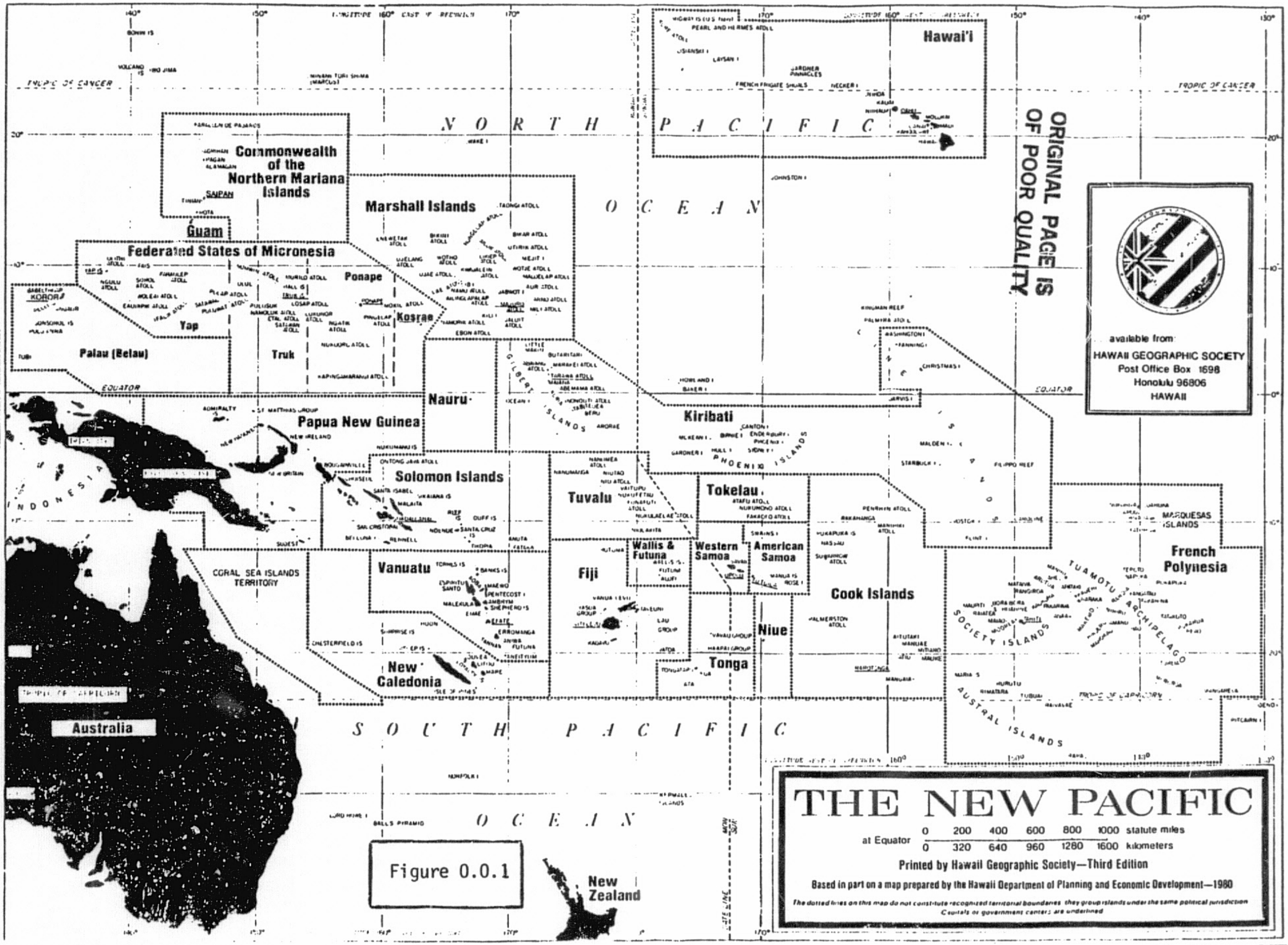
THE NEW PACIFIC
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Printed by Hawaii Geographic Society—Third Edition
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HAWAII GEOGRAPHIC SOCIETY
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NORTH PACIFIC OCEAN
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TROPIC OF CANCER
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Hawai'i
Commonwealth of the Northern Mariana Islands
Guam
Marshall Islands
Federated States of Micronesia
Ponape
Kosrae
Yap
Truk
Palau (Belau)
Nauru
Kiribati
Papua New Guinea
Solomon Islands
Tuvalu
Tokelau
Wallis & Futuna
Western Samoa
American Samoa
Fiji
Vanuatu
New Caledonia
CORAL SEA ISLANDS TERRITORY
Cook Islands
Niue
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TUAMOTU ARCHIPELAGO
SOCIETY ISLANDS
AUSTRAL ISLANDS
PHOENIX ISLANDS
GILBERT ISLANDS
INDONESIA
Australia
New Zealand

Figure 0.0.1

0. EXECUTIVE SUMMARY

0.1 The First Year's Report

In 1980, the Public Service Satellite Consortium (PSSC) undertook an investigation of the communications requirements of the island nations of the Pacific under contract to the National Aeronautics and Space Administration (NASA) and the National Telecommunications and Information Administration (NTIA) of the U.S. Department of Commerce. The second and final year of the study, funded solely by NASA, is described in this report.

The first year's investigation examined user needs in terms of the development of commercial enterprise, social services and political cohesion. It proposed and described a range of alternative technological solutions to communications requirements and reinforced the need for cooperation among the island nations to meet each country's specific, unique requirements. The study pointed out that national governments must be assured of economic, social and political benefit from any cooperative regional effort. This approach was reconfirmed by senior government representatives from nine Pacific island nations at a users' meeting co-convened by the South Pacific Bureau for Economic Cooperation (SPEC) and PSSC in Suva, Fiji, in June of 1981. The message was clear that designers of any regional system must recognize the importance of augmenting and improving existing systems in the process of developing a comprehensive, regional communications solution.

Given these constraints, the first year's investigation considered a number of different forms of terrestrial and satellite connections between islands, but concluded that, in general, the islands are too scattered for submarine cables, too far apart for cost-effective point to point microwave links and lack the financial resources for large numbers of million-dollar-plus earth stations. The study concluded that a satellite option would provide the most suitable solution for the region, albeit with certain caveats. The space segment must provide an appropriately configured coverage pattern and sufficient power to ensure the use of small, affordable, maintenance-simple earth stations. Agreement must be reached by the region's political leadership on a representative organ which would address issues of finance, management, implementation and operation. These conclusions were drawn after discussions by the PSSC project team during seven months of field visits in 1981 with hundreds of individuals representing major user interests in 13 Pacific countries--government officials, traditional leaders, villagers and students--all of whom agreed that improved rural telecommunications throughout the Pacific would be of substantial benefit to integrated national development.

0.2 Present Study (1981-1982)

In this second year (1981-82) of the NASA-funded investigation, PSSC has refined recommendations from the year one study. Recognizing that development--whether of telecommunications or other sectors of a national infrastructure--does not take place in a vacuum, PSSC has undertaken an examination of the economic structure with emphasis on forecasts of economic growth, stressing particularly the relationship between the growth of regional trade and telecommunications potential for the region as a whole. Moreover, the present study identifies the optimal satellite configuration, provides more precise estimates of actual costs and estimates the financial return on investment for a Pacific island satellite network. Essentially, the present study recommends a suitable satellite while indicating the financial implications of such a system.

0.3 Definition of the Pacific Basin

For the purposes of this study, the Pacific islands include the coral atolls and high, volcanic islands between the Asian mainland and North and South America, excluding Australia and New Zealand except where their policies might affect Pacific island populations.

Included are the island groups whose indigenous populations are Polynesian, Micronesian and Melanesian. The Philippines, Indonesia, Hawaii, the Galapagos (Ecuador) and Easter Island (Chile) are excluded. Lord Howe and Norfolk Island telecommunications needs are viewed as met by Australia.

The definition of the Pacific islands used here includes: American Samoa, the Cooks, Fiji, French Polynesia, Guam, Kiribati, Nauru, New Caledonia, Niue, Papua New Guinea, the Solomon Islands, the Tokelau, Tonga, Tuvalu, Vanuatu, Wallis and Futuna Islands and Western Samoa. The Trust Territory of the Pacific Islands, once the compact terminating the Trusteeship has been signed, approved by Congress and reconfirmed by plebescite, will result in four separate entities: the Republic of Belau, the Commonwealth of the Northern Marianas, the Republic of the Marshall Islands and the Federated States of Micronesia, which includes the States of Yap, Truk, Ponape and Kosrae. These new entities are treated separately.

0.4 Political Background to Telecommunications Development

Since the founding meeting of the South Pacific Forum--the annual meeting of prime ministers of the Pacific island nations, Australia and New Zealand--the prime ministers have discussed the inadequacy of telecommunications in the Pacific islands. From the outset, the political importance of telecommunications development was established.

In 1972, the governments requested and received financial and technical assistance from the United Nations International Telecommunications Union (UN/ITU) and established the South Pacific Bureau for Economic Cooperation (SPEC) to assist the governments of the region with telecommunications development. Since 1973, annual regional meetings have been convened by SPEC for governments to review progress and plan further development of telecommunications in the region.

Twelve island nations are currently linked internationally through INTELSAT, and four earth stations are planned for the Federated States of Micronesia. Two for the Republic of the Marshall Islands and one in the Republic of Belau will be operational by the end of 1982.

In the face of these dramatic achievements, deficiencies in the national or domestic networks, particularly in rural telecommunications, are all the more glaring.

Thus, at the 1980 South Pacific Forum, the prime ministers, realizing that collectively the countries could benefit from developments in both satellite and earth station technology, directed SPEC to advise potential satellite space segment providers (including Australia, the U.S., Japan and the European Economic Community) that the Pacific island nations would be interested in sharing satellite space segment.

As a result, NASA and the International Telecommunication Union (ITU) decided to investigate rural telecommunications in the region and requested that PSSC provide a description of those communications systems already in place and a projection of what would be desirable.

PSSC's first year's study (see Pacific Basin Communications Study Final Report, Two Volumes, PSSC, October, 1981), stressing the investigation of user requirements, was followed by the present, NASA-funded effort.

A SPEC-sponsored investigation of rural telecommunications requirements in the Pacific, funded by Australia and New Zealand, was also undertaken. Also, the Japanese government later announced intentions to mount yet another communications study. It is anticipated that the technically specific, design oriented SPEC investigation will serve to complement the broader PSSC planning study. Together, the SPEC and PSSC efforts should provide information necessary for imminent planning decisions by Pacific island telecommunications authorities.

0.5 Consultants

Walter Morgan, President of the Communications Center of Clarksburg, Clarksburg, Maryland, joined the Pacific Basin Communications Study project team at the outset of year one. In concert with PSSC technical staff, he designed and coordinated the research of both years' engineering investigation and advised the representatives at the Users' Meeting co-convened by SPEC and the PSSC in Suva, Fiji, in June of 1981.

Dr. Donald Lamberton, Professor of Economics, University of Queensland, Australia, was a major contributor to the research design. Dr. Lamberton, who has provided ongoing counsel as the project developed, nominated (and PSSC contracted with) Dr. Neil D. Karunaratne, Professor of Economics, University of the South Pacific, Suva, Fiji, and Dr. Marcellus Snow, Associate Professor, University of Hawaii, Honolulu, Hawaii, to contribute to the economic analysis of the study.

Bert Cowlan, a New York based international communications consultant, has contributed widely to the development of this study, participating in discussions with project staff and, on behalf of the project, with officials in Fiji, Hawaii, New York, Geneva and Vienna. Mr. Cowlan also reviewed the final draft of the report.

0.6 Satellite Options for the Pacific Islands

The engineering analysis conducted in this study focuses on satellite options (Section 2) in connection with a parametric study of the number, distribution, size and cost of earth stations (Section 3) for the Pacific islands. The research concludes that in-orbit domestic satellites of the United States, Canada and Indonesia are unable to provide appropriate coverage.

Section 2 reviews the potential of increased and expanded INTELSAT service in the Pacific and the possibility of using the INMARSAT (mobile maritime) system. While INTELSAT presently provides service to and from most Pacific capitals, the Pacific island nations are not covered by the INTELSAT hemi or zone beam and must be served by the low-powered global beam that requires powerful, expensive earth stations. The research reveals that power levels with an INTELSAT global beam are below one-twentieth of what might be provided by an optimally designed or modified satellite. INMARSAT is intended primarily for communication between ships and from ship to shore. Because international regulations prohibit the use of fixed earth stations with INMARSAT, some policy planners hope to recast the definition of islands as "permanently anchored ships." Although INMARSAT's capacity is limited, and it operates in a frequency range suitable for only a short-term solution (making investment in it substantially less attractive), it must be considered as an option. Forthcoming decisions, conversely, make INTELSAT a more attractive option. Thus, INTELSAT and INMARSAT provide the basis of the economic analysis described in Sections 4 and 5.

Two satellites under construction which could conceivably provide service for the Pacific area are the Australian domestic satellite and the Western-most satellite of NASA's Tracking and Data Relay Satellite System (TDRSS). The first Australian satellite, AUSSAT I, will provide coverage to Papua New Guinea but not to the rest of the Pacific islands. AUSSAT's use of 14 GHz could pose a serious problem with service interruption during the torrential rainfall that is frequent in that part of the world. (The traffic volume, however, might not require virtually interruption-free service.) The official Australian position remains that the needs of the Pacific will be taken into account in the planning of the second generation of the domestic satellite which is projected for a decade from now.

The emergence of the TDRSS option is covered in Sections 2.1.6 and 2.3 of this report. The political problems that abound are currently under discussion both within the United States government and between U.S. agencies and those representing the expressed interest of 13 Pacific island prime ministers. In a meeting in New Zealand in August of 1982, they reiterated their 1980 request for information on the possibility of acquiring available space segment on TDRS.

Those interested in the utilization of TDRS in the Pacific postulate that by restraining the complete deployment of the C-band antenna, the spacecraft's beam could be repositioned from the current North Pacific configuration to coverage of the Pacific islands without interfering with the spacecraft's primary mission. Such a change would provide twelve high-powered C-band transponders with adequate coverage of the island South Pacific (excluding Papua New Guinea) to allow the use of small, affordable earth stations. Further technological and cost studies are required.

An interesting model has been proposed. By installing six additional INTELSAT Standard B earth stations in Micronesia and thus bringing the urban centers of the Central Pacific into regular satellite communication for the first time*, augmenting the INTELSAT links to South Pacific capitals, using AUSSAT for Papua New Guinea and possibly using TDRSS to meet the rural needs of the island South Pacific, virtually all populations of the Pacific Basin will be covered by a basic network of satellite communications facilities. Because TDRS remains a tentative option, this study focuses on increased and expanded uses of the INTELSAT system as the most viable system.

0.7 Parametric Study of the Number, Distribution, Size and Cost of Earth Stations

The engineering analysis continues with an exercise in macro or aggregate planning to determine the number, size, cost and distribution of earth stations for the Pacific islands. A computer model based on actual population distribution was prepared to project the number of earth stations and their likely locations within the region.

Besides population, numbers of islands in a given area and the relative capability of each area to support an earth station were also considered. As the purpose of this exercise was to determine the number of earth stations required to meet Pacific islands needs, jurisdictional boundaries were not viewed as constraints, nor was the fact that Standard A and B earth stations service a number of the region's capitals.

Projected numbers of earth stations for 100, 500, 1,000, 2,500, 5,000, 10,000, 50,000 and 100,000 people per earth station were determined for comparison and for future study. One earth station per 2,500 people was selected on the basis of serving the individual island districts and the population. This also coincided with the estimates utilized by economists in Section 4. One earth station per 2,500 people would require approximately

*The use of ATS-1 has been limited to a few hours a day.

1,400 earth stations, a number which could be reasonably manufactured, purchased, transported and assembled for island use in the near term. It is anticipated that this number of earth stations would form the backbone of the Pacific Basin telecommunications network.

To illustrate the technique for determining the size and cost of earth stations, a hypothetical antenna pattern was overlaid on the South Pacific excluding Papua New Guinea (whose needs will be met by the Australian AUSSAT). The TDRS pattern described in Section 2 was used in this example. If the earth stations that could be covered by AUSSAT or INTELSAT were removed, 400 earth stations would remain for placement throughout the rest of the South Pacific.

Section 3.3 shows the distribution of earth stations based on population, number of islands and number of nations, while Section 3.4 illustrates the size and cost of earth stations by replotting the map used in Section 3.3. A figure is also used to convert the satellite power into earth station requirements. A link budget is enumerated for planning purposes. Using a 5° by 5° grid, project engineers determined the earth station diameter and constructed a table with a list of earth stations by size and total costs.

Section 3.5 looks at the INTELSAT alternative and includes, as an example, a table with a breakdown for the COMSAT earth station currently under construction for use with INTELSAT in the Republic of Palau, northwest of Papua New Guinea in the Caroline Islands.

Appendix B comprises an extensive listing of United States-based suppliers of earth stations and earth station components.

0.8 Economic Considerations and Forecasts for Improved Telecommunications

The quest for a modern lifestyle is reflected in both the increased amount of money people spend on imports and the massive migration from the countryside to the few urban centers in the islands. Thus, development strategies that attempt to improve the region's standard of living and stem the tide of rural exodus will succeed only if living conditions in rural communities are improved.

The rural subsistence economy is fragile and prone to such frequent natural hazards as devastating typhoons. Rural development is slow because there is a nearly complete lack of basic services. Telecommunications development can be an effective instrument for promoting economic development. Satellite communications may be the only way to provide an affordable, reliable medium for delivering emergency communications, basic health care, education and community care services to remote areas. One beneficial effect may be to stem the increasing rural to urban migration and rising urban unemployment in the Pacific islands.

Economic Development and National Development Plans

A survey of current national development plans among Pacific island countries reveals the commitment of island leaders to development through a strategy of collective self-reliance. They wish to trade and cooperate in economic development among their own island nations as never before. Their decision to integrate and develop through "collective self-reliance" runs counter to some findings which argue that the prospects for intra-island trade and economic cooperation are very poor. Sections 4.1 and 4.2 of this study, based on the work of economist Dr. Neil Karunaratne, express the contention that such findings are based on unsupportable value judgements and outmoded static theories of trade. They fail to reflect the growing political will and momentum for regional cooperation among the island nations. The present study, however, argues that telecommunications development will reinforce the stability and economic growth of the region and will dispel the gloomy economic forebodings that have typically characterized reports on Pacific island development prospects.

The Role of Trade and Telecommunications

Dr. Karunaratne investigated the nature of the relationship between trade and telecommunications in the Pacific islands. According to his econometric analysis, the supply of telecommunications in the islands is positively related to the diversification of the narrow range of export commodities, but the demand for telecommunications does not show a significant connection with the import of commodities. In effect, in a country with one major crop or mineral for export, the level of telecommunications will grow if other industries, perhaps in other areas of the country, are intensified. Karunaratne also found that the level of telecommunications consumption is negatively related to market diversification. One interpretation postulated is that island nations are already exporting to the optimal markets.

It is widely recognized today that the single crop, mineral or other product export-oriented development of the past in the Pacific is incongruous with the post-independence economic development aspirations of the island nations. This enclave type of trade and telecommunications development can only increase the economic dependence of the island nations on metropolitan trading partners. Moreover, the benefits of this type of enclave development accrue only to a narrow group of island people and expatriates. The recent development planning strategies of the Pacific island nations aim at much more broadly based economic development so that the fruits of economic growth are spread more evenly among larger sections of the population.

Further empirical analyses indicated that telecommunications expansion for Pacific island nations is closely related to the growth of GNP of the former colonial or metropolitan partners regardless of the fact that the metropolitan partners are situated far from the island nations. The contemporary development planning strategies of Pacific nations explicitly advocate the countermanding of the inequalities in income and other disabling effects brought about by the perpetuation of colonial trading patterns. Thus, Pacific island development planning is committed to economic restructuring and the diversification of their narrow export structures and economic bases.

The most recent development plans of the Pacific islands emphasize the need for more equitable distribution of the fruits of economic development and trade. The development of telecommunications on the basis of traditional trade networks and rural-urban demands will be counter-developmental from the perspective of Pacific island planning strategies. Telecommunications development has to be reoriented to meet the basic needs of the rural and remote island populations that have been by-passed by both the trade and the telecommunications growth of the past. These areas must be connected with their national capitals and, within each nation, with other areas and remote outer islands.

As recently as August, 1982, at the South Pacific Forum, the annual meeting of the Pacific island prime ministers, government leaders have voiced their desire to use modern satellite telecommunications for broadly based economic development. They recognize that satellite communications has the potential to deliver basic services to the rural and remote outer islands in a timely and cost-effective manner. This break with past thinking about economic development and telecommunications requires a new orientation, perhaps best achieved under the aegis of an existing international agency.

The demand projections for telecommunications in the Pacific islands, based on conservative estimates, indicate that by the mid-1980's, there will be sufficient user demand to support the sustained use of at least three transponders, one of which will cater mainly to rural needs. By the turn of the century, it is projected that demand from the island nations will justify the rental of a dedicated satellite to cater exclusively to island needs. A joint approach by the Pacific nations to bargain for the best terms in satellite leasing arrangements and for sharing the burden of cost seems warranted. Even on the basis of the criterion of narrow commercial profitability, the catalytic effects that satellite telecommunications can have in expediting and spreading economic development among the scattered island population is perceived as dramatic.

The development of satellite-based telecommunications for the Pacific islands can be provided at little marginal cost to the advanced nations that own satellite technology. (TDRSS is an excellent example.) Assistance in the provision of space capacity could also promote the strategic objectives of both the metropolitan nations and the islands themselves by developing stability among the Pacific island nations at little cost to the metropolitan nations.

0.9 <u>INTELSAT and INMARSAT Options: Cost and Tariff Scenarios</u>

Based on data from Karunaratne's research, Dr. Marcellus Snow examined the economic, financial and institutional aspects of a communications satellite system for the Pacific Basin. His report (Section 5) outlines options for providing telecommunications by satellite to 18 of the Pacific Basin political entities. The first or interim system, from 1985 to 1991, assumes that satellite capacity will be leased from either

INTELSAT or INMARSAT. The second or permanent system, from 1992 to 2000, will be a multi-purpose system providing both conventional paid telecommunications traffic and more directly development-oriented services such as health care, education and earth and ocean resources surveys. It is assumed that the permanent system will be jointly owned by the Pacific Basin entities themselves through ownership shares which reflect their relative usage of the system.

Costs are first calculated for the interim (1984-1991) system. Cost items include: earth stations, depreciated over the 15-year period; leasing of satellite capacity; operating, maintenance and management expenses; miscellaneous overhead expenses; and interest on loans for earth station acquisition, assumed at eight percent over a 15-year period. Costs are presented first for all 18 Pacific Basin entities, and then for 16 entities after French Polynesia and New Caledonia (FP/NC) have been excluded.

Satellite traffic is assumed to grow at a calculated rate in terms of paid minutes per year from 1985 onwards. Fixed ratios reflecting standard engineering practice are then used to determine how many full-time voice circuits (the equivalent of a two-way telephone call), earth stations and satellite transponders will be required. (A transponder is the basic communications component of a satellite and provides about 600 voice circuits. Satellites typically have had 12, and increasingly now provide 24 transponders.) It is assumed that enough earth stations will be operational at the beginning of the interim period (1985) to satisfy traffic requirements at the end of the interim period (1991). Finally, figures for costs, traffic, earth stations and satellites are broken down according to (1) whether FP/NC is included or excluded and (2) whether international/urban or domestic/rural communication is involved.

In determining whether INTELSAT or INMARSAT capacity is the less expensive option for meeting the traffic needs of the interim system, it is assumed that INTELSAT will make transponders available for $800,000 per year as it currently does for INTELSAT members' domestic-only traffic; and that INMARSAT will make its capacity available for $2.00 per minute (Case I) or $1.00 per minute (Case II), both below current tariffs. In either event, the institution involved would have to be approached by representatives from the Pacific island entities. If INTELSAT satellites are used, INTELSAT would have to make an exception to allow its concessionary transponder lease rate to be applied to international traffic between Pacific island entities, as well as domestically. If INMARSAT capacity is used, INMARSAT would have to be persuaded to allow (1) usage of land-to-land links in what has heretofore been an exclusively maritime system; and (2) concessionary rates of $2.00 or even $1.00 per minute, contrasted with the present charge of $5.25 per minute.

For the interim Pacific island system as provided by INTELSAT transponders, traffic is projected to grow from 1,904 circuits in 1985 to 3,534 circuits in 1991. This would require 1,271 earth stations to be installed in 1985, nearly all of which would cost about $120,000 each and be about 6.5 meters in diameter. Transponder needs would grow from three in 1985 to seven in 1991. Total annual costs would grow from $50.5 million in 1985 to $68.9 million in 1991. This corresponds to costs per circuit of from $26,504 (1985) to $19,509 (1991) and costs per paid minute of from $1.67 (1985) to $1.16 (1991). These costs are very roughly of the same order of magnitude as those experienced by the Pacific Basin telecommunications authorities today in providing existing circuits from entity to entity. It is anticipated that costs could be held at today's levels well into the future while the interim system provided more dense coverage to areas which today have either no communications links or quite undependable ones.

If INMARSAT provided the satellite capacity for the interim system, the same traffic and earth station figures would still apply. The earth stations, however, would be smaller and less expensive--on the order of 1.3 meters in diameter and costing $50,000 each. Also, operating costs for the earth stations and overhead expenses generally would be less. Nevertheless, analysis indicates that even so, the greater cost of the INMARSAT space segment, whether at $2.00 or $1.00 per minute, would make the INTELSAT option less expensive than the INMARSAT option for the interim system in almost all cases examined. If all 18 Pacific island entities are considered, INMARSAT costs exceed INTELSAT costs by a factor of 1.60 in 1985, growing to a factor of 2.12 by 1991. This assumes $2.00 per minute for INMARSAT charges. If $1.00 per minute is assumed, the factor is 1.00 (costs equal) in 1985 and grows to 1.26 by 1991. If French Polynesia and New Caledonia were excluded, the INMARSAT option becomes slightly more attractive. In that case, the INMARSAT/INTELSAT cost ratio grows from 1.39 in 1985 to 1.87 in 1991 if a $2.00 per minute INMARSAT charge is assumed. For a $1.00 per minute charge and excluding French Polynesia and New Caledonia traffic, INMARSAT actually becomes less expensive than INTELSAT during 1985-1988 and then slightly more expensive during 1989-1991.

Implications of Trade, Economic Growth, Structural Change and Tariff Policy for Telecommunications Traffic and Revenue

Whichever system is employed for interim usage, a tariff structure must be selected that will allow the system to be paid for. Typically, the approach has been to charge a per-circuit price equal to the total cost divided by the number of circuits. This is average cost pricing, and while it is administratively simple and seems fair as well, it has some disadvantages relative to other approaches. One such approach would be to consider subgroups of users who differ in their ability or willingness to pay for circuits--in other words, their sensitivity to price. Possible criteria for separating users into groups of differing ability to pay include location (rural or urban); per capita income; time of day; type of user (business or residential); and so on. It is shown that charging higher prices to users with high ability to pay, and lower prices to users with low ability to pay, often increases overall traffic to such an extent that all benefit, even those paying higher prices. Nevertheless, determining the criteria for separating user groups, as well as measuring their ability to pay accurately, are important problems still to be addressed.

Is telecommunications a prerequisite for development or a result of it? While some feel uncertain about the precise role of telecommunications in economic growth and development, clearly it is both a cause and an effect although the quantitative nature of the relationship is yet to be captured. There is enough strong evidence to justify the implementation of an interim system. Experience during 1985-91 will determine the requirements for the permanent system for 1992-2000. To allow a maximum effect on development goals, the permanent system should be wholly owned by the Pacific island entities and designed as multi-purpose system. In this way, it could provide for development-oriented needs directly as well as indirectly by furnishing the conventional paid telecommunications also needed for development.

Institutional Considerations

Existing institutional barriers to the interim system (various concessions by INTELSAT or INMARSAT; attracting French Polynesia and New Caledonia who currently are not part of the UN/ITU South Pacific Regional

Telecommunications Development Project; ownership and tariff policy; and so on) should be addressed by the Pacific Basin entities jointly through such existing organizations as the UN/ITU and the South Pacific Bureau for Economic Cooperation (SPEC) at the highest diplomatic levels.

0.10 Summary Considerations

The 1980 call by the prime ministers of the South Pacific nations for improved telecommunications in the Pacific region engendered considerable interest in the islands' communications. Once each government assesses the present PSSC study, the SPEC study and information from INTELSAT, the island nations will be faced with a series of political, technical and socio-economic decisions for consideration in both a national and regional context.

In planning, the leadership of the Pacific island governments has determined that the most efficient and effective means of improving telecommunications and enhancing development opportunities is the implementation of a comprehensive region-wide system, extending both satellite and terrestrial communications technology into underserved or unserved areas. All available studies support this decision.

Such a system will meet the unique, individual needs of each nation while bolstering the economic prospects for the region as a whole.

A corporate structure meshing appropriately with local telecommunications authorities, international carriers and existing legal systems must be created. Accordingly, a decision must be made whether a national government, an international agency or a newly created organization will manage the network.

Satellite technology is obviously a mainstay of the development of affordable, reliable telecommunications for the Pacific. Governments must assess carefully the comparative advantage of the extended utilization of INTELSAT, the possible employment of INMARSAT, TDRSS, the second generation of the Australian domestic satellite system and, eventually, a dedicated satellite for the region.

Training, pricing and management are all questions requiring consideration by the nations before the ultimate design of an ideal communications system can be chosen and implemented.

A great deal has been accomplished in the past two years: two major studies have been completed, encouraging signs suggest INTELSAT's willingness to accommodate the unique requirements of the Pacific region and far-reaching international interest in the Pacific has been generated. The Pacific island nations can only benefit from this surge of interest. Fortified with all this new information, government officials in the region can now make a series of decisions which will lead to the implementation of improved telecommunications. A meeting of Pacific island ministers of communications is scheduled for the spring of 1983. It is anticipated that findings from the present study will be reflected in those deliberations.

1. INTRODUCTION

1.1 The First Year's Report

In 1980, the Public Service Satellite Consortium (PSSC) undertook an investigation of the communications requirements of the island nations of the Pacific under contract to the National Aeronautics and Space Administration (NASA) and the National Telecommunications and Information Administration (NTIA) of the U.S. Department of Commerce. The second and final year of the study, funded solely by NASA, is described in this report.

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Given these constraints, the first year's investigation considered a number of different forms of terrestrial and satellite communications to facilitate communications between islands, but concluded that, in general, the islands are too scattered for submarine cables, too far apart for cost-effective point-to-point microwave links and lack the financial resources for large numbers of million-dollar-plus earth stations. The study concluded that a satellite option would provide the most suitable solution for the region, albeit with certain caveats. Any space segment must provide an appropriately configured coverage pattern and sufficient power to ensure the use of small, affordable, maintenance-simple earth stations. Agreement must be reached by the region's political leadership on a representative organ which would address issues of finance, implementation, management and operations. These conclusions were drawn after discussions by the PSSC project team in 1981 with hundreds of individuals representing major user interests in thirteen Pacific countries--government officials, traditional leaders, villagers and students--all of whom agreed that improved rural telecommunications throughout the Pacific would be of substantial benefit to integrated national development. The reader is referred to the "Pacific Basin Communications Study," Final Report, October 1981, for additional background information.

1.2 Present Study (1981-1982)

In this second year (1981-1982) of the NASA-funded investigation, PSSC has refined recommendations from the first study. Recognizing that development--whether of telecommunications or other sectors of a national infrastructure--does not take place in a vacuum, PSSC has undertaken an examination of the economic structure and forecasts of economic growth, stressing particularly the relationship between the growth of regional trade and telecommunications potential for the region as a whole. Moreover, the present study identifies the optimal satellite configuration, provides more precise estimates of actual costs and estimates the financial return on investment for a Pacific islands satellite network. Essentially, the present study describes and recommends suitable satellites and discusses the economic and political implications of such systems.

1.3 Background and Perspective

A major factor in the successful development of the Pacific island nations is the implementation of communication systems that will adequately meet their unique national and regional needs. Improved telecommunications between the island nations of the Pacific has been a long-standing high priority objective. Communications must provide these nations with links beyond national boundaries. The creation of such international service is well underway; nearly every country in the Pacific region is linked internationally by an International Telecommunications Satellite Organization (INTELSAT) satellite. Ideally, however, a communication system should provide every citizen of each island entity with adequate access to meet the most basic personal and community needs, in both an urban and rural environment.

The development of international links between capitals and the steady, though not rapid, economic gains in those capitals have led to dramatic improvements in the urban centers of the islands. Conversely, urban development has caused a reduction of attention to rural development, and as the gap widens between the two, governments have been required to refocus their attention on rural issues. Health services, education, agriculture and other economic development, disaster warning and relief are all aspects of rural development requiring attention that cannot be provided adequately until rural telecommunications links are substantially improved.

1.4 Definition of the Pacific Basin

For the purposes of this study, the Pacific islands include the coral atolls and high, volcanic islands between the Asian mainland and North and South America, excluding Australia and New Zealand except where their policies might affect Pacific island nations.

Included are the island groups whose indigenous populations are Polynesian, Micronesian and Melanesian. Excluded are the Phillipines, Indonesia, Hawaii, the Galapagos (Ecuador) and Easter Island (Chile). (Lord Howe and Norfolk Island telecommunications needs are viewed as met by Australia.)

The definition of the Pacific islands used here includes: American Samoa, the Cooks, Fiji, French Polynesia, Guam, Kiribati, Nauru, New Caledonia, Niue, Papua New Guinea, the Solomon Islands, the Tokelau, the Kingdom of Tonga, Tuvalu, Vanuatu, Wallis and Futuna Islands and Western Samoa. The Republic of Belau, the Commonwealth of the Northern Marianas, the Republic of the Marshall Islands and the Federated States of Micronesia, which includes the states of Yap, Truk, Ponape and Kosrae, still legally compose the Trust Territory of the Pacific islands, but because steps toward terminating the Trusteeship are in process and because responsibility for telecommunications development has fallen to each entity, these island states are viewed individually in this report.

1.5 The Chronology of Independence

In the 1960's, Western Samoa and Nauru joined the Kingdom of Tonga as independent Pacific states. Fiji followed Nauru in 1970, and in the past decade Papua New Guinea, Kiribati, the Solomon Islands, Tuvalu and Vanuatu have also gained independence. Meanwhile, the U.S. rapidly increased its commitments in manpower development and upgrading of the infrastructure of the Trust Territory of the Pacific islands. Niue and the Cooks have stable, permanent relationships with New Zealand while they are internally self-governing.

1.6 Political Background to Telecommunications Development

At the founding meeting of the South Pacific Forum--the annual meeting of Pacific island prime ministers and those of Australia and New Zealand--in 1971, the prime ministers of the region discussed the inadequacy of telecommunications in the Pacific islands. Indeed, its limitations had curtailed their ability to plan the very meeting to which they had come to discuss the issue. From the outset, the political importance of telecommunications was established.

In 1972, the governments requested and received UN/ITU financial and technical assistance; in 1973, with the establishment of the South Pacific Bureau for Economic Cooperation (SPEC), the secretariat and action arm of the Pacific Forum, the prime ministers agreed that because both economic and social development were hampered by lack of efficient telecommunications, it was essential to provide an adequate telecommunications network in the region. The Forum charged SPEC with assisting in the coordination of the development of regional telecommunications. Since 1973, the annual regional meetings have been convened by SPEC for the governments to review progress and plan further development of telecommunications.

Presently, twelve island entities have been linked internationally by satellite through INTELSAT. An earth station is planned for each of the four states of the Federated States of Micronesia, two for the Republic of the Marshall Islands and one in the Republic of Belau, all of which will be operational before the end of 1982.

In the face of these dramatic achievements, deficiencies in national or domestic networks, particularly in rural communications, are all the more glaring.

Analysis by the ITU South Pacific Regional Telecommunications Development Project has revealed that these deficiencies--in management structures of telecommunications authorities, in technical and commercial planning expertise, in operation and maintenance and skilled and experienced staff--are the direct result of the need by the governments to provide modern and adequate telecommunications within a very short time frame.[1]

1.6.1 Call for Assistance

Thus, the Pacific Forum meeting of prime ministers in Kiribati in 1980, recognizing that the development of their rural areas is a common national goal, again stressed the need for improved rural telecommunications. Realizing that collectively the countries could benefit from developments in both satellite and earth station technology, the prime ministers directed SPEC to advise potential satellite space segment providers (including those in Australia, the United States, Japan and the European Economic Community) that the Pacific island countries would be interested in sharing satellite use with them.

1.6.2 United States Study

The appropriate United States agencies, including NASA and the National Telecommunications and Information Administration (NTIA) of the U.S. Department of Commerce, took cognizance of the prime ministers' interest. Also, NASA was concerned about what type of system would pro-

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[1]UNDP Project Document: "Development of Telecommunications in the South Pacific. Starting date: January 1, 1982. UNDP/ITU, Suva, Fiji, 1981.

vide follow-on to ATS-1, how communications satellites in the 30/20 GHz band might be used for service in the Pacific and how a possible cooperative project with Canada involving experimental mobile satellite communications could benefit at least some entities in the Pacific Basin. Given these concerns and interests, NASA and NTIA decided to investigate rural telecommunications in the region and requested that PSSC provide a description of those communications systems already in place and a projection of what would be desirable.

The first year's study, stressing the investigation of user requirements, was followed by the present, solely-NASA-funded effort.

1.6.3 The SPEC-Sponsored Rural Telecommunications Study of the South Pacific

Concurrent with PSSC's preliminary field investigation, plans for a SPEC-sponsored investigation of Pacific islands telecommunications requirements were formalized. By the end of 1981, a staff of three engineers from Australia and New Zealand began field work on the Rural Telecommunications Study of the South Pacific. It is anticipated that the technically specific design orientation of this Australian and New Zealand-funded study completed in September of 1982 will serve to complement the broader planning study reflected in the PSSC report. Together these efforts should provide information to assist Pacific islands telecommunications authorities in making planning decisions.

1.6.4 Japanese Study

At the Pacific Telecommunications Conference in Honolulu, Hawaii, January, 1982, the Japanese Research Institute for Telecommunications and Economics (RITE) announced that a study on satellite usage in the Pacific would be undertaken. The Ministry of Posts and Telecommunications advised

SPEC early in 1982, and preliminary questionnaires have been widely distributed.

1.7 Scope of Work of the Present Study

In the second year contract with NASA, PSSC identified and executed the following scope of work. Certain modifications were made to the original scope of work to accommodate new developments (e.g., the Australian Domestic Satellite (AUSSAT) and the Tracking and Data Relay Satellite System (TDRSS) that arose as options during the course of the investigation).

Expansion of Revised Tasks for NASW-3488

1. Describe interim satellite service possibilities in the Pacific Basin.

1.1 Examine the requirements and costs to acquire interim satellite service in the Pacific Basin using existing communication satellites (i.e., INTELSAT, INMARSAT).

1.2 Explore other interim arrangements utilizing proposed satellite systems (e.g., AUSSAT and TDRSS).

1.3 Investigate other interim satellite options (i.e., repositioning of domestic satellite for service in the Pacific).

2. Determine system requirements and costs for establishing dedicated satellite service in the Pacific Basin.

2.1 Describe satellite system alternatives for the Pacific Basin (i.e., Ku-band, C-band, S-band, Hybrid).

2.2 Establish system parameters and projected capacity for a dedicated Pacific Basin satellite (i.e., 2-4-6-8 transponders, of hybrid 2 of S-Band and 4 of C-Band).

2.3 Identify suppliers and carriers with market interest in the Pacific.

2.4 Examine the technical requirements and costs to establish a ground network.

2.4.1 Analyze statistical parameters for establishing the ground network.

2.4.2 Analyze technical requirements and costs for a ground network.

2.5 Determine space segment costs.

2.6 Re-examine status of small earth stations with INTELSAT global beam. What has been done to date? How well? What is proposed?

2.7 Review status of the art of HF single sideband radio.

3. Examine economic considerations in establishing a satellite system in the Pacific Basin. Re-examine definition of the region and likely participants in cooperative regional communications effort.

3.1 Investigate Pacific Basin willingness and ability to pay for interim and dedicated satellite service.

3.1.1 Examine the economic structure and changes in that structure (e.g., changing patterns of trade that could generate changed communication flows).

3.1.2 Forecast economic growth prospects.

3.2 Examine the options and associated operational, maintenance and management costs as well as analyze the projected recurring revenue from a Pacific Basin Satellite Network.

3.3 Identify regional and international sources of funds for interim and dedicated satellite services in the Pacific.

3.4 Explore alternative industry-based funding for establishing satellite service in the Pacific.

3.5 Project recurring revenue potential to stimulate industry investment interests.

3.6 Prepare a preliminary business plan for a Pacific Basin Satellite Network.

3.6.1 Consider system requirements in light of economic growth prospects.

3.6.2 Incorporate such allowances as necessary for the expansionary effects of the new availability of communications.

3.6.3 Estimate the likely demand for telecommunications services, given alternative pricing (tariff) policies.

4. Investigate and, when appropriate, correlate parallel telecommunications studies and relate them to the Pacific Basin Communications Study (i.e., AID Rural Satellite Project, East-West Center studies, South Pacific Bureau for Economic Cooperation/Australia/New Zealand study, etc.).

5. Maintain continuing dialogue with representatives from Pacific Basin nations.

5.1 Disseminate information on the Pacific Basin Communications Study to interested parties.

5.2 Prepare and distribute information updates on telecommunications needs in the Pacific.

5.3 Participate in meetings that address Pacific Basin telecommunications (i.e., ITU meeting in Sydney, Australia, October, 1981; Pacific Telecommunications Conference, Hawaii, January, 1982; SPEC/South Pacific Forum Meeting, August, 1982).

1.8 Methodology

The broad range of tasks represented in the scope of work required the assistance of specialists with Pacific expertise not available within the Consortium, particularly in the field of economics. Moreover, knowledge of the region and sensitivity to Pacific-specific issues were a high priority in the search for appropriate economists and engineering planners.

In managing the study, the project coordinator, consistent with the scope of work, contacted potential consultants, assigned the tasks and coordinated their research efforts to ensure the emergence of a synthesized, integrated report which would address fully each of the tasks identified in the contract. The consultants--economists and telecommunications planners based in Fiji, Australia, Hawaii and Washington, D.C.--formed a panel of experts on the relationship between trade and telecommunications. They met with officials at INTELSAT and COMSAT in Washington, INMARSAT in London and with officials of the United Nations International Telecommunication Union South Pacific Regional Telecommunications Development Project (UN/ITU) and the South Pacific Bureau for Economic Cooperation (SPEC), in Suva, Fiji during the course of the study. The methodology used by individual consultants is integrated into the chapters to which they contributed.

The project coordinator also maintained dialogue by participating in major Pacific-focused conferences on telecommunications. PSSC presented the findings of the first year's investigation at the invitation of SPEC at the 8th South Pacific Telecommunications meeting in Sydney, Australia, in October, 1981. The project coordinator presented a paper on the first year's investigation at the Pacific Telecommunications Conference in Honolulu in January of 1982, and in the spring of 1982, consulted with the UN/ITU, meeting with the project staff of the South Pacific Regional Telecommunications Development Project in Suva, Fiji, and with the team leader of the South Pacific Bureau for Economic Cooperation telecommunications study in Melbourne, Australia.

1.9 A Note on Consultants

Walter Morgan, President of the Communications Center of Clarksburg, Clarksburg, Maryland, joined the Pacific Basin Communications Study project team at the outset of year one. In concert with the PSSC technical staff, he designed and coordinated the research of both years' engineering investigation and advised the representatives at the Users' Meeting co-convened by SPEC and PSSC in Suva, Fiji, in June of 1981. Mr. Morgan was formerly senior staff scientist at COMSAT Laboratories.

Presentation of the 1981 report at several international fora generated discussions with economists and telecommunications officials with particular interest in the economic issues which influence telecommunications development. Discussions with several of these experts at the Conference on Telecommunications and Trade Relations in the Pacific Community at the East-West Center, Honolulu, Hawaii, in September of 1981, and at the 8th South Pacific Regional Telecommunications Meeting in Sydney, Australia, in October of that year, influenced the direction of the second year's study and have served to validate PSSC's hypotheses on economic issues relating to telecommunications in the Pacific Basin. In particular, Dr. Donald M. Lamberton, Professor of Economics at the University of Queensland, Australia, who has provided the study with ongoing counsel, advised us that Dr. Neil Karunaratne, Professor and Head of the Department of Economics at the University of the South Pacific, would be an ideal candidate to investigate the structure and prospects for the growth of trade in the region and that Dr. Marcellus S. Snow, Associate Professor of Economics at the University of Hawaii, well recognized as an expert on INTELSAT, would be able to analyze the satellite options available to the Pacific and conceptualize a business plan appropriate for a regional telecommunications system.

After meeting with PSSC project staff in Suva, Fiji, Dr. Karunaratne agreed to undertake an economic analysis of the structure and changes in patterns of trade in the Pacific island nations. In Hawaii, Dr. Snow contracted to investigate systems requirements, demand, pricing and projected recurring revenue from a Pacific Basin satellite network and to project costs for managing, operating, maintaining and funding such a network. Dr. Snow met with INTELSAT officials in Washington, D.C.; Dr. Lamberton interviewed representatives of INMARSAT in London; and Dr. Snow, Dr. Karunaratne and officials from both SPEC and the UN/ITU South Pacific Regional Project convened in Suva, Fiji, to review the research design and discuss economic implications of an improved telecommunications system for the Pacific region.

Bert Cowlan, a New York-based international communications consultant, has contributed widely to the development of this study, participating in discussions with project staff and, on behalf of the project, with officials in Fiji, Hawaii, New York, Geneva and Vienna. Mr. Cowlan also reviewed the final draft of the report.

1.10 A Note on Staff

Dr. Elizabeth L. Young, President of PSSC, served as principal investigator of the contract with NASA. The project was administered by the Planning and Development Department of the Consortium, under the direction of Dr. Louis A. Bransford, Vice President. Ms. Jane N. Hurd, Project Coordinator, assumed primary responsibility for the design and implementation of the entire two-year project. Besides the contributions of the aforementioned consultants and members of the PSSC engineering staff in Denver, Mr. W. Daniel Gorton, Director, Systems Engineering, and Mr. Steven Dutka, Senior Systems Engineer, this report reflects the considerable editorial coordination and content review of Ms. Joan Rosenhauer, the editorial and production assistance of Ms. Regina Purvis, and the logistical support of Ms. Karen Hutcheson and Ms. Kay Cunningham, all of PSSC Headquarters in Washington, D.C.

2. SATELLITE OPTIONS FOR THE PACIFIC ISLANDS

Any discussion of satellite options for the Pacific must begin with ATS-1. The ATS-1 was launched on December 15, 1967. Its design life was for 18 months; yet, it is still being used in 1982 although its services have been curtailed. Recently it was moved to a more stable orbital location to conserve power, its future use will be evaluated annually by NASA.

The use of this experimental satellite for educational exchanges at first and, later on, for certain critical administrative functions, has, if nothing else, proven the absolute necessity for the Pacific Basin to acquire improved communications.

It has accomplished yet another objective. The Pacific island people have acquired hands-on experience with satellite technology. Enhancement of the use of advanced satellite technology will not pose quite the problem it might in some other developing areas of the world. It has been an experience valued by the countries involved; the technology is demystified; and there are persons well acquainted with both the technology involved and, more importantly, with the utilization of satellite technology to accomplish specific Pacific goals and objectives.

Section 2 reviews the satellite system options which might be used for improved telecommunications service within the Pacific islands. Among the satellite options discussed in this section are the presently in-orbit domestic satellites of the United States and Indonesia, which PSSC research concludes are unable to provide coverage appropriate to the area of interest.

This section reviews the potential of increased and expanded INTELSAT service in the Pacific and the possibility of using the INMARSAT (mobile maritime) system. As presently operated, INTELSAT provides service into the Pacific, but the power levels are only five percent of what is typically provided by domestic U.S. satellites used with the low-cost, backyard earth stations which proliferate across the United States. The island nations are not covered by the INTELSAT hemi or zone beams. They are serviced by global beams which require large, powerful and expensive earth stations.

INMARSAT is intended primarily for communication between ships and from ship to shore. At present, the use of fixed earth stations is not permitted on INMARSAT. The hope of recasting the definition of islands as permanently anchored ships still prevails. Although INMARSAT's capacity is limited--which makes investment in the system substantially less attractive--it must be considered as an option. The INTELSAT and INMARSAT options provide the basis of the economic analysis discussed in Section 4.

Two satellites under construction which could conceivably provide service for the Pacific islands are the Australian domestic satellite and the western-most satellite (171°W) of NASA's Tracking and Data Relay Satellite System (TDRSS). The first Australian satellite (AUSSAT I) will provide coverage to Papua New Guinea, but most of the island Pacific lies east of the beam and will not be provided with coverage. AUSSAT I's use of 14 GHz will likely pose a severe problem with service interruption during the torrential rainfall that is frequent in the Pacific islands. The official Australian position remains that the needs of the Pacific will be taken into account in the planning of the second generation of the Australian domestic satellite.

The emergence of the TDRSS option is covered in Sections 2.1 and 2.3

of this report. The political problems that abound are currently under discussion both within the United States Government and between U.S. agencies and those representing the expressed interest of 13 Pacific island prime ministers. Those interested in the utilization of TDRSS in the Pacific postulate that by restraining the complete deployment of the C-band antenna, the spacecraft's beam could be repositioned from the current North Pacific configuration to coverage of the Pacific islands without interfering with the spacecraft's primary mission. Such a change would provide 12 high-powered C-band transponders with adequate coverage for the island South Pacific (excluding Papua New Guinea) that would allow the use of small, affordable earth stations. Additional investigation has been recommended.

The installation of six additional INTELSAT Standard B earth stations in Micronesia will bring the urban centers of the central Pacific into satellite communication for the first time. With this increased coverage, INTELSAT links to South Pacific capitals, the utilization of AUSSAT for Papua New Guinea and the possible use of TDRSS to meet the rural needs of the islands, virtually all populations of the Pacific Basin would be covered by a basic network of satellite communications facilities.

Because TDRS remains a tentative option, this study focuses on increased and expanded uses of the INTELSAT system as the most viable service.

2.1 Assorted Solutions: Prospects and Problems

During the past several years, the telecommunications requirements of the Pacific islands have garnered the attention of the political, social science and technological community both within the Pacific region and in distant, technology- and aid-providing nations. The project staff has examined the many theories and assorted solutions proposed to improve communications in the Pacific region. In particular, discussion with Mr. Richard Butler, newly elected Secretary General of the ITU, have influenced the investigation of possible solutions by the project staff. The prospects and problems associated with the options are raised in this section. For ease of reference in reviewing the prospects and problems associated with satellite options, Figure 2.1 provides information on the telecommunications satellite frequencies described in this section.

2.1.1 Dedicated Hybrid C/S Band Satellite

The first year's investigation focused primarily on the possibility of a satellite in the 2.5 GHz band or one with hybrid capacity at both 2.5 and at 6/4 GHz. Through discussions with designers, suppliers and regional telecommunications officials, it became evident that the cost and schedule for the design of a special satellite of this class would be prohibitive in a region where resources are so few and economies so fragile.

Short of a specially designed satellite, one particularly expedient approach might have been to modify the ARABSAT configuration to make it suitable to the Pacific island nations. Although the ARABSAT option still exists, there probably would only be one U.S. bidder (Ford Aerospace & Communications Corporation), who would, therefore, be the only supplier. A limited amount of equipment is already available for use at 2.5 GHz, and any unique equipment for the Pacific would take time, would require additional expenditure of funds and would pose a risk.

Ku-band was deemed unsuitable because its effectiveness is limited by the excessive amounts of rainfall typical in the island environment. The advantage of the 2.5 GHz is that it is an easy operating frequency range with little rain attenuation, and earth stations can be constructed by relatively unskilled personnel. Maintenance is also fairly easy, and

	TELECOMMUNICATIONS SATELLITE FREQUENCIES (GHz)		
LETTER BAND	EARTH TO SPACE (UPLINK)	SPACE TO EARTH (DOWNLINK)	SHORT NAME
S	2.655 - 2.690	2.500 - 2.655	2.5
C	5.925 - 6.425	3.700 - 4.200	6/4
X	7.900 - 8.400	7.250 - 7.750 *	8/7
Ku	14.000 - 14.500	10.950 - 11.200 ** 11.450 - 11.700 **	14/11
Ku	14.000 - 14.500	11.700 - 12.200 ***	14/12
	17.300 - 18.100	12.200 - 12.700	DBS ****
Ka	27.500 - 30.000	17.700 - 20.200	30/20
	30.000 - 31.000	20.200 - 21.200 * 42.500 - 43.500 *	30/20 * 30/44 *

NOTES:
* = Military only
** = International (Intelsat) only
*** = The upper boundary is subject to change in 1983 (between 12.100 and 12.200 GHz).
**** = DBS means Direct Broadcast Satellite. The lower boundary is subject to change in 1983 (between 12.100 and 12.300 GHz).

FIGURE 2.1

some experience with this band already exists in Pacific microwave links that operate on adjacent frequencies. Also, the simplicity of the antennas encourages local manufacture.

As indicated in the earlier report, the 2.5 GHz band also has the great advantage of being listed for operation with mobile stations in addition to fixed (island) stations. This dual use could be important in an area such as the Pacific island nations where mobile facilities may be the only link for some villages or outer islands.

2.1.2 PALAPA A1-A2

The PALAPA series of satellites was constructed by the Hughes Aircraft Company. The satellites are of the same design used for the Anik A (Canada) and WESTAR I - III (U.S.) satellites. They consist of a spin-stabilizer design with a despun antenna. Twelve transponders of 36 MHz each are carried with a 5-watt power level. These satellites are nearing the end of their design life and will be replaced very soon by two 24-transponder PALAPA B satellites. It has been suggested that PALAPA A1 and A2 be moved to the east to provide service to the Pacific islands.

Among the difficulties are the fact that the coverage pattern does not match the area of interest, and--as in the case of a used car--there is no way of knowing when old parts may fail. One predictable and realistic limitation is fuel. These satellites will run out of fuel in the next few years after which they will start to drift toward the orbital graveyard of the Pacific (near 106° W longitude). Finally, the delicate political considerations would have to be examined.

The advantage of the PALAPA option is that the satellites might be available with twelve to 24 months.

The number of transponders surviving on the PALAPA A series is unknown; however, Figure 2.2 shows the performance of a comparable satellite series used in Canada. WESTAR has also been suggested, but WESTAR I and II have already lost two and one transponders, respectively. The remaining capacity is in question and, therefore, not suitable for use in the Pacific.

2.1.3 Construction of the Spare Western Union Satellite

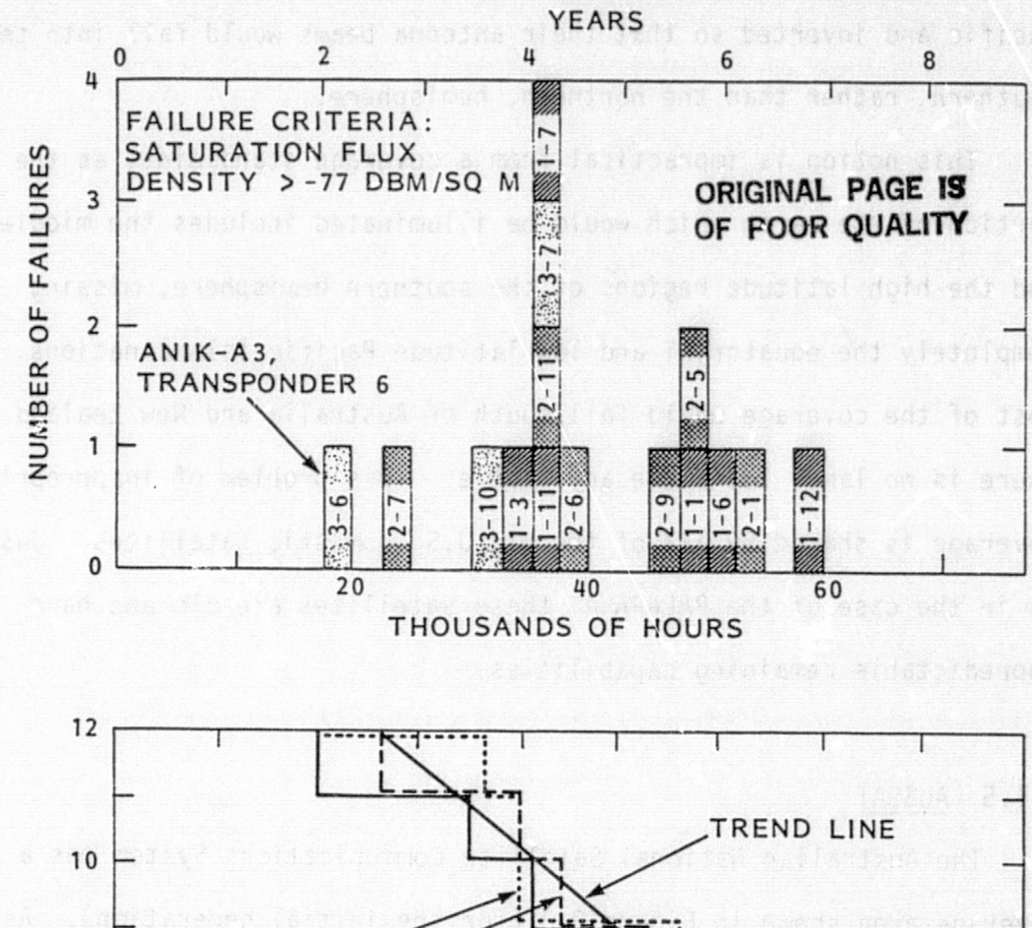
Rumors prevail that Hughes Aircraft Company has the major components for the construction of another satellite of the early WESTAR/ANIK/PALAPA series, the same 12-transponder satellite mentioned in the previous section.

Apparently, the unfinished satellite is owned by Western Union, and, if a buyer can be found, Western Union and Hughes would no doubt complete the construction for a substantial fee. Previous attempts to find a buyer have been unsuccessful. Within the industry, an unsubstantiated price of $50 million (plus launch costs) has been quoted. Given that new 24-transponder satellites cost substantially less, this price seems excessive. It is also likely that only one satellite could be constructed (without a spare). This approach does not appear attractive from an economic or operational standpoint. Weak as it is, however, this remains an option for an underserved area such as the Pacific.

2.1.4 WESTAR I (or II)

The old Western Union satellites have been replaced by WESTAR IV and V. It has been proposed that these satellite could be moved to the

FIGURE 2.2: PERFORMANCE OF CANADIAN ANIK SATELLITES



Pacific and inverted so that their antenna beams would fall into the southern, rather than the northern, hemisphere.

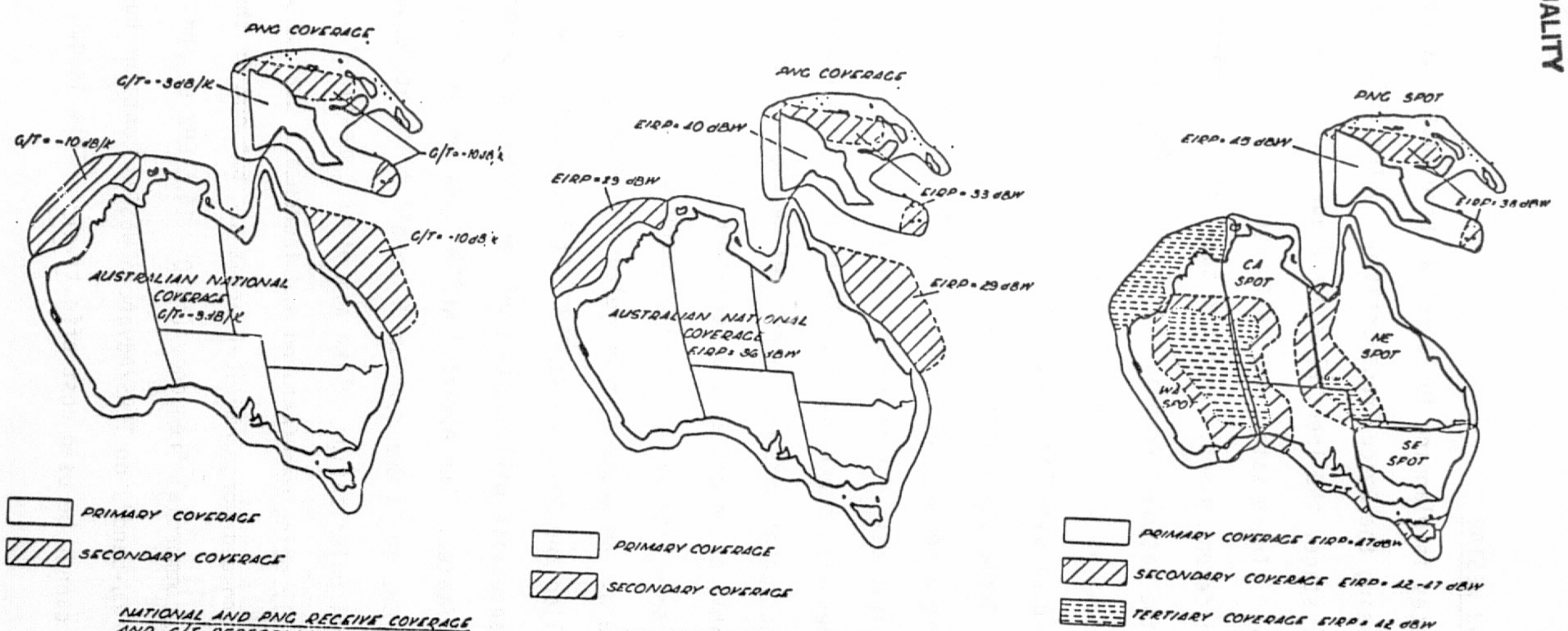
This notion is impractical from a coverage standpoint, as the portion of the earth which would be illuminated includes the middle and the high latitude regions of the southern hemisphere, missing completely the equatorial and low-latitude Pacific island nations. Most of the coverage would fall south of Australia and New Zealand where there is no land, let alone any people. This problem of inappropriate coverage is shared by all of the old U.S. domestic satellites. Just as in the case of the PALAPA A, these satellites are old and have unpredictable remaining capabilities.

2.1.5 AUSSAT

The Australian National Satellite Communications System has a coverage area shown in Figure 2.3 (for the initial generation). As can be noted from the diagram, the coverage touches very few of the Pacific island nations.

Mid-April, 1982, discussions between PSSC and officials of the Australian Department of Communications reconfirmed the government policy on extending use of AUSSAT to the Pacific islands. That policy remains unaltered. Prime Minister Malcolm Fraser reiterated earlier this year that his government will consider the needs of the Pacific island nations in the planning of the second generation of the Australian domestic satellite. If the first generation satellites are launched in 1985 and last seven years, then the earliest date for the second generation would be 1991 (assuming there is a one-year overlap between the first and second generation). This is along time for the Pacific island nations to wait.

FIGURE 2.3



NATIONAL AND PNG RECEIVE COVERAGE AND G/T PERFORMANCE

(TRUE VIEW PROJECTION FROM 160°E)

NATIONAL AND PNG TRANSMIT COVERAGE AND FSS EIRP PERFORMANCE

(TRUE VIEW PROJECTION FROM 160°E)

PNG AND SPOT BEAM TRANSMIT COVERAGE AND HACBSS EIRP PERFORMANCE

(TRUE VIEW PROJECTION FROM 160°E)

AUSSAT COVERAGE

2.1.6 TDRS/Advanced WESTAR

The United States is planning to launch a three satellite series beginning in 1983 using the Space Transportation System (STS) and a high-energy upper stage, the Inertial Upper Stage (IUS), commonly called the "Shuttle." These satellites, although identical in all respects, have two different names. When the satellites and earth stations are in service to the National Aeronautics and Space Administration, they are collectively known as the Tracking and Data Relay Satellite System (TDRSS). An individual satellite is called a Tracking and Data Relay Satellite (TDRS). These satellites sit at the geostationary altitude and through tracking antennas can follow low-orbit satellites collecting weather and scientific data for relay onto an earth station in the United States. They also track the Shuttle itself. This approach improves the collection of this data and makes weather and other information available on essentially a real-time basis.

An identical satellite was originally designed to be used in commercial service by the Western Union Telegraph Company. In this service, it is called the Advanced WESTAR. It has become apparent that this part of the satellite will not be used for commercial purposes within the United States. The Advanced WESTAR uses two frequency bands. The lower band (6 GHz up, 4 GHz down or "C-band") does not reuse the frequencies by dual polarization unlike all other domestic U.S. satellites currently being manufactured and launched. Dual polarization is needed in the crowded North American orbit arc but not in the Pacific void. The higher commercial frequency (14.0 - 14.5 GHz up and 11.7 - 12.2 GHz down or "Ku-band") on TDRS/Advanced WESTAR contains huge blocks of spectrum that cannot be used cost effectively. This is due to the channelization plan of 225 MHz in each transponder which cannot be easily subdivided. The higher frequency is attenuated by the torrential rainfall in the Pacific. The earth station costs are higher, and the technology is more difficult at this frequency.

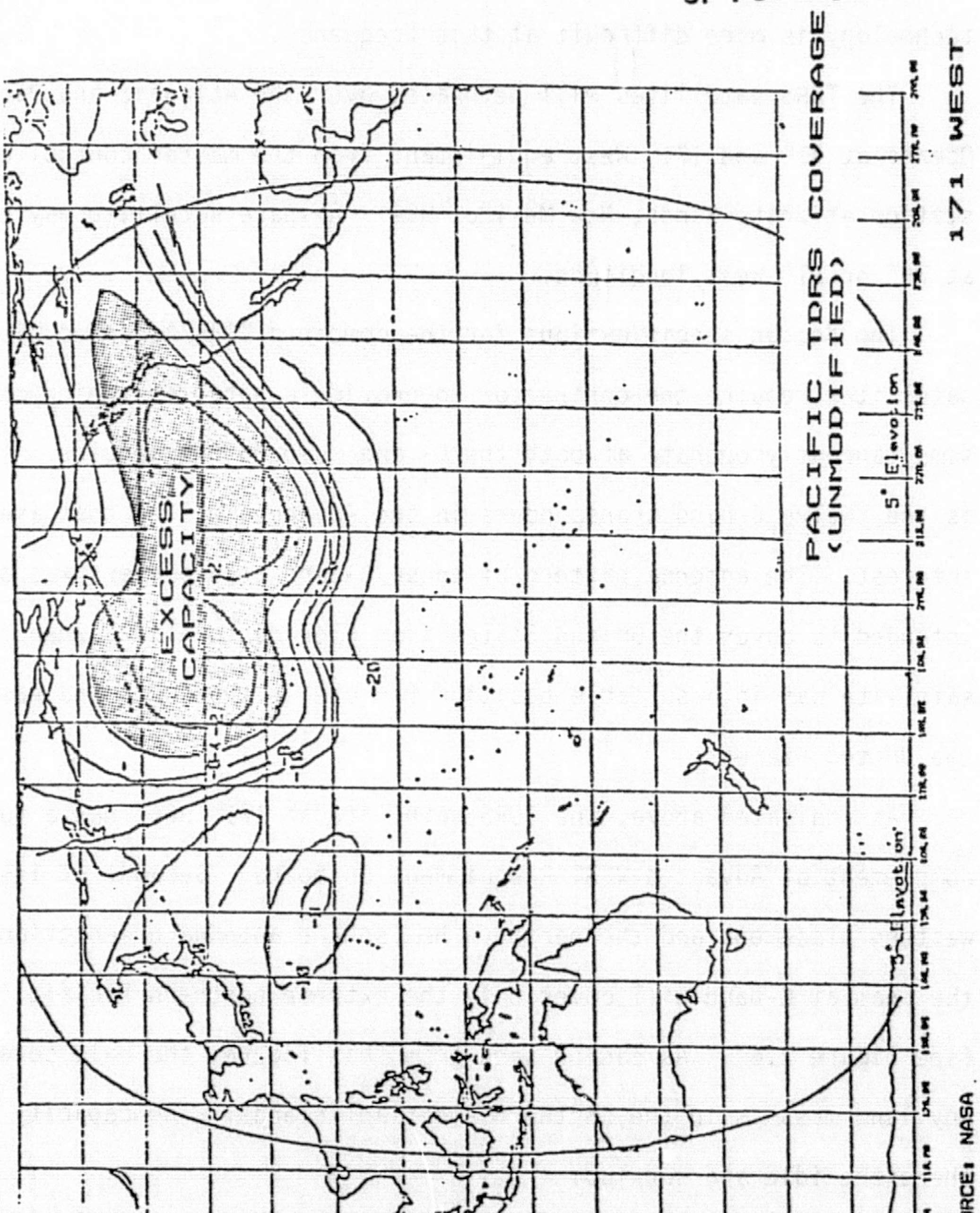
The TDRS satellites will be placed over the Atlantic and Pacific Oceans at 41° and 171° West equidistant from the master control earth station at White Sands, New Mexico, USA. A spare satellite may be placed at 79° or 91° West longitude.

The design specifications for the combined TDRS/Advanced WESTAR satellites require the contractor to provide a satellite which can simultaneously operate at both the C- and Ku-band frequencies. It is the twelve C-band transponders in the Advanced WESTAR that are of interest. The antenna pattern of these C-band transponders was originally intended to cover the United States from Florida to Alaska when the satellite was in a suitable position for use in the south and east of the United States.

As indicated above, the TDRS satellite at 171° West has a full complement of Advanced WESTAR equipment on board. Because of its western placement and the northern hemisphere antenna orientation, the beam at C-band will cover only the extreme northern Pacific (see Figure 2.4). As can be seen from this figure, the only coverage of any land mass is in the northern Aleutian Islands. The capacity is therefore idle and surplus.

It has been proposed that this beam could be tipped southward to cover many of the Pacific island nations. Figure 2.5 shows the potential coverage of one such re-orientation.

FIGURE 2.4


PACIFIC TDRS COVERAGE
(UNMODIFIED)
171 WEST
EXCESS CAPACITY
5° Elevation
SOURCE: NASA

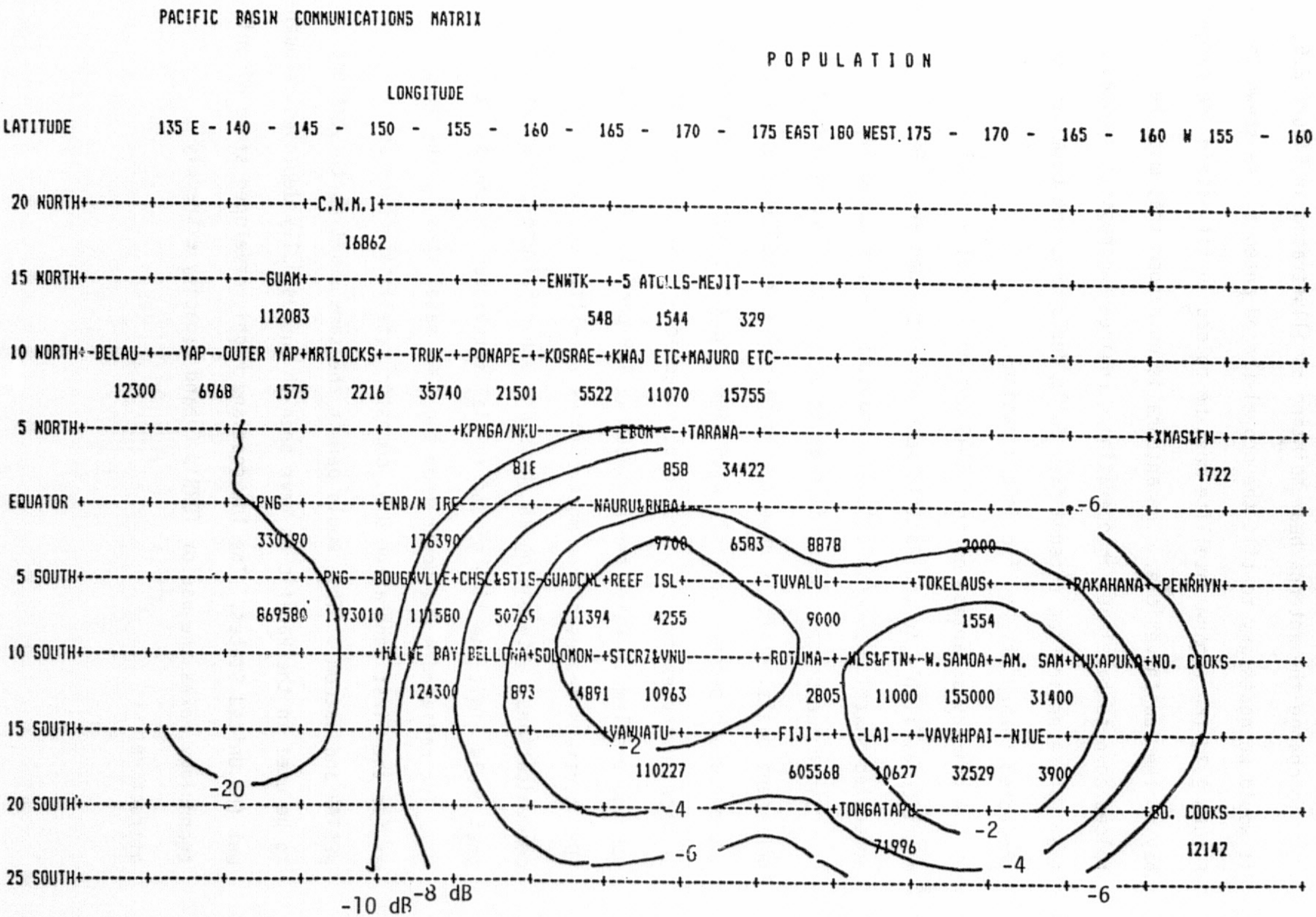


FIGURE 2.5: PACIFIC TDRS COVERAGE (MODIFIED)

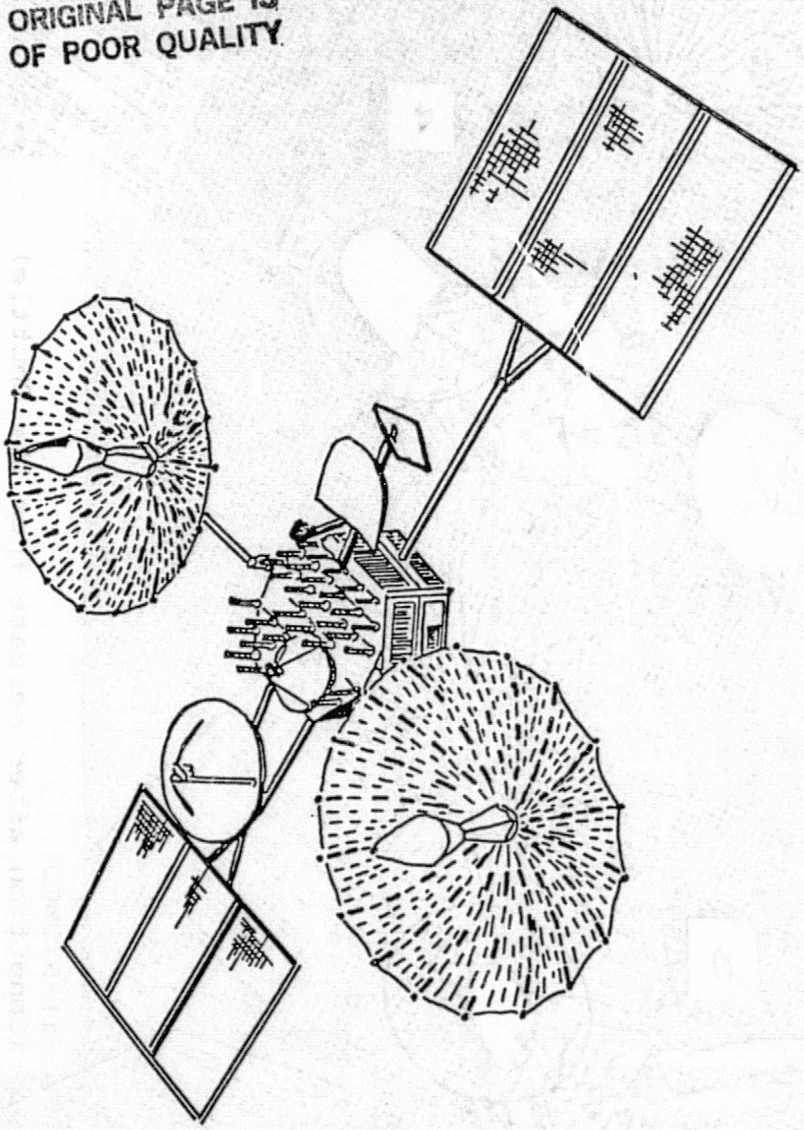
To change the antenna beam pointing as illustrated in Figure 2.6, it would be necessary to tilt the shovel-shaped antenna. As shown in Figure 2.7, the entire satellite must be folded to fit within the cargo bay of the launch vehicle. The antenna is on a boom that must be folded down to be placed in operation. Engineering reports indicate that by preventing the antenna from fully deploying, the beam can be projected toward the Pacific island nations.

A primary advantage of this TDRS option is that a satellite might be available to the Pacific soon after the January, 1983, scheduled Shuttle launch; Table 2.1 shows the launch schedule.

Since the United States intends to occupy this location on a permanent basis, there is hope that replacement satellites and spare systems would become available with time. No guarantee of continuous service in the early years should be expected because of the potential spacing problems. While the Advanced WESTAR part is very simple, the TDRS portions represent the most complex satellite yet built for communications, with moving antennas and other failure-prone components that could limit the life of the initial satellites in the series.

The radiated 4 GHz power from the TDRS satellites is the same as for the first generation U.S. domestic satellites (such as WESTAR and Satcom). This would permit the same small earth stations to be used in the Pacific as have been so successfully deployed throughout the United States. The low-cost and highly developed state of this technology makes the use of TDRS's C-band capacity extremely attractive.

FIGURE 2.6: TDRS ANTENNA BEAM POINTING



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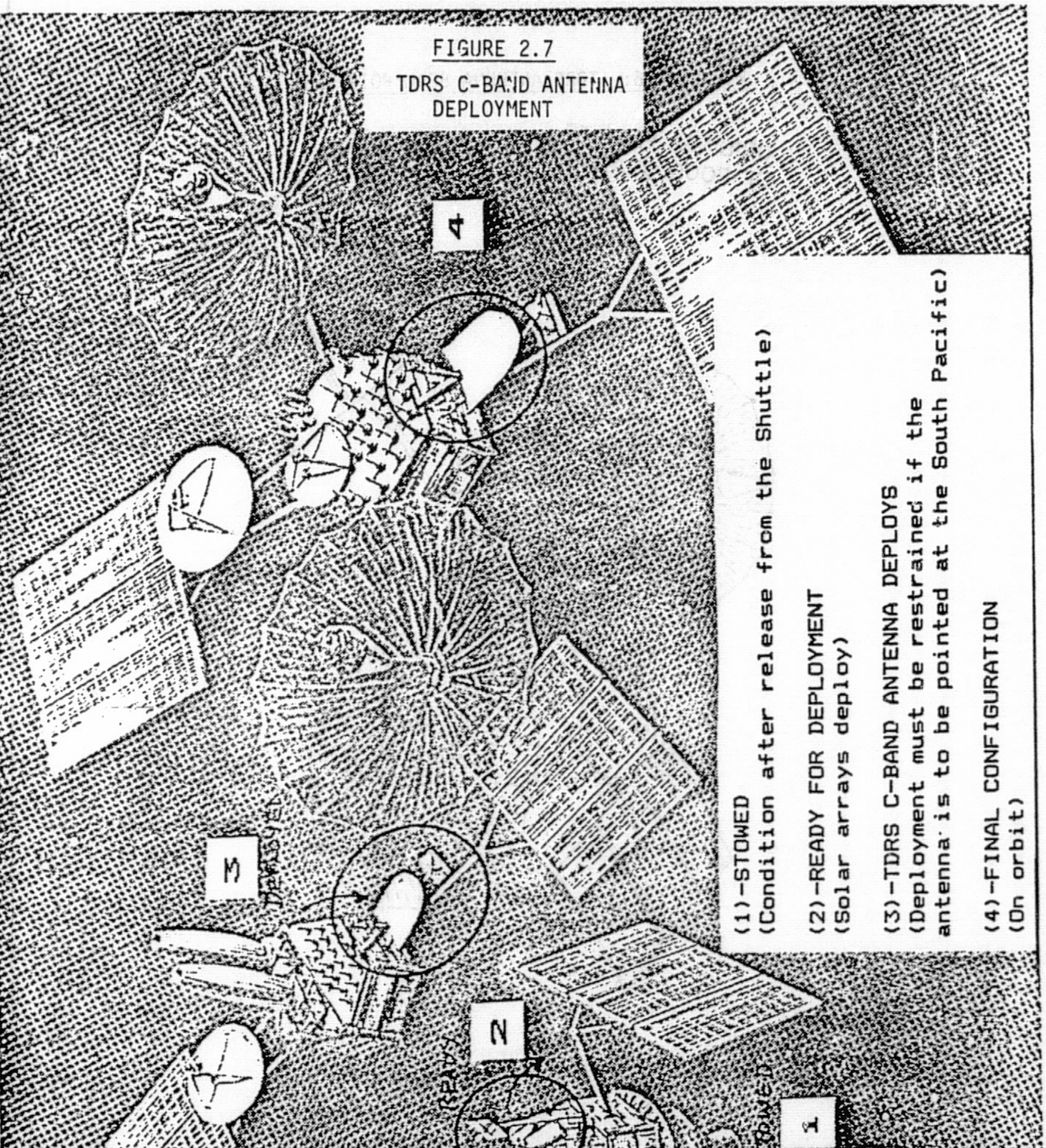


FIGURE 2.7

TDRS C-BAND ANTENNA DEPLOYMENT

TABLE 2.1

TDRS LAUNCHES

TDRS-A	STS-6	Jan. 20, 1983
TDRS-B	STS-8	July 4, 1983
TDRS-C	STS-12	March 18, 1984
TDRS-D	STS-15	June 12, 1984

Source of Data: "STS Flight Assignment Baseline," July 1982, NASA, Houston, Texas. (JSC-13000-7)

One of the disadvantages is that the orbit location is very near a proposed Soviet satellite (Statstionar-10). The fequency bands of these two satellites slightly overlap. To avoid interference, it may be necessary to give up between 72 MHz and 100 MHz of spectrum. This still leaves at least 400 MHz available for Pacific island service, a quantity estimated by Pacific telecommunications experts to be more than satisfactory for some time to come. Additional information on the TDRS option is contained in Section 2.3.

2.1.7 Japanese Satellites

At the Pacific Telecommunications Conference (PTC '82) in Honolulu, the Japanese government announced that the Research Institute for Telecommunications and Economics intended to undertake a study of Pacific islands telecommunications requirements. A 1987 satellite launch date appeared in the distributed timeline, yet no official contact with SPEC or governments was reported as of this writing (8/82). In a paper discussed at a Manila telecommunications workshop in June, 1982, Dr. Koji Imakita, executive vice president of Mitsubishi Electric, proposed a Japanese satellite for use in the Pacific. Imakita's paper turned quickly to generalizations about "Pacific requirements" with no indication of specific target countries, whether on the Asian rim or in the Pacific Basin. As there is no present commitment to this satellite, and assuming a three to five year development time, it does not appear that a Japanese satellite would be a particularly viable solution to the Pacific island nations' problems, despite Japan's continuing search for a sphere of influence, especially in the third world.

2.2 Additional Solutions: Two Viable Options

In the conceptualization of the second year's study, INTELSAT and INMARSAT received primary emphasis because they remain the only viable satellite options presently available for extending Pacific islands' commercial telecommunications service. The benefits and the regulatory constraints involved in using both INTELSAT and INMARSAT are more fully described in Sections 4 and 5 on the economic aspects of improved communications in the Pacific.

2.2.1 INTELSAT

The coverage patterns of the International Telecommunications Satellite Organization's (INTELSAT) Pacific satellites are shown in Figure 2.8. The void in the central Pacific is the result of a very deliberate engineering choice. Figure 2.9 shows the coverage for the same satellite in the Atlantic Ocean region. In the Atlantic, the traffic demands are so high that the frequencies must be reused on both sides of the Atlantic. Zone beams cover South America and Africa. In the mid-Atlantic, interference is received from both these zone beams. It is impractical to provide service into the mid-Atlantic except through the global beam. Fortunately, there are no mid-Atlantic islands. An identical satellite with the same beam patterns is used in the Pacific. Unfortunately, there are hundreds of inhabited islands between the two southern zone beams.

Since the global beam's power from an INTELSAT satellite is substantially lower (at least 10 to 20 times), larger, more expensive earth stations are required. Typical earth stations in the Pacific have antennas of 11 to 20 meters and cost at least $1,700,000 (i.e., the

FIGURE 2.8: INTELSAT V COVERAGE PATTERN

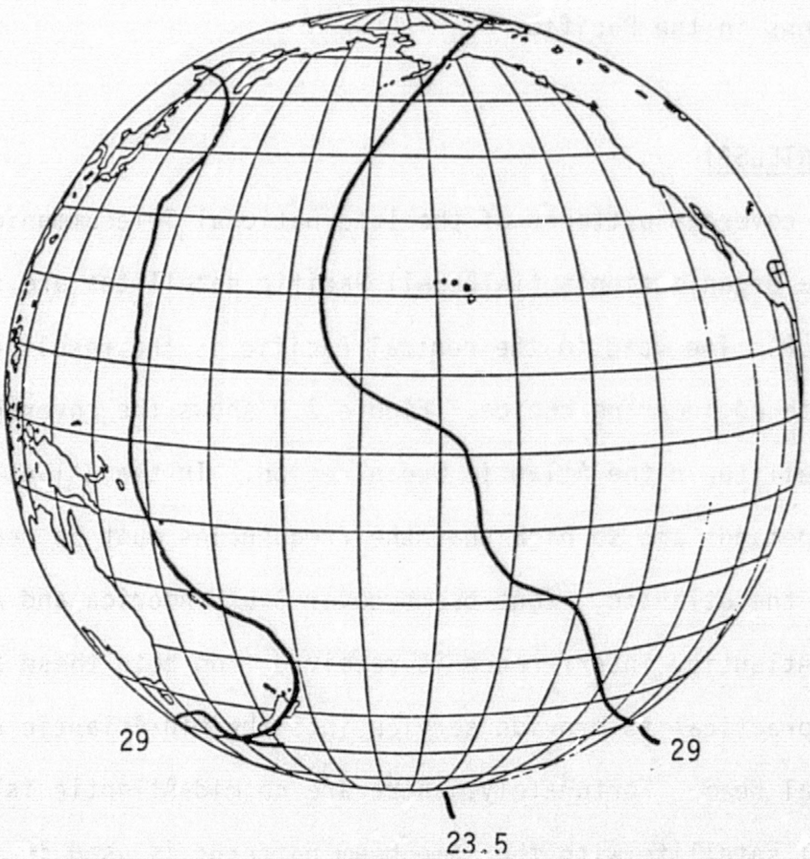
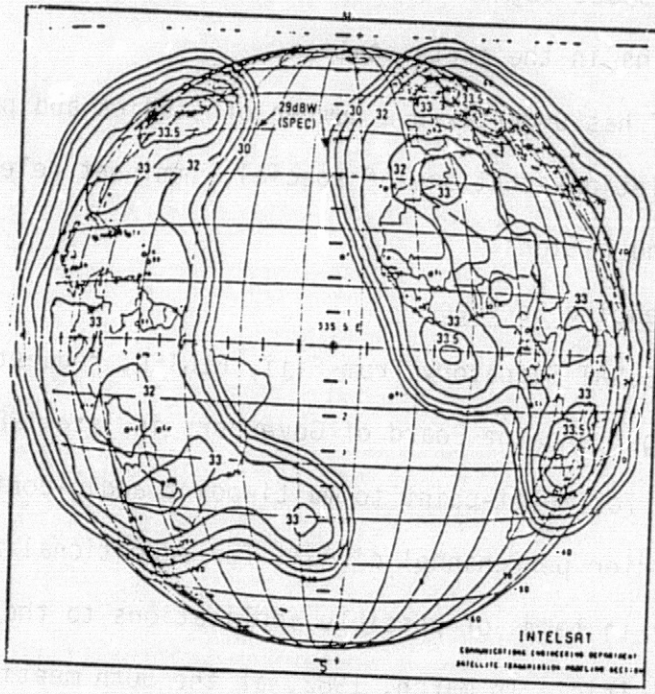


FIGURE 2.9



TYPICAL INTELSAT V BEAM COVERAGES
OF THE ATLANTIC OCEAN REGION

COMSAT earth station under construction in Palau).

As will be shown later in the Pacific island grid also used in Section 3, INTELSAT has earth stations on islands with populations of 100,000 and more except where special considerations are involved.

INTELSAT has just recently instituted a new reduced rate structure for the space segment (see Section 5), but a major unchanged cost element remains in the earth station.

INTELSAT has undertaken a number of studies and projects--some nearing completion--that are of special, imminent relevance to the Pacific island nations.

Audio-Conferencing Service

The INTELSAT Signatory from Fiji, FINTEL, requested the INTELSAT Executive Organ and the Board of Governors in late 1981 to establish a new tariff for multi-point to multi-point audio-conferencing over a single carrier per channel circuit for educational applications, particularly in terms of possible applications to the University of the South Pacific. In March, 1982, at the 50th meeting of the INTELSAT Board of Governors, this new tariff was approved. FINTEL is currently coordinating (for other Pacific INTELSAT users) the introduction of this audio-conferencing service in the South Pacific which most likely will be used only after the cessation of a reliable signal, and, therefore, reasonable service, from the weakening ATS-1.

Development of Lower Cost Earth Stations to Work with the INTELSAT Space Segment

For years, INTELSAT has operated a global satellite system that carries two-thirds of the world's overseas traffic primarily on high density routes between and among large countries. These requirements plus global television distribution resulted in the definition of a satellite system of relatively low power and broad geographical coverage that works to high gain earth stations of considerable complexity and cost. Over time, INTELSAT has expressed interest in accommodating user needs for thin route traffic and remote communities in both domestic and regional applications. For international service, Standard A stations of 30 meters with a cost of $4 to $10 million were supplemented by 11 meter Standard B stations of a cost of $1 to $3 million. Even more recently, a Standard D earth station for domestic service designed to operate with higher powered 72 MHz transponders with downlink power of 29 to 30 dBW has been proposed. As of August, 1982, however, there is no INTELSAT satellite with that power and bandwidth in orbit or authorized to provide this service on a single hop basis to the Pacific islands, although double hop solutions are under consideration. It is anticipated that this three to eight meter type of domestic terminal with a cost ranging from $75,000 to $300,000 will likely be approved by INTELSAT by the end of 1982. These Standard D stations, however, operate in concert with Standard B earth stations.

According to Marcel Perras, the business manager of INTELSAT, there are plans to introduce a service into the Pacific which would permit small (3-4.5m) earth stations to be located on the outlying islands, provided there is a large earth station (7-13m) at some nodal location. For a small station to speak to a small station, the signal must travel through the satellite to the nodal station and then back up through the satellite a second time before it reaches the second small station. This double hopping requires additional satellite capacity and, of course, the use of the expensive nodal station which may be in the INTELSAT Standard B range.

According to Perras, INTELSAT estimates the need for fewer than 100 of these small stations in the early years and fewer than 20 of the INTELSAT Standard B-type earth stations in the same time period.

The INTELSAT study is continuing, and Perras indicated that it is hoped that if the Board of Governors accepts the results, service could eventually be introduced in coordination with the island nations.

The new audio-conference tariff initiated for the Pacific certainly provides a positive sign of INTELSAT's growing interest in meeting the needs of the Pacific islands.

2.2.2 INMARSAT

The International Maritime Satellite Organization (INMARSAT) also has satellites in the Pacific. At present this is the Pacific Marisat but will soon be replaced by an INTELSAT-V carrying a maritime communications subsystem (MCS) on board. INMARSAT services operate at 1.6/1.5 GHz and are intended for use only with ships and oil rigs. It appears that INMARSAT may be willing to consider stations on aircraft and perhaps even on islands, which might be envisioned, as one consultant suggested, "as permanently anchored ships."

A particular advantage here is that the earth station is relatively simple, with a 1.4 meter antenna, and with a much lower cost than INTELSAT (approximately $40,000 to $80,000).

The economics of the per-minute charges are discussed in Section 5, which provides further information on INMARSAT.

2.3 Tracking and Data Relay Satellite System (TDRSS) Option Emerges

As mentioned in Section 2.1.6, the potential to gain access to a new satellite arose during the course of this investigation. Late in 1981, PSSC learned of the possiblity that otherwise unused C-band capacity on the 171° W satellite of the TDRSS to be used primarily to monitor the shuttle and lower orbiting satellites such as LANDSAT could be utilized in the Pacific. PSSC recognized TDRSS as an option for the Pacific and prompted the dialogue which has begun between NASA and the Pacific nations.

In its briefing papers for preparation for UNISPACE '82--the second United Nations Conference on the Exploration and Peaceful Uses of Outerspace--the Office of Technology Assessment of the United States Congress (OTA) asserted that "the United States has a major opportunity to improve its relations in the developing countries by assisting in upgrading their communications service and thereby enhancing their prospects of economic growth by creative use of the Tracking and Data Relay Satellite System" [UNISPACE '82--A Background Report, July 14, 1982, p. 64]. OTA said the TDRS "initiative would cost relatively little but would demonstrate United States commitment to the welfare of the developing world" (ibid.). The issue was not formally introduced at UNISPACE '82.

Technically and financially, TDRS/West is a far better prospect for improving Pacific islands communications than other available options discussed in this report. A major constraint, however, lies in the uncertainty of its availability and the, as yet, unresolved issue of control of the C-band capacity. The National Aeronautics and Space Administration (NASA) and the private company responsible for the TDRS project, SPACECOM, must resolve this internal issue before any further negotiations are undertaken. During the summer of 1982, the question of whether or not the Pacific island nations would be invited by the U.S. government to use TDRS's excess C-band capacity for commercial purposes was at issue at both UNISPACE '82 and at the South Pacific Forum, the annual meeting of prime ministers from the eleven independent Pacific island nations, Australia and New Zealand. The United States delegation to UNISPACE '82 did not commit itself to including the TDRS option as an initiative for the United States to undertake. At the Forum meeting in Rotorua, New Zealand, August 9 and 10, 1982, a communique was issued regarding the use of TDRS in the Pacific. "The Forum (the 13 prime ministers) agreed to express to the United States Government its interest in acquiring access to a planned satellite communication system which could be launched in 1983." The Forum instructed the South Pacific Bureau for Economic Cooperation (SPEC), its secretariat, to indicate to the United States Government (Department of State and NASA) that telexed messages from SPEC should be viewed as an official expression of the prime ministers' interest in assuring that they see TDRS as a highly suitable means of meeting the urgent telecommunications needs of South Pacific countries. Such messages expressing SPEC's interest in further discussions on the possibility of modifying TDRS to meet Pacific needs have been sent to U.S. government officials. The Pacific islands leadership is definitely interested in securing use of what has been termed "otherwise unutilized space capacity" for the Pacific island nations.

2.3.1 A Guide to the Application of the TDRS C-Band Capacity in the Pacific

As described in Section 2.1.6, the westernmost Tracking and Data Relay Satellite (TDRS) is destined for 171° W longitude over the Pacific. It carries twelve transponders for use at C-band (3.700 - 4.200 and 5.925 - 6.425 GHz). The spacecrafts have been designed for simultaneous operation at both Ku-band and C-band frequencies.

Figure 2.10 shows the coverage of the Pacific afforded by this satellite with a modified C-band antenna. The particular subregion of the Pacific region that would be covered by TDRS/West extends from the Cook Islands on the east through to the Solomons on the west. Figure 2.11 shows the complimentary services provided by INTELSAT and PALAPA satellites.

Based on extensive discussions with the heads of state and the local telecommunications authorities in these island nations, several areas have been excluded from the proposed TDRS beam. These include French Polynesia and New Caledonia whose telecommunications requirements are currently being met by France, the Federated States of Micronesia where COMSAT is installing earth stations to work to INTELSAT and the Commonwealth of the Northern Marianas, already served by INTELSAT.

The TDRS C-band offers substantially higher radiated power than the global INTELSAT service. Because of the location of the INTELSAT satellite (nearly overhead for this particular set of islands), it is not possible to use the hemi or zone beams, which cover only the extreme rim nations (such as Australia, Japan, the United States and Canada). Discussions with INTELSAT on the possibility of relocating to the east and west one of the nearly retired INTELSAT satellites so the zone beams could cover the Pacific island nations have led to the conclusion that such a scheme is impractical.

2.4 High Frequency Radio: Advantages and Disadvantages

Any discussion of satellite options must include a reference to single side-band radio. Single side-band high frequency (HF) radio is at present a widely accepted means of communications in the Pacific.

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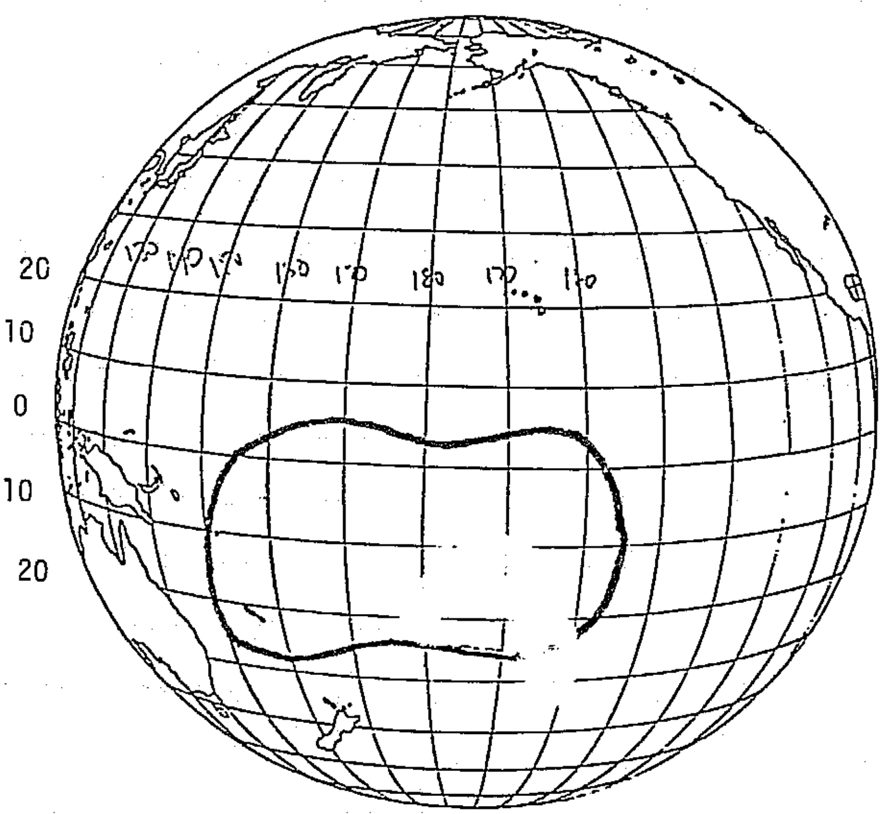
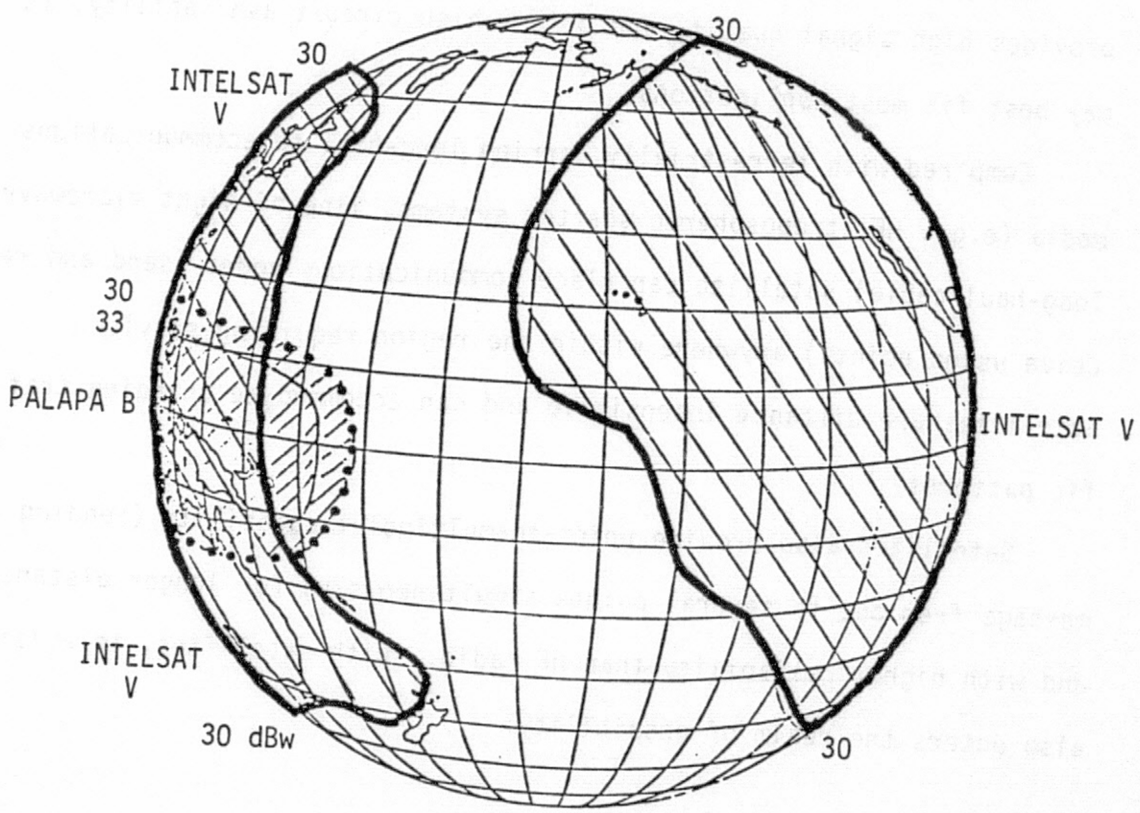
FIGURE 2.10



TDRS COVERAGE AT 6/4 GHz

FIGURE 2.11



6/4 GHz COVERAGE PROVIDED BY
INTELSAT V & PALAPA B

Its use requires minimal service and operator training. Fading, interference and the need for frequency hopping to maintain contact limit the effectiveness of HF use.

2.4.1 Satellites' Ascendency

Satellite technology has overshadowed HF because it is flexible, provides high signal quality and offers high circuit availability; it may best fit most applications.

Compared with terrestrially carried long-haul telecommunications media (e.g., HF, tropospheric scatter systems, line-of-sight microwave, long-haul cable) satellite can place communications nodes (send and receive usage points) anywhere within the region requiring service. Satellites are distance insensitive and can accommodate changing traffic patterns.

Satellites also provide point-to-multipoint capability (sending a message from one to several points simultaneously) for longer distances and with higher reliability than HF radio. With satellites, television also enters the realm of possibility.

2.4.2 The Potential for Complementarity

Cost ultimately weighs heavily in an HF/satellite comparison. Because HF is widely used--though not necessarily reliable--and is available in the Pacific, it is prudent to discuss the merits of this option and to examine general costs of using HF radio for long-haul communications by detailing two specific scenarios where HF is compared to satellite use. Facts and figures used here were provided to PSSC engineers by the ITU project staff in Suva, Fiji (see Section 2.4.5).

There is little dispute that HF radio and satellite use complement one another when applied in appropriate environments; although satellite technology has eclipsed HF radio, the HF industry continues to provide valuable, needed services to underserved regions.

2.4.3 Nature of HF Propagation

High frequency (HF) radio has been used for decades for both local and long distance telecommunications. Using the ITU definition, HF radio consists of that part of the spectrum between 3 and 30 MHz. This region (also known as short wave) depends on the ionosphere to reflect the signals radiated by relatively simple antennas. The strength of the received HF signal depends on many factors including the time of day, the height of the ionosphere and the distance from the transmitter. Directional antennas may be employed to increase the signal strength and its direction. Because the short wave frequencies are so widely used and because the ionosphere is often unpredictable, substantial fading and co-channel interference takes place. HF radio links have been used for many years for communications. Most advanced nations do not depend on the HF radios for domestic services. They have replaced these links with microwave, cable and satellite distribution methods. However, there are many regions of the world where these technologies may not be applicable and, therefore, HF radio is still widely used.

HF radio is used for long distance voice, facsimile (especially weather) and radio teletype services. It is also widely used by ships.

HF is widely accepted in the Pacific at this time and can require a rather minimal amount of service and operator training. The operator must have the ability, however, to cope with the fading and the interference. In some cases, this may require frequency hopping to maintain contact, especially if circuit availability demands are high.

Optimum use of the radio frequency spectrum for full-duplex telephony (voice, analog) is usually by means of single side-band transmission. The modulation process may be envisioned as a direct translation of the frequencies to radio frequencies for efficient transmission. Several voice-frequency (VF) channels can be accommodated simultaneously by one transmitter or receiver, the pair being called a transceiver. A system carrying more than one VF generally uses independent side-band (ISB) modulation.

Typical systems operate with transmitter powers of 100 watts to 10 kilowatts and can carry up to four VF channels simultaneously using independent side-band transmission. One or more of the VF channels can be subdivided for low-speed telegraph channels using voice frequency telegraph (VFTG) equipment.

It is not possible to transmit wideband signals such as high-speed data (above 300 baud), program-grade audio (15 KHz) or real-time video over such a system owing to both the bandwidth restrictions imposed by controlling spectrum management authorities and to the deleterious effects of frequency selective fading on non-voice signals. Voice signals are usually not adversely effected since the human ear is especially forgiving to frequency selective impairments. Conventional bandwidth compression techniques (slow scan and facsimile) may provide some form of visual communications over a VF channel similar to methods currently used in the United States and other nations. But one should not count on resounding success transmitting visual images over HF radio.

2.4.4 Recent HF Radio Developments

The HF spectrum, while considered by many to be an unmanageable, dead technology, seems to be coming under the reins of research and microprocessor control to a new level of reliability.

Certain propagation conditions may render one radio frequency useless, while another frequency which is only slightly different may provide clean, solid communications. This has been a "headache" in HF radio. To allow operators to make rapid frequency changes to a more reliable frequency at any given time, many companies dealing in HF equipment have developed aids for operators.

The so-called "chirp sounder" developed by Barry Research about six years ago is an assistance to well-qualified operators but requires operator interpretation and intervention to select the best frequency. It is also costly, informally priced at $100,000.

A fully automatic system has been quite recently developed and marketed by the Collins Radio Group in Cedar Rapids, Iowa. Under microprocessor control, an interactive, machine-intelligent scanning of the authorized frequencies takes place between radio terminals. Communication circuit reliability can be dramatically improved without operator intervention given that several radio frequencies are available spanning the HF band and that design factors are built into the system allowing such frequency-hopping.

The Collins HF80 series with scanning allows co-location of transmitter and receiver at any given terminal although optimum reliability occurs with spatial separation.

The U.S. National Bureau of Standards has been pivotal in the development and updating of ionospheric modeling for propagation prediction. A computer program called IONCAP was released in March of 1978 with several important revisions and amended models of the ionosphere, such as density profiles, improved loss equations and Sporadic-E layer characterization.

Several companies involved in HF radio utilized IONCAP or similar programs to determine system design parameters for grade-of-service and reliability commensurate with the application.

There are a number of companies involved in HF radio that were contacted by PSSC. While some of the well-known companies have deserted the market, others seem to be doing well. A tabulation of firms contacted in connection with this study and who are still in the market is given below.

1. Collins Telecomm. Products Cedar Rapids, IA 319/395-4120	HF80 series 1,3 & 10 KW Automatic Adaption Antennas AT&T supplier
2. Stoner Los Angeles, CA 714/987-4624	SSB-112A 100 Watt Not FCC-Approved No scanning Simplex-requires total Operator intervention
3. Harris Dealer, San Francisco 415/957-1300	100-W to 10 KW Uses Barry Research or other scanners--64 channel
4. Scientific Radio Rochester, NY 716/458-3733	150-W to 10 KW Selective call scanning Phone patch Already has numerous radios in Pacific Uses NBS IONCAP
5. Granger Associates Santa Clara, CA 408/727-3101	Antennas only
6. Technology for Communications Int'l Mountain View, CA 415/961-9180	Antennas only Uses IONCAP and similar prediction programs
7. U.S. National Bureau of Standards ITS-Boulder, CO 303/497-3000	Government-based research information dissemination, creator of IONCAP

2.4.5 Specific Cost Scenarios

Appendix A describes a scenario outlined by an ITU representative with a working appreciation for telecommunications in the Pacific Basin. The examples include communications (1) between Funafuti, Tuvalu and Fiji and (2) between the Tokelau and Western Samoa.

2.4.6 HF in Transition

One cannot deny the potential utility of HF radio for many applications particularly for low-density thin-route traffic requirements. Individual applications necessitate individual solutions. But considering all applications together, satellite communications offer greater potential for general satisfaction of needs than any other transmission technology.

2.5 Communications Alternatives Summary

As indicated in Appendix A, the cost of a simple HF radio link between two islands is quite high. In a link between Tuvalu and Fiji, the cost at each end is approximately US$500,000 or about US$1 million for the combined two-way link. In comparison, satellite earth stations run between several thousand to one million dollars per station depending on the satellite used and the station capacity. Each earth station can contact any other station at any time, which is difficult for HF services.

Table 2.2 shows the trade-off between the satellite equivalent radiated power and earth station figure of merit (G/T). A higher-power satellite allows a lower G/T in each of the many earth stations.

In a system in which there are only a few hundred earth stations worldwide (such as INTELSAT), an acceptable practice is to place many low-power transponders on a large satellite. Since the earth stations are

TABLE 2.2

TDRS C-BAND EARTH STATIONS

SATELLITE EIRP (DBW)	33-35	31-33	29-31	27-29	25-27	15-25	>15	DBW
NUMBER OF EARTH STATIONS	66	104	48	51	56	666	429	QTY
EARTH STATION G/T (DBI/K)	14	16	18	20	22	27	*	DBI/K
TYPICAL ANTENNA DIA (M)	3	3	4.5	4.5	6.0	8.5	*	M
LNA (K)	150	120	150	120	150	100	*	K
COST OF EACH EARTH STATION	25	28	30	32	40	50	*	$X1000
TOTAL COST OF CLASS OF E.S.	350	2912	1440	1632	2240	33300	*	$X1000
GRAND TOTAL LESS INTELSAT								41874$X1000

* USE INTELSAT FOR THESE CASES

owned by entities other than INTELSAT, the need for huge and expensive earth stations is of less concern to INTELSAT.

Regional and domestic systems have somewhat the inverse incentive. Substantially higher satellite power permits the use of smaller and less expensive earth stations. Instead of a few hundred earth stations, these systems now contain several thousand or even tens of thousands of earth stations. The majority of the U.S. domestic earth stations are receive-only terminals. These are used for the reception of television, radio programs and teletype services. It is estimated that there are now more than 50,000 earth stations in the United States. This would not be possible if the power level were in the international range (or about 20 times lower).

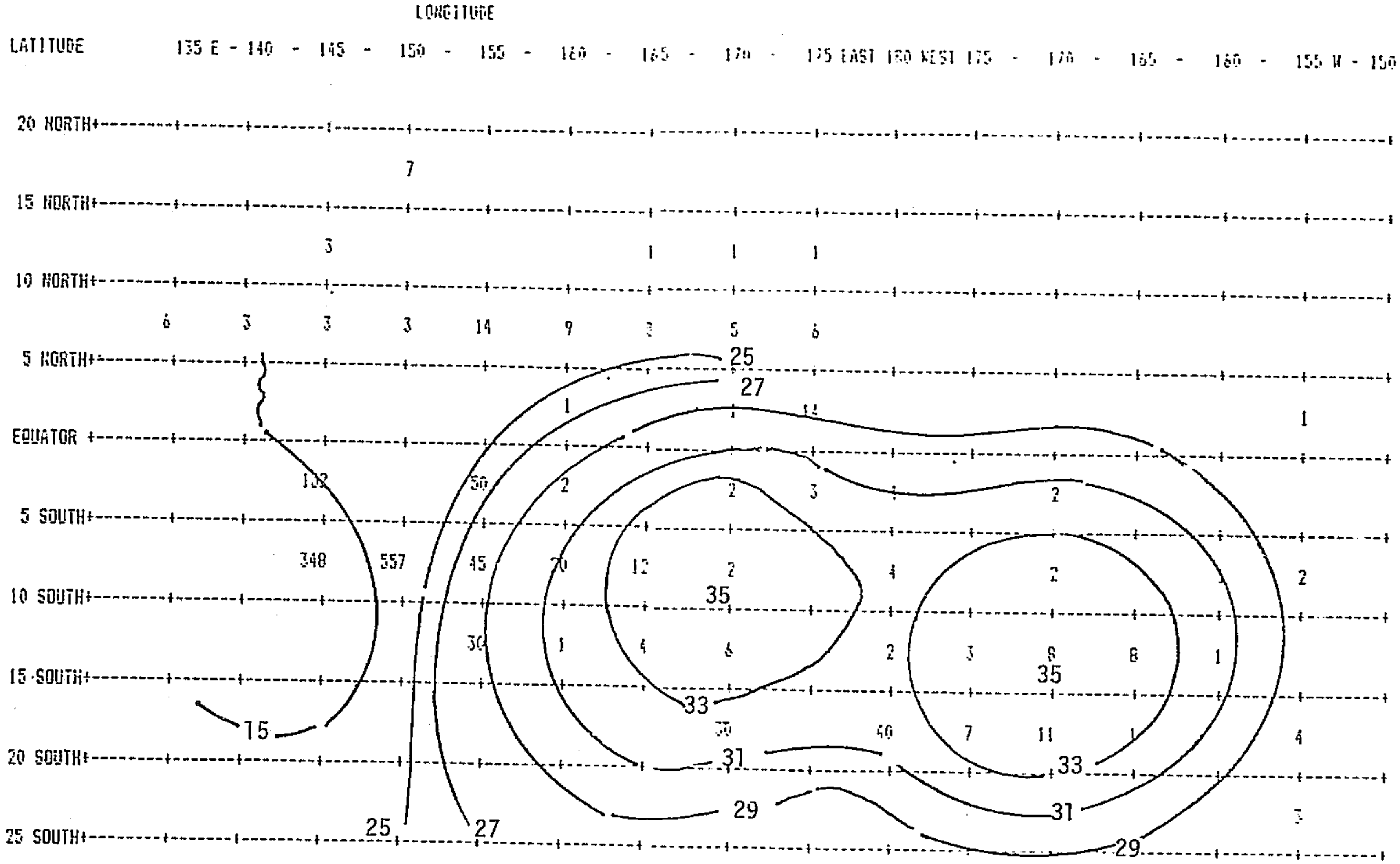
The Pacific island nations have requirements similar to domestic systems. Figure 2.12 shows the e.i.r.p. levels throughout the Pacific.

Figure 2.13 shows the figure of merit necessary to carry three voice channels into each of these areas.

Figure 2.14 shows the antenna diameter that might be used in these earth stations. Finally, Figure 2.15 provides some estimates of the cost of each of these stations.

TDRS remains attractive, but too tentative for present planning purpose. Therefore, a review of all the possible satellite options returns to INTELSAT as the most available, workable option for the immediate future.

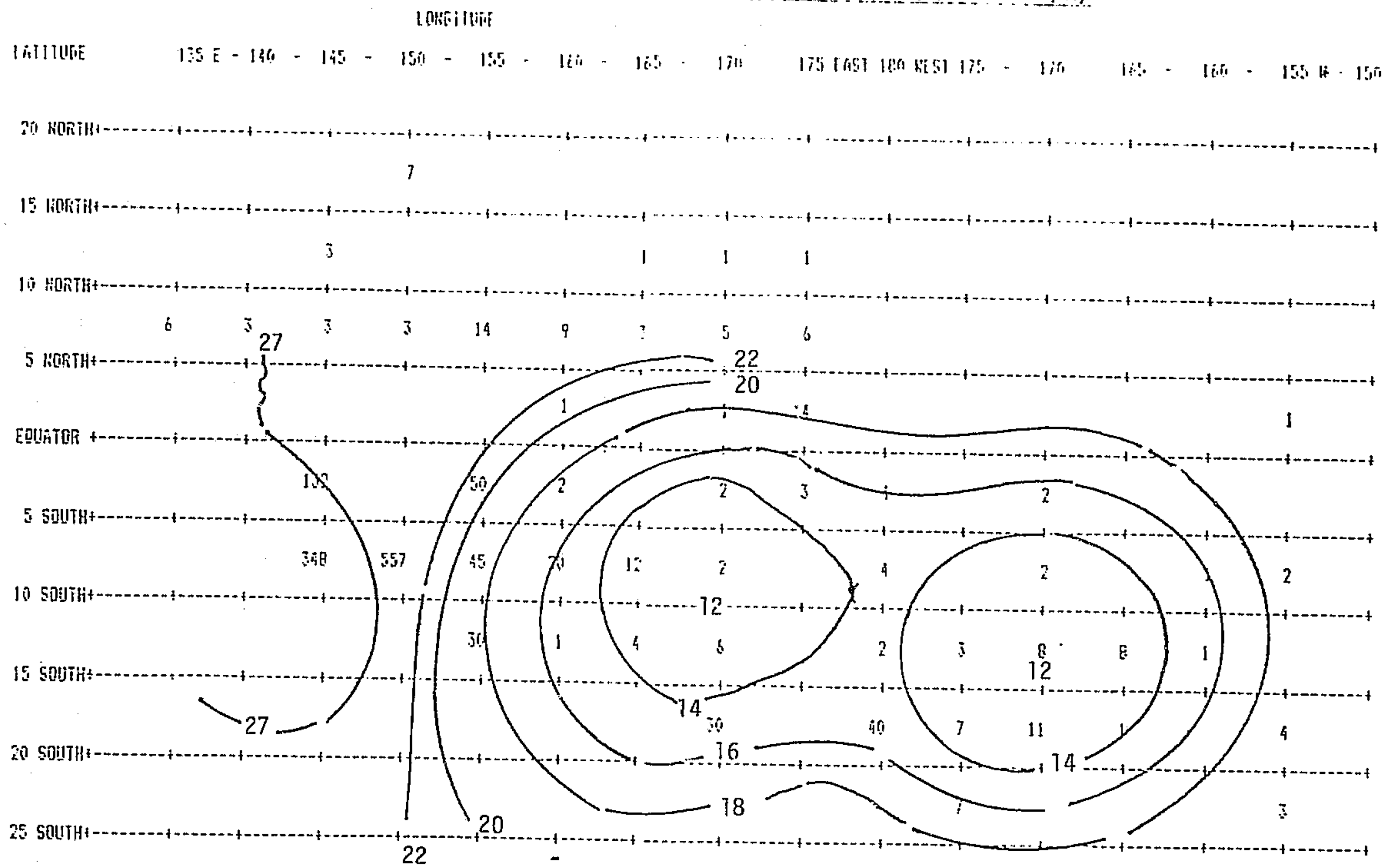
FIGURE 2.12: TDRS C-BAND RADIATED POWER (in dBW)



PACIFIC BASIN COMMUNICATIONS MATRIX

NUMBER OF EARTH STATIONS BASED ON POPULATION, ISLANDS & NATIONS

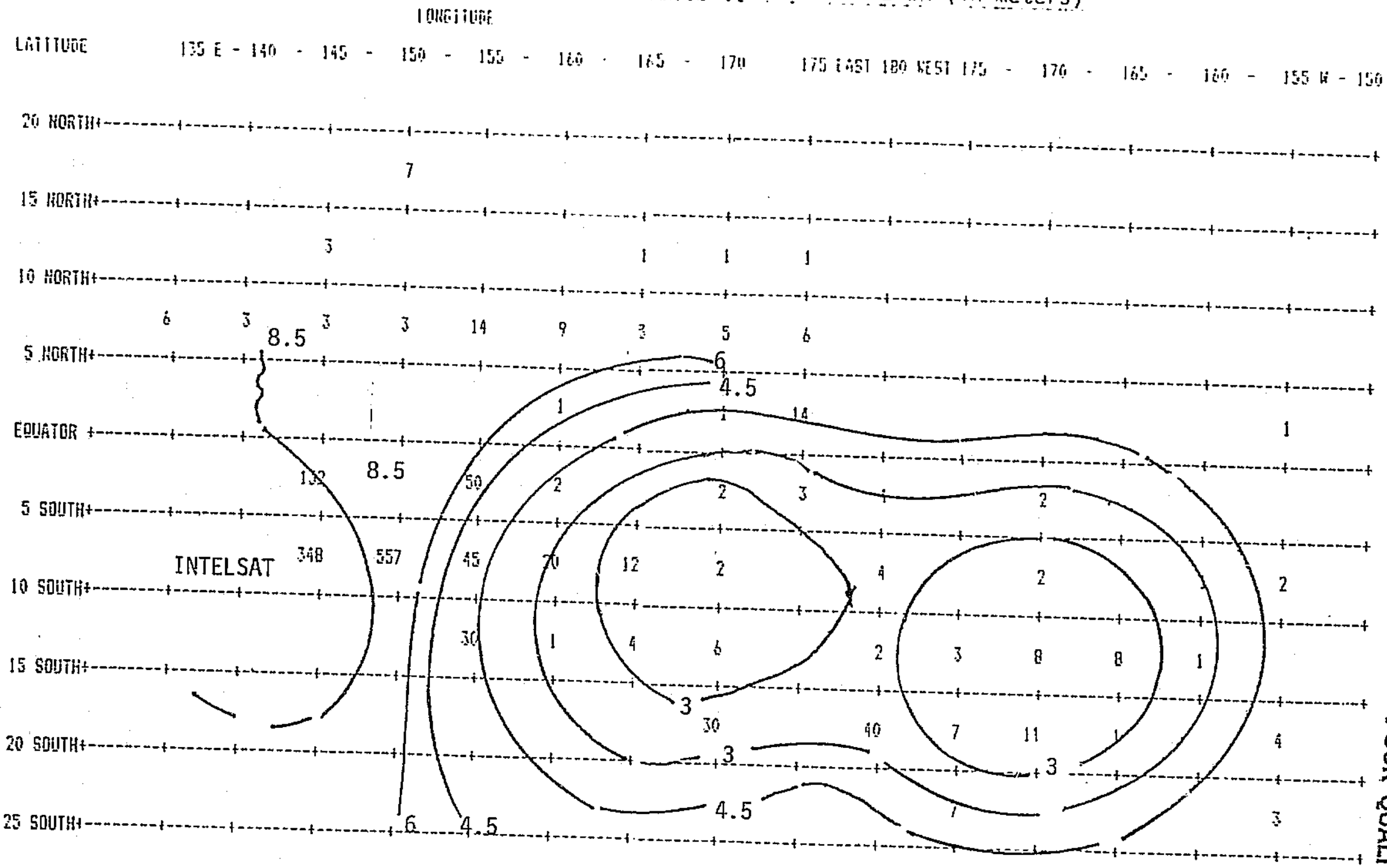
FIGURE 2.13: EARTH STATION FIGURE OF MERIT (G/T in dBi/K)



PACIFIC BASIN COMMUNICATIONS MATRIX

NUMBER OF EARTH STATIONS BASED ON POPULATION, ISLANDS & NATIONS

FIGURE 2.14: EARTH STATION ANTENNA DIAMETER (in meters)



PACIFIC BASIN COMMUNICATIONS MATRIX

NUMBER OF EARTH STATIONS BASED ON POPULATION, ISLANDS & NATIONS

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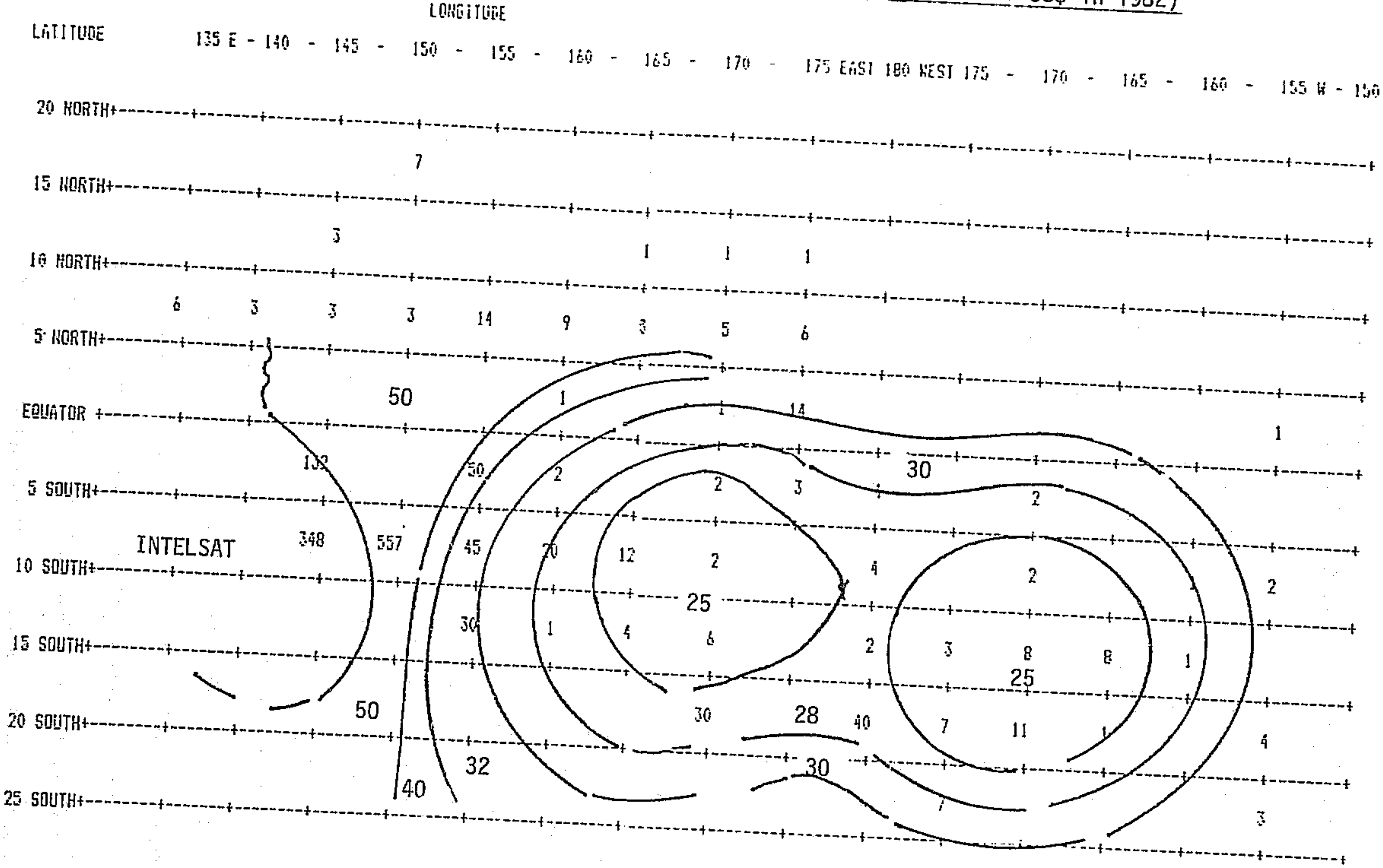
FIGURE 2.15: APPROXIMATE EARTH STATION COST (thousands of US$ in 1982)



PACIFIC BASIN COMMUNICATIONS MATRIX

NUMBER OF EARTH STATIONS BASED ON POPULATION, ISLANDS & NATIONS

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3. A PARAMETRIC STUDY OF THE NUMBER, DISTRIBUTION, SIZE AND COST OF EARTH STATIONS FOR THE PACIFIC ISLANDS

Section 3 presents the results of an exercise in macro or aggregate planning to determine the number, size, cost and distribution of earth stations for the Pacific islands. A computer model based on actual population distribution was prepared to project the number of earth stations and their likely locations within the Pacific region.

Besides population, numbers of islands in a given area and the relative capability of each area to support an earth station were also considered. As the purpose of this exercise was to determine the number of earth stations required to meet Pacific islands needs, jurisdictional boundaries were not viewed as constraints, nor was the fact that Standard A and B earth stations service a number of the region's capitals.

Projected numbers of earth stations for 100, 500, 1,000, 2,500, 5,000, 10,000, 50,000 and 100,000 people per earth station were determined for comparison and for future study. One earth station per 2,500 people was selected on the basis of serving the individual island districts and the population. This also coincided with the estimates utilized by economists in Sections 4 and 5. One earth station per 2,500 people would require approximately 1,400 earth stations, a number which could reasonably be manufactured, purchased, transported and assembled for island use in the near term. It is anticipated that this number of earth stations would form the backbone of the Pacific Basin telecommunications network.

To illustrate the technique for determining the size and cost of earth stations, a possible antenna pattern was overlaid on the South Pacific excluding Papua New Guinea whose needs, it is anticipated, will be met by the Australian AUSSAT. The TDRS pattern described in Section 2 was used in this example. If the earth stations that could be covered by AUSSAT were removed, 400 earth stations would remain for placement throughout the island Pacific excluding Papua New Guinea.

Section 3.3 shows the distribution of earth stations based on population, number of islands and number of nations, while Section 3.4 shows the size and cost of earth stations by re-plotting the map used in Section 3.3. A figure is also used to convert the satellite power into earth station requirements. A link budget is enumerated. Using the same grid, project engineers determined the earth stations by size and total costs.

Section 3.5 looks at the INTELSAT alternative and includes a table with a breakdown for the COMSAT earth station currently under construction for use with INTELSAT in the Republic of Palau, northwest of Papua New Guinea in the Caroline Islands.

Appendix B comprises an extensive listing of United States-based suppliers of earth stations and earth station components.

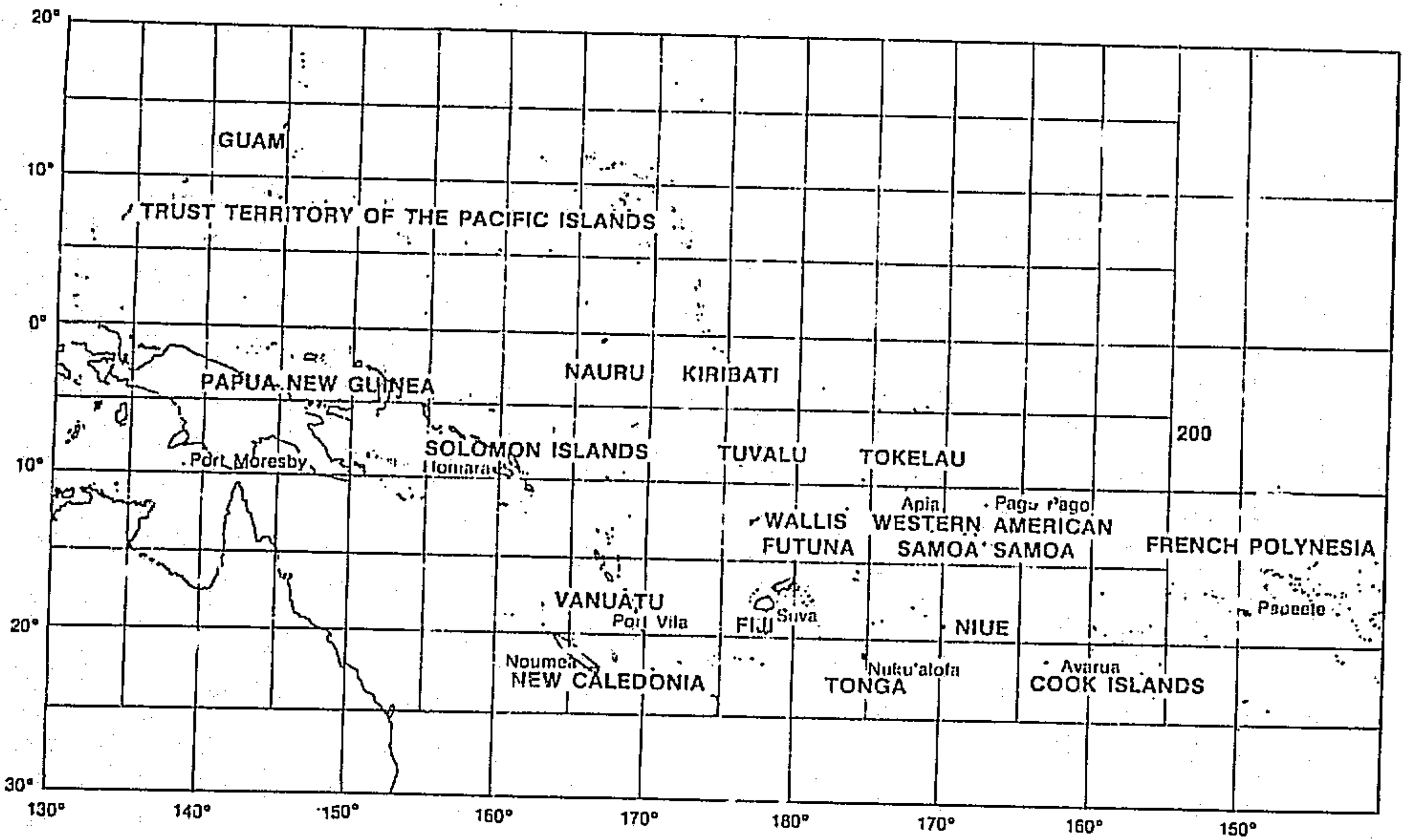
3.1 Graphic Depictions

Figure 3.1 is a map showing the Pacific island nations. This map has been converted into a computer presentation by subdividing it into over 100 individual squares of 5 degrees in longitude by 5 degrees in latitude. Each square contains about 300,000 square kilometers or 120,000 square miles. Each square is twice the size of the state of Pennsylvania. These squares will be used to help determine the number of earth stations, their potential location and the resulting total earth segment cost for various configurations of the space segment.

For the purpose of this report, the space segment is defined as (1) the satellite (or portion thereof for a shared system) providing the communications, (2) the launch vehicle costs and (3) a share of any costs associated with the maintenance of the spacecraft on station.

FIGURE 3.1

MAP I PACIFIC ISLAND NATION (5° GRID)



The earth segment consists of the (1) transmit, (2) receive[2], and (3) transmit/receive earth stations. There are several subclasses of earth stations based on the amount of traffic per station. These range from single channel through a few channels to several hundred channels in the case of a major trunk station. The earth segment also includes a network control center which manages the transponder resources and keeps track of user traffic. It also provides interconnectivity between users.

As a rule of thumb, stations with fewer than five voice channels are assumed to be self-sufficient (having teletype or telephone equipment in the station). The larger earth stations are assumed to be connected to the existing telephone network. No extra costs such as extension lines from the present exchanges to the new earth stations have been included for connection into these networks as these connections will most likely be relatively short and do not constitute a major cost increment.

3.1.1 Population Per Square

The population within each 5° by 5° square was estimated using the most current demographic information available (see Figure 3.2). In a few cases, a single nation or island falls entirely within a single square, making the process fairly easy. In most cases, however, a square contains several islands or even more than one country (see Section 3.1.3). In this case, an estimate had to be made for each island or island group and totaled. Obviously, vast expanses of the

[2]While the remainder of this section discusses only two-way earth stations, there is obvious potential for a high-powered satellite radio distribution service to small receive-only stations. These could be fed from the national center by a transmitting earth station.

FIGURE 3.2

PACIFIC BASIN COMMUNICATIONS MATRIX

POPULATION

LONGITUDE

```
LATITUDE     135 E - 140 - 145 - 150 - 155 - 160 - 165 - 170 - 175 EAST 180 WEST 175 - 170 - 165 - 160 W 155 - 160

20 NORTH+--------+---------+---------+-C.N.M.I+---------+---------+---------+---------+---------+---------+---------+---------+---------+---------+---------+---------+
                                     16862
15 NORTH+--------+---------+-----GUAM+---------+---------+---------+-ENWTK--+-5 ATOLLS-MEJIT--+---------+---------+---------+---------+---------+---------+---------+
                         112083                                     548    1544    329
10 NORTH+-BELAU-+---YAP--OUTER YAP+MRTLOCKS+---TRUK-+-PONAPE-+-KOSRAE-+KWAJ ETC+MAJURO ETC--------+---------+---------+---------+---------+---------+---------+
            12300   6968   1575    2216   35740   21501   5522   11070   15755
 5 NORTH+--------+---------+---------+---------+---------+KPNGA/NKU---------+-EBON---+TARAWA--+---------+---------+---------+---------+---------+-XMAS&FN-+---------+
                                                    818             858    34422                                                      1722
EQUATOR +--------+---------+---PNG--+---------+ENB/N IRE-NKUMNU-+--------NAURU&BNBA+---------+---------+---------+---------+---------+---------+---------+---------+
                         330190         176390    436            9700    6583    8878           2000
 5 SOUTH+--------+---------+---------+--PNG---BOUGNVLLE+CHSL&STIS-GUADCNL+REEF ISL+---------+-TUVALU-+---------+TOKELAUS+---------+RAKAHANA+-PENRHYN+---------+
                         869580 1393010  111580  50769  111394  4255          9000          1554                   269     608
10 SOUTH+--------+---------+---------+---------+MILNE BAY-BELLONA+SOLOMON-+STCRZ&VNU---------+-ROTUMA-+-WLS&FTN+-W.SAMOA+-AM. SAM+PUKAPUKA+NO. COOKS---------+
                                        124300    1893   14891   10963          2805  11000  155000  31400   1336
15 SOUTH+--------+---------+---------+---------+---------+---------+---------+VANUATU-+---------+--FIJI--+---LAU--+-VAV&HPAI--NIUE--+---------+---------+---------+
                                                               110227          605568  10627  32529   3900     51    3841
20 SOUTH+--------+---------+---------+---------+---------+---------+---------+---------+---------+---------+TONGATAPU---------+---------+---------+SO. COOKS---------+
                                                                                       71996                              11525
25 SOUTH+--------+---------+---------+---------+---------+---------+---------+---------+---------+---------+---------+---------+---------+---------+---------+---------+
```

area are either uninhabited ocean or islands devoid of any appreciable population; yet some areas have relatively densely populated communities. This map may be used to determine the number of earth stations per square if based on population per earth station.

3.1.2 Islands Per Square

Clearly, population is not the only indicator of the number of earth stations required in each square. Some countries contain only one or very few islands but have a very high population concentration. Since these areas tend to have an already developed telephone network (irrespective of quality), their urban centers could be served by one or a few earth stations of greater capacity thus lowering the total number of stations for that square.

Other squares, however, contain many islands and, therefore, might need more earth stations for the outlying islands than a pure population-per-earth-station count might otherwise reveal. The criteria used for the construction of this map was the number of islands shown on The New Pacific Map, published by the Hawaiian Geographical Society. The analysis is shown in Figure 3.3.

3.1.3 Countries Per Square

The coverage and number of earth stations may also be dictated by the number of countries in each of those 5° by 5° squares. Borders run through the surrounding waters of the countries and rarely through land masses. Because latitudinal and longitudinal lines were typically used to mark national boundaries, countries per square are clearly demarcated. Eight squares contain islands of more than one country and two contain islands belonging to three different countries (see Figure 3.4).

FIGURE 3.3

```
                PACIFIC  BASIN  COMMUNICATIONS  MATRIX                    NUMBER OF ISLANDS PER SQUARE ‡

                                     LONGITUDE

LATITUDE        135 E - 140  -  145  -  150  -  155  -  160  -  165  -  170  -  175 EAST 180 WEST 175  -  170  -  165  -  160 W 155  - 160
                          +++++++++++++++++++++++++

                                  4         1
20 NORTH+--------+---------+---------+-C.N.M.I+--------++++++++++++++++++++++++++++++++++++++--------+---------+---------+---------+---------+---------+

                                            12
15 NORTH+--------++++++++++----GUAM+---------+---------+---------+-ENWTK--+-5 ATOLLS-MEJIT--+---------+---------+---------+---------+---------+---------+

                                  1                                         7        36        3
10 NORTH++BELAU++---YAP--OUTER YAP+MRTLOCKS+---TRUK-+-PONAPE-+-KOSRAE-+KWAJ ETC+MAJURO ETC++++++++---------+---------+---------+---------+---------+---------+

                    6        9        10        17        34        12        13        71        31
 5 NORTH+++++++++---------+---------+---------+---------+KPNGA/NKU---------+-EBON---+TARAWA--+---------+---------+---------+---------+---------+XMAS&FN++++++++++++++

                                                          8                   5        16                                                        3
EQUATOR +--------++++++++++++/PNG////////////ENB/N IRE/NKUMNU/////////NAURU&BNBA+---------+---------++++++++++++++++++++++++++++++++++++++---------+---------+   +

                              23        22        21                          1         6         6                  10                          1
 5 SOUTH+--------+---------++-/+/+/+/--PNG---BOUGNVLLE/CHSL&STIS/GUADCNL/REEF ISL+---------+-TUVALU-+---------+TOKELAUS+---------+RAKAHANA+-PENRHYN+---------+   +

                              14        4         44        51        12        5                   16                  11              1         7         1
10 SOUTH+--------+---------+---------+---------+MILNE BAY-BELLONA+SOLOMON-+STCRZ&VNU---------+-ROTUMA-+-WLS&FTN+-W.SAMOA+-AM. SAM+PUKAPUKA+NO. COOKS++++++++++++

                                        1         19        1         4         24        1         3         3         4         8         4
15 SOUTH+--------+---------+---------+/+/+/+/+/+/+/+/++++++++++++++++++VANUATU++---------+--FIJI--+---LAU--+-VAV&HPAI--NIUE--+---------+---------+---------+

                                                                                42        1         28        28        11        1         1         6
20 SOUTH+--------+---------+---------+---------+---------+---------+---------+---------++++++++++++++++++TONGATAPU---------+---------+---------+SO. COOKS---------+

                                                                                                    7         8                             3
25 SOUTH+--------+---------+---------+---------+---------+---------+---------+---------+---------++++++++++++++++++++++++++++++++++++++++++++++++++---------+

‡ = SOURCE MAP:"THE NEW PACIFIC"-THIRD EDITION, HAWAII GEOGRAPHICAL SOCIETY (1980)     TOTAL NUMBER OF ISLANDS IN AREA OF INTEREST INCL PNG:    763
++++ = AREA OF INTEREST    //// = PNG
                                                                                                                                  EXCL PNG:    629
```

FIGURE 3.4

PACIFIC BASIN COMMUNICATIONS MATRIX

NUMBER OF NATIONS PER SQUARE

LONGITUDE

LATITUDE 130 E - 135 - 140 - 145 - 150 - 155 - 160 - 165 - 170 - 175 EAST 180 WEST 175 - 170 - 165 - 160 - 155 W - 150

20 NORTH	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
15 NORTH	0	0	1	1	0	0	1	1	1	0	0	0	0	0	0	0
10 NORTH	1	1	1	1	1	1	2	1	1	0	0	0	0	1	0	0
5 NORTH	1	0	0	0	0	1	0	0	1	0	0	0	0	1	1	0
EQUATOR	0	0	1	1	1	1	0	1	1	1	0	1	0	1	1	0
5 SOUTH	0	0	1	1	1	2	1	0	0	1	0	1	0	1	2	1
10 SOUTH	0	0	0	1	1	1	0	2	1	2	0	2	2	1	0	0
15 SOUTH	0	0	0	0	0	0	0	1	0	1	0	1	1	1	1	0
20 SOUTH	0	0	0	0	0	0	0	0	0	0	2	1	0	0	1	0
25 SOUTH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

3.1.4 Earth Stations Per Population Square

One of the parameters employed in this portion of the study was the number of people per earth station. Figure 3.5 shows the number of earth stations necessary if each station served 100,000 people. Overlaid on this map is a list of INTELSAT stations presently in service. Figures 3.5 through 3.13 show the number of earth stations which would be required if population were the sole criterion.

The strengths and weaknesses of this approach are apparent from the figures. This approach provides an equitable distribution of earth stations; however, on some islands (e.g., Fiji) the population is concentrated on several islands, thereby distorting the true number of earth stations that would be necessary. On the other hand, Fiji's two major islands have good telephone service, which would reduce the number of earth stations required for that country.

3.1.5 Economic Indicators

Selected economic implications of this parametric study appear below. While the economic considerations of telecommunications development in the Pacific islands are discussed in more detail in Section 4 and 5 of this report, it is important to note here that the present parametric analysis corroborates the findings in the sections that follow, which show that there are two indicators of high significance in the correlation between telecommunications demand and trade. These indicators are the gross domestic product (GDP)[3] per person in each of the island groups and the diversification of exports.

[3] The gross domestic product (GDP) is the total of goods and services produced within a nation.

FIGURE 3.5: EARTH STATION DISTRIBUTION (1 per 100,000 people)

INTELSAT

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	3	0	2	0	0	0	0	0	0	0	0	0	0	0
			PNG			GUADCNL									
0	0	9	14	1	1	1	0	0	0	0	0	0	0	0	0
0	0	0	0	1	0	0	0	0	0	0	2	0	0	0	0
							VANUATU								
0	0	0	0	0	0	0	1	0	6	0	0	0	0	0	0
														SO. COOKS	
0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0

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FIGURE 3.6: EARTH STATION DISTRIBUTION (1 per 100 people)

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	169	0	0	0	0	0	0	0	0	0	0	0	0
0	0	1121	0	0	0	5	15	3	0	0	0	0	0	0	0
123	70	16	22	357	215	55	111	158	0	0	0	0	0	0	0
0	0	0	0	0	8	0	9	344	0	0	0	0	0	17	0
0	0	3302	0	1764	4	0	97	66	89	0	20	0	0	0	0
			PNG			GUADCNL									
0	0	8696	13930	1116	508	1114	43	0	90	0	16	0	3	6	0
0	0	0	0	1243	19	149	110	0	28	110	1550	314	13	0	0
							VANUATU								
0	0	0	0	0	0	0	1102	0	6056	106	325	39	0	38	0
														SO. COOKS	
0	0	0	0	0	0	0	0	0	0	720	0	0	0	115	0

Total ES: 45,718

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FIGURE 3.7: EARTH STATION DISTRIBUTION (1 per 500 people)

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	34	0	0	0	0	0	0	0	0	0	0	0	0
0	0	224	0	0	0	1	3	1	0	0	0	0	0	0	0
25	14	3	4	71	43	11	22	32	0	0	0	0	0	0	0
0	0	0	0	0	2	0	2	69	0	0	0	0	0	3	0
0	0	660	0	353	1	0	19	13	18	0	4	0	0	0	0
		PNG				GUADCNL									
0	0	1739	2786	223	102	223	9	0	18	0	3	0	1	1	0
0	0	0	0	249	4	30	22	0	6	22	310	63	3	0	0
							VANUATU								
0	0	0	0	0	0	0	220	0	1211	21	65	8	0	8	0
														SO. COOKS	
0	0	0	0	0	0	0	0	0	0	144	0	0	0	23	0

Total ES: 9,143

FIGURE 3.8: EART'I STATION DISTRIBUTION (1 per 1,000 people)

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	17	0	0	0	0	0	0	0	0	0	0	0	0
0	0	112	0	0	0	1	2	0	0	0	0	0	0	0	0
12	7	2	2	36	22	6	11	16	0	0	0	0	0	0	0
0	0	0	0	0	1	0	1	34	0	0	0	0	0	2	0
0	0	330	0	176	0	0	10	7	9	0	2	0	0	0	0
		PNG				GUADCNL									
0	0	870	1393	112	51	111	4	0	9	0	2	0	0	1	0
0	0	0	0	124	2	15	11	0	3	11	155	31	1	0	0
							VANUATU								
0	0	0	0	0	0	0	110	0	606	11	33	4	0	4	0
														SO. COOKS	
0	0	0	0	0	0	0	0	0	0	72	0	0	0	12	0

Total ES: 4,571

FIGURE 3.9: EARTH STATION DISTRIBUTION (1 per 2,500 people)

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0
0	0	45	0	0	0	0	1	0	0	0	0	0	0	0	0
5	3	1	1	14	9	2	4	6	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	14	0	0	0	0	0	1	0
0	0	132	0	71	0	0	4	3	4	0	1	0	0	0	0
		PNG			GUADCNL										
0	0	348	557	45	20	45	2	0	4	0	1	0	0	0	0
0	0	0	0	50	1	6	4	0	1	4	62	13	1	0	0
						VANUATU									
0	0	0	0	0	0	0	44	0	242	4	13	2	0	2	0
													SO. COOKS		
0	0	0	0	0	0	0	0	0	0	29	0	0	0	5	0

Total ES: 1,828

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FIGURE 3.10: EARTH STATION DISTRIBUTION (1 per 5,000 people)

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0
0	0	22	0	0	0	0	0	0	0	0	0	0	0	0	0
2	1	0	0	7	4	1	2	3	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0
0	0	66	0	35	0	0	2	1	2	0	0	0	0	0	0
		PNG				GUADCNL									
0	0	174	279	22	10	22	1	0	2	0	0	0	0	0	0
0	0	0	0	25	0	3	2	0	1	2	31	6	0	0	0
						VANUATU									
0	0	0	0	0	0	0	22	0	121	2	7	1	0	1	0
													SO. COOKS		
0	0	0	0	0	0	0	0	0	0	14	0	0	0	2	0

Total ES: 914

FIGURE 3.11: EARTH STATION DISTRIBUTION (1 per 10,000 people)

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0
1	1	0	0	4	2	1	1	2	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0
0	0	33	0	18	0	0	1	1	1	0	0	0	0	0	0
		PNG			GUADCNL										
0	0	87	139	11	5	11	0	0	1	0	0	0	0	0	0
0	0	0	0	12	0	1	1	0	0	1	16	3	0	0	0
						VANUATU									
0	0	0	0	0	0	0	11	0	61	1	3	0	0	0	0
														SO. COOKS	
0	0	0	0	0	0	0	0	0	0	7	0	0	0	1	0

Total ES: 457

FIGURE 3.12: EARTH STATION DISTRIBUTION (1 per 50,000 people)

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
0	0	7	0	4	0	0	0	0	0	0	0	0	0	0	0
		PNG			GUADCNL										
0	0	17	28	2	1	2	0	0	0	0	0	0	0	0	0
0	0	0	0	2	0	0	0	0	0	0	3	1	0	0	0
						VANUATU									
0	0	0	0	0	0	0	2	0	12	0	1	0	0	0	0
													SO. COOKS		
0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0

Total ES: 91

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FIGURE 3.13: EARTH STATION DISTRIBUTION (1 per 100,000 people)

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	3	0	2	0	0	0	0	0	0	0	0	0	0	0
		PNG			GUADCNL										
0	0	9	14	1	1	1	0	0	0	0	0	0	0	0	0
0	0	0	0	1	0	0	0	0	0	0	2	0	0	0	0
						VANUATU									
0	0	0	0	0	0	0	1	0	6	0	0	0	0	0	0
													SO. COOKS		
0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0

Total ES: 45

In the parametric analysis, Figure 3.12 shows the number of earth stations that would be required if there were one earth station per 50,000 people. Ninety-one earth stations would need to be placed in sixteen different 5° by 5° squares--a number which is close to the INTELSAT estimate in Section 2.2.1. This number further indicates the possible distribution of service that could be provided by the proposed new INTELSAT service. Note that, based on this criterion, several island nations with fewer than 50,000 inhabitants would not be served at all.

Figure 3.11, with one earth station per 10,000 people, shows distribution in 33 squares, while Figure 3.9, with one earth station per 2,500 inhabitants expands the coverage to 1,826 earth stations in 42 squares. With one per 1,000 people, Figure 3.8 shows 4,566 earth stations in 46 of the 135 squares.

Several important conclusions can be drawn from this work. The present method of locating INTELSAT earth stations in the Pacific is to place them at national capitals which are, for the most part, the major urban centers. One difficulty with this method is that the urban centers which have the benefits of advanced infrastructures are further developed with the implementation of advances in telecommunications; whereas lesser developed rural areas do not enjoy the advances that create the richer quality of life found in urban centers. Section 4 describes the effects of such infrastructure deprivation on rural populations and the exodus from rural to urban environments that results. If communications were made available to rural inhabitants, this migration could be slowed and possibly stemmed or reversed.

A higher-powered satellite permits the economic deployment of many small earth stations into the rural areas and may invite economic development. It is believed that in addition to the obvious economic advantages, satellite communications in the Pacific will have a profound influence on social and political changes. It is anticipated that the most important economic rewards would be achieved through expansion of voice and telex service. Television will come in time, but for now television may be counterproductive if it raises expectations without contributing appropriately to the well-being of the rural as well as urban areas of the Pacific.

3.2 Conclusions of the 5° by 5° Square Study

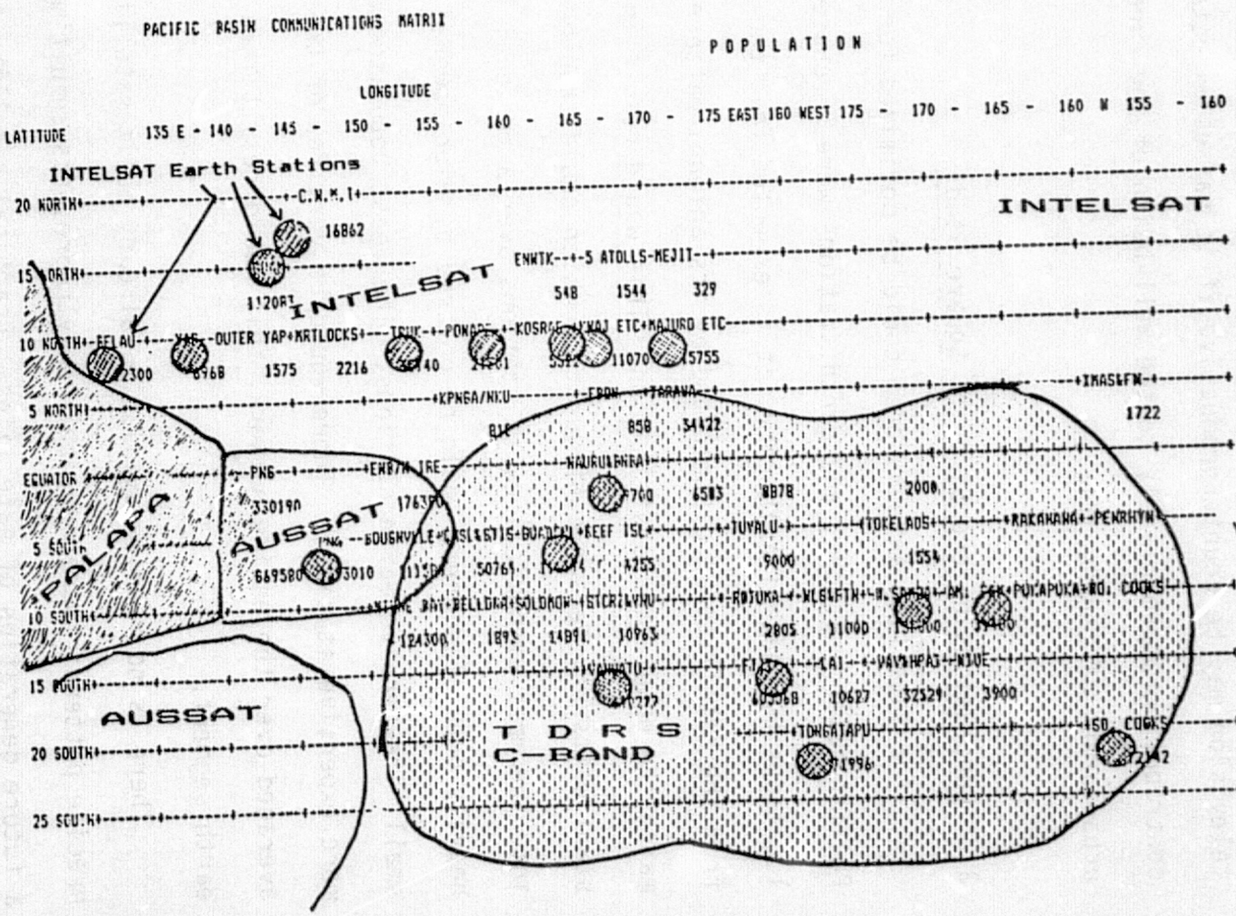
If a satellite antenna beam could be optimized for coverage of the Pacific island nations, and earth stations were purchased and assigned locations by central authority, it is expected that the power output from the satellite as distributed by its antenna pattern would closely match the population distribution. This would result in a nearly constant watts-per-person configuration which could then be translated into the most economical earth stations over a regional basis. The heavily populated areas would be covered by high-powered signals using small, inexpensive earth stations. The least populated areas could use more expensive stations. There would be very few of these. When averaged over the entire network, this would result in a least-cost earth segment.

There is no readily available, already built satellite with this precise pattern; therefore, this only represents an ultimate goal for a future generation of satellites. Practical satellite antennas have beams shaped over the entire earth or other specific geographical areas such as the United States.

Figure 3.14 shows the combined coverage of INTELSAT, PALAPA-B, TDRS and AUSSAT for optimized coverage of the Pacific nations.

FIGURE 3.14

PACIFIC OCEAN COVERAGE
Population of Each 5 x 5 degree square is shown



3.3 Distribution of Earth Stations

After completing the parametric analysis of population, the number of islands and the number of nations per square, the project staff determined the number of earth stations that would be required per square assuming that one earth station per 2,500 people would provide an adequate basis for a satellite-utilizing communications network for the Pacific islands. Figure 3.15 shows the distribution of earth stations based on both the parametric analysis and actual information on the demographic configuration of each 5° by 5° square. In some squares, the number of earth stations has been increased to take into account the number of islands. In other cases, such as Guam, the number of earth stations has been reduced because the population of the island is so concentrated.

3.4 Size of Earth Stations

Table 3.1 shows a link budget for a station in Fiji for the present INTELSAT global beam and for a hypothetical TDRS/C-band beam.

For the present analysis, the minimum earth station antenna diameter chosen was three (3) meters to limit the potential for any interference from adjacent satellites. In this example, a very crude (150 Kelvin) low-noise amplifier is used for the TDRS beam.

The calculations and analysis of this section are based on the following assumptions: (1) both satellites operate with a network of approximately 1,400 earth stations; (2) during the busy hours, 20 percent of the stations are in use; (3) traffic is spread across four transponders; (4) voice activity is employed.

FIGURE 3.15: DISTRIBUTION OF EARTH STATIONS

MAP I PACIFIC ISLAND NATION (5° GRID)

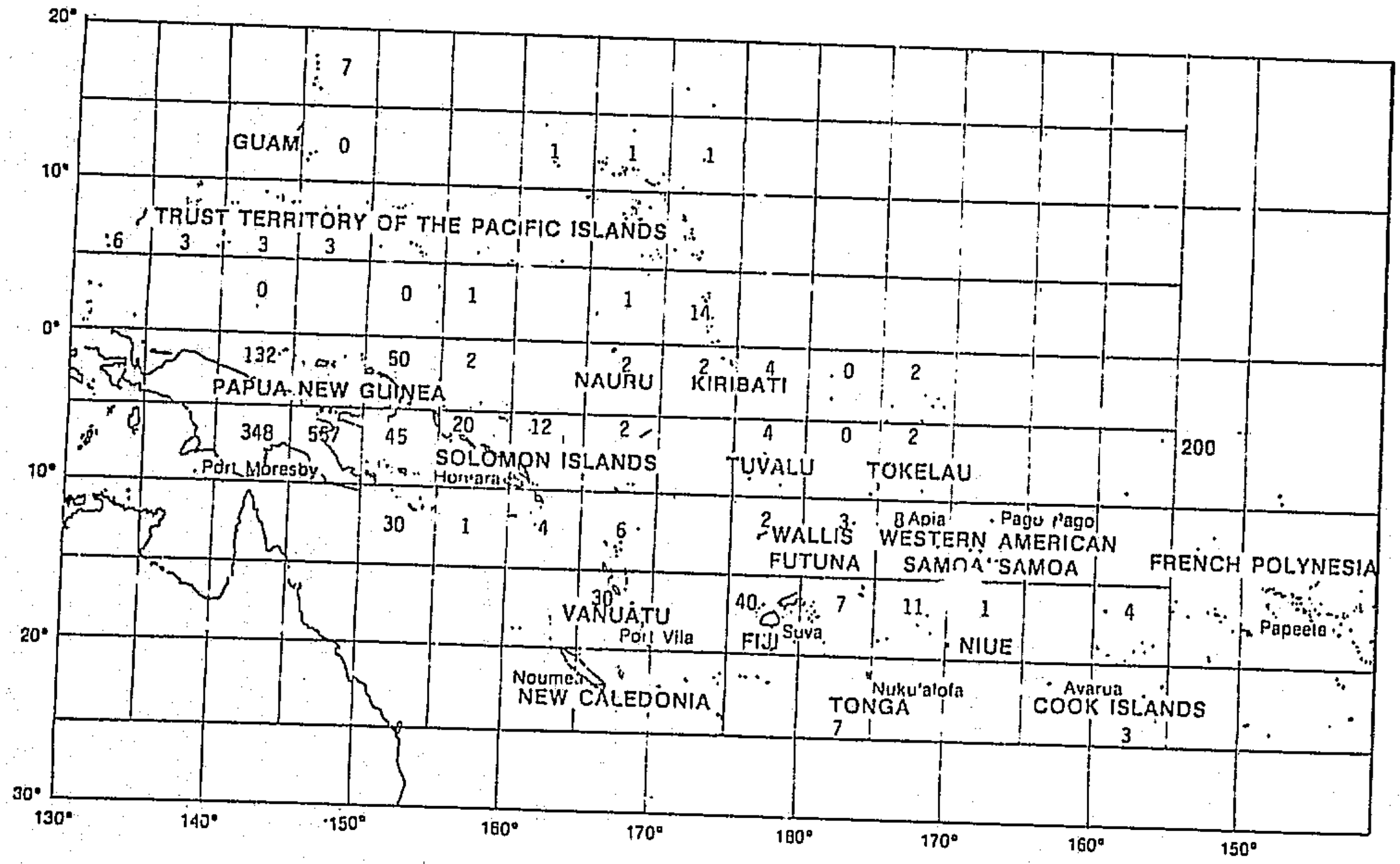


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TABLE 3.1: LINK BUDGETS

SATELLITE NAME:	INTELSAT		TDAS-C
BEAM NAME:	GLOBAL		SOUTH PACIFIC
LOCATION:	(166 WEST)		171 WEST
	174 EAST		
EARTH STATION LOC:	FIJI		UNITS
FREQUENCY	3.95	#	4.00 GHZ
SATURATION EIRP	25.00	#	35.00 DBW
OFF AXIS LOSS	0.50	#	3.50 DB
NO OF USERS(TOTAL)	1400		1400 USERS
BUSY HR ACTIVE	20		20 %
	280		280 USERS
VOICE ACTIVITY	40		40 %
BUSY HR CARRIERS	112		112 CARRIERS
TRANSPONDERS USED	4		4 TRANSPND
CARRIERS/TRANSPDR	28		28 CARRIERS
OUTPUT BACKOFF	4	#	4 DB
ACTUAL USEFUL EIRP	20.50		27.50 DBW
EIRP PER CARRIER	6.03		13.03 DBW
ELEV ANGLE	70.00	#	60.00 DEGREES
DISTANCE	35974		36512 KM (APPR
PATH LOSS	195.50		195.74 DB
RAIN LOSS	0.00	##	0.00 DB

ILL LEVEL @ EARTH	-156.97		-149.97 DBW/SQ M
E.S. ANT DIA	5.00	#	3.00 METERS
ANT. EFFICIENCY	65	#	55 PERCENT
ANT. GAIN ON AXIS	44		39 DBI
LNA TEMP	100	#	150 KELVIN
SKY NOISE	40	##	45 KELVIN
SYST NOISE TEMP	140		195 KELVIN
E.S. G/T	23		16 DBI/K
E.S. MAINT. MARGIN	0.20	##	0.70 DB
CARRIER TO THERMAL	-168		-168 DBW/K
BOLTZMANNS CONST.	228.60		228.60 DB
C/KT	61		61 DBHZ
NOISE BANDWIDTH	0.04	#	0.04 MHZ
C/N (DOWN)	15		15 DB
C/N (UP)	26.00	#	28.00 DB
C/IM (SAT)	32.00	#	32.00 DB
C/I (DOWN)	22.00	#	22.00 DB
C/(N+I) TOTAL	13.93		13.65 DB
REC. THRESHOLD	9.00	#	9.00 DB
MARGIN	4.93		4.85 DB

Additional charts and tables are provided for comparison. Figure 3.16 shows the TDRS overlay on this set of earth stations. Figure 3.17 plots the required figure of merit which was used to construct Table 3.2 for the TDRS example. This table shows the quantities and costs of the earth stations in each of the two systems.

When the TDRS e.i.r.p. falls below the threshold shown, the present analysis assumes that the INTELSAT service will be used (which will reduce the cost of the earth station). Likewise, this will provide for a connection with the subregional system through one of the existing INTELSAT stations by means of a double hop. The table provides an estimate of the total costs. Figures 3.18 and 3.19 show the antenna size and cost of each earth station.

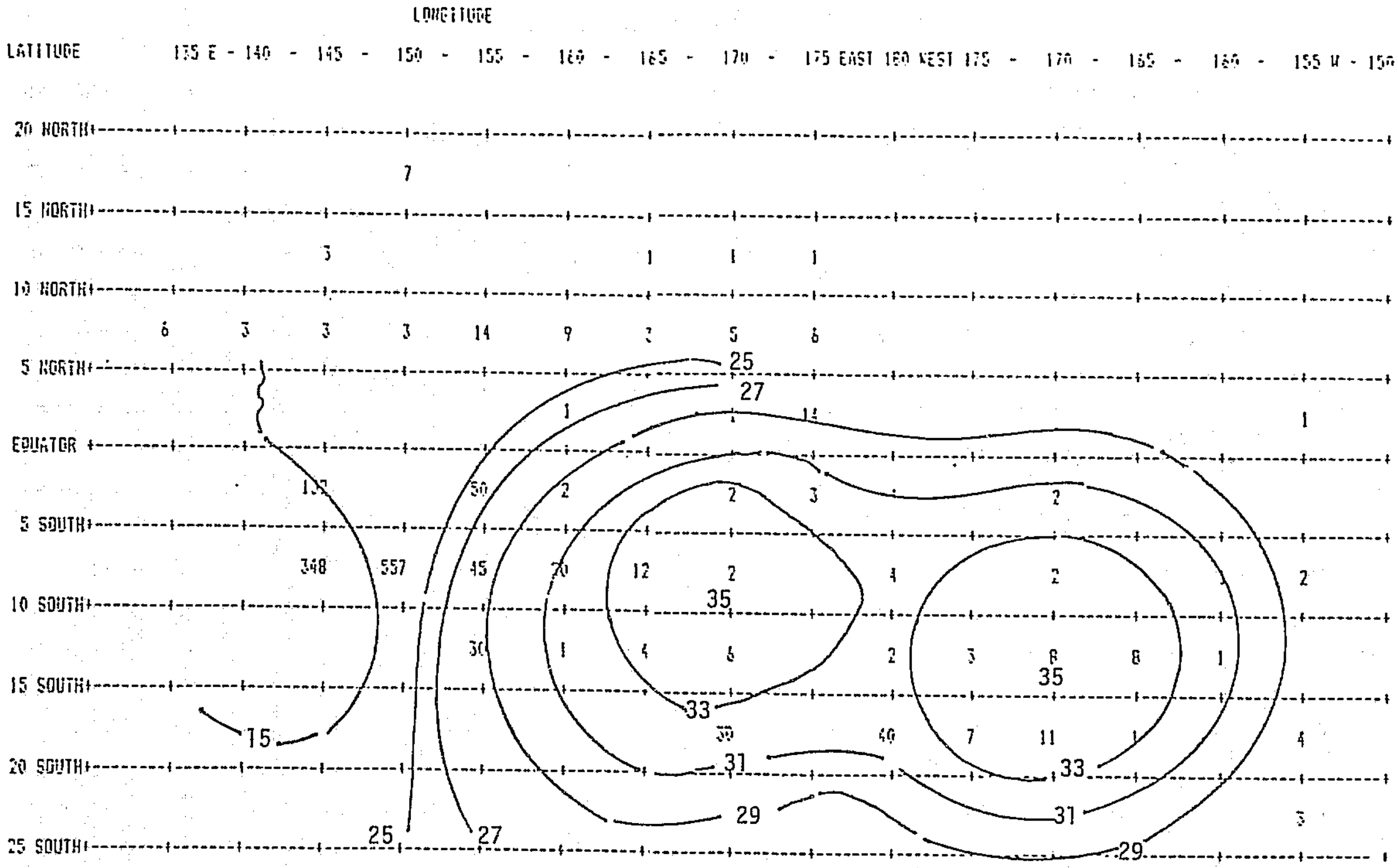
An alternative would be to place the nearly 1,000 Papua New Guinea earth stations into the AUSSAT system. This alternative would substantially reduce the earth station costs shown in Table 3.2 to about ten million dollars.

3.5 INTELSAT Earth Station Costs

Table 3.3 is an excerpt from the public record on the COMSAT filing for the INTELSAT Standard B earth station currently under construction in the Republic of Palau in the Western Caroline Islands in Micronesia. If 1,400 earth stations of this size and type were erected, the cost would be about two billion dollars. Even if economies of scale allowed a substantial reduction in cost, the amount would remain staggering.

If the potential INTELSAT nodal system had 1,400 earth stations at \$50,000 to \$100,000, the cost would be at least seventy million dollars, in addition to the costs of Standard A or B earth stations required for the international nodes. While some of these are already extant in

FIGURE 3.16: TDRS C-BAND RADIATED POWER (in dBW)



PACIFIC BASIN COMMUNICATIONS MATRIX

NUMBER OF EARTH STATIONS BASED ON POPULATION, ISLANDS & NATIONS

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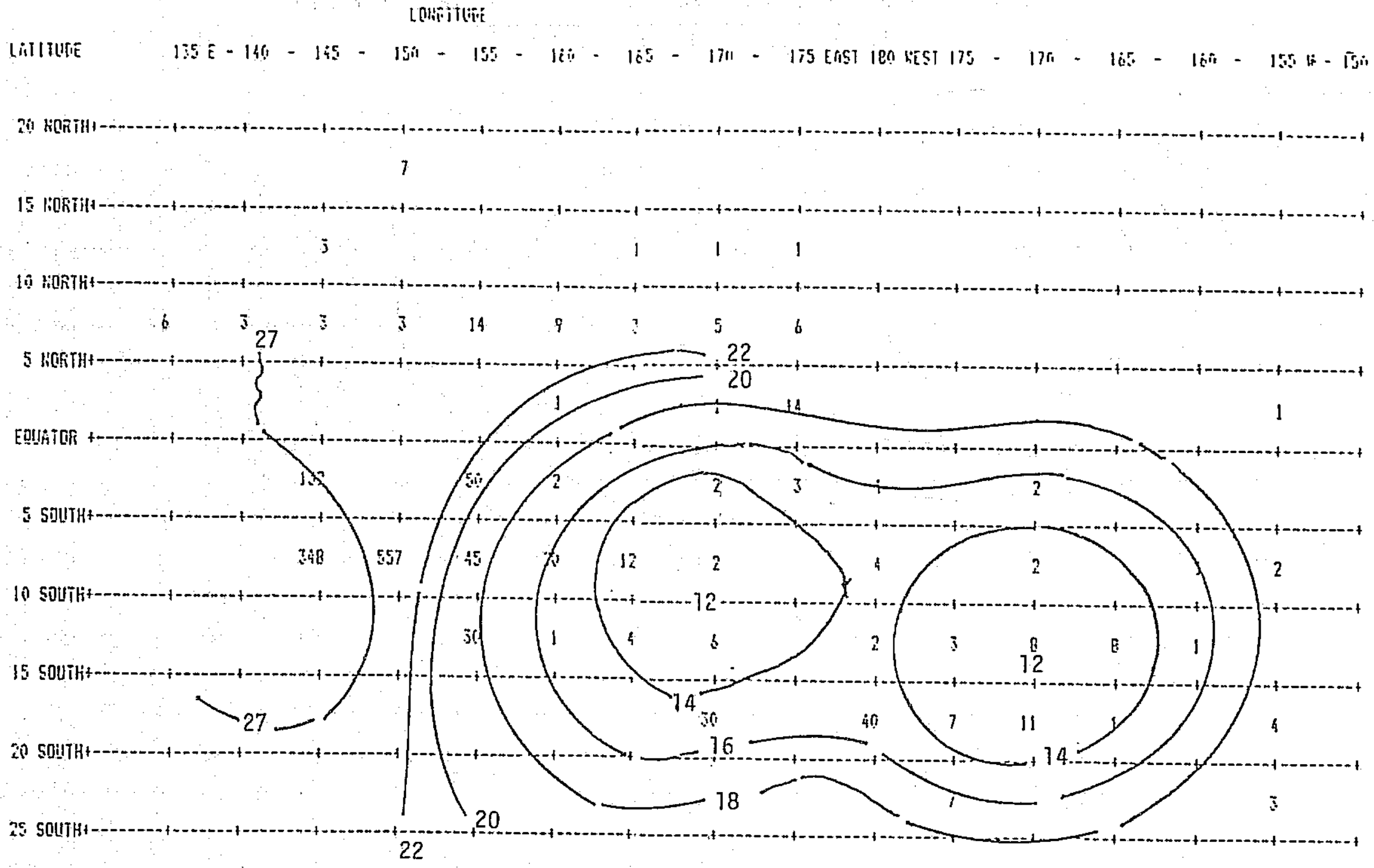
FIGURE 3.17: EARTH STATION FIGURE OF MERIT (G/T in dBi/K)



PACIFIC BASIN COMMUNICATIONS MATRIX

NUMBER OF EARTH STATIONS BASED ON POPULATION, ISLANDS & NATIONS

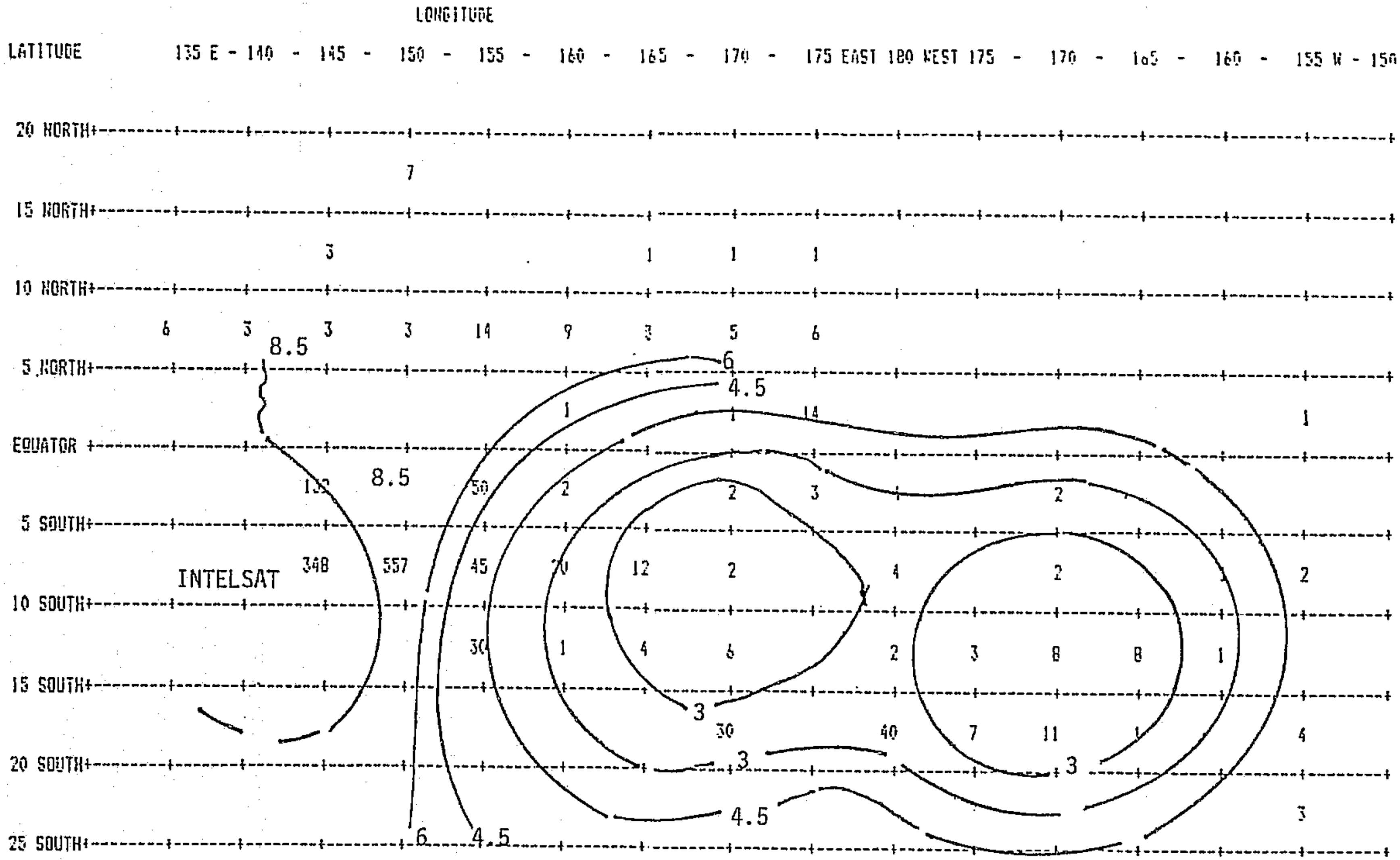
TABLE 3.2

TDRS C-BAND EARTH STATIONS

SATELLITE EIRP (DBW)	33-35	31-33	29-31	27-29	25-27	15-25	>15	DBW
NUMBER OF EARTH STATIONS	66	104	48	51	56	666	429	QTY
EARTH STATION G/T (DBI/K)	14	16	18	20	22	27	‡	DBI/K
TYPICAL ANTENNA DIA (M)	3	3	4.5	4.5	6.0	8.5	‡	M
LNA (K)	150	120	150	120	150	100	‡	K
COST OF EACH EARTH STATION	25	28	30	32	40	50	‡	$X1000
TOTAL COST OF CLASS OF E.S.	350	2912	1440	1632	2240	33300	‡	$X1000
GRAND TOTAL LESS INTELSAT								41874$X1000

‡ USE INTELSAT FOR THESE CASES

FIGURE 3.18: EARTH STATION ANTENNA DIAMETER (in meters)



PACIFIC BASIN COMMUNICATIONS MATRIX

NUMBER OF EARTH STATIONS BASED ON POPULATION, ISLANDS & NATIONS

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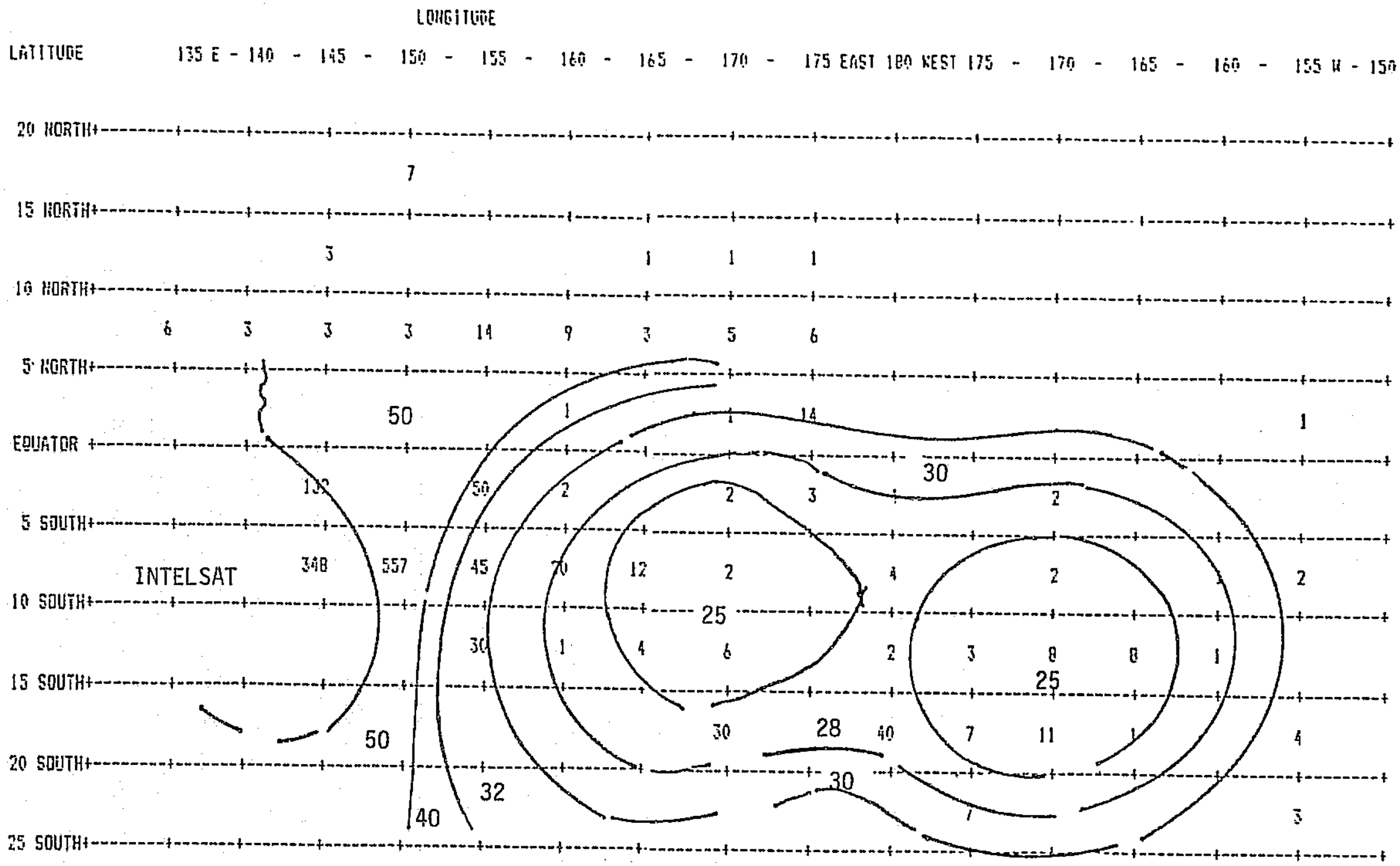
FIGURE 3.19: APPROXIMATE EARTH STATION COST (thousands of US$ in 1982)



PACIFIC BASIN COMMUNICATIONS MATRIX

NUMBER OF EARTH STATIONS BASED ON POPULATION, ISLANDS & NATIONS

TABLE 3.3

CAPITAL COSTS
STANDARD B EARTH STATION
REPUBLIC OF PALAU

	Total Investment
Antenna, Feed, etc.	$ 310,000
Low Noise Amplifier Subsystem	75,000
HPA Subsystem	95,000
GCE Subsystem	60,000*
TV Video Subsystem	25,000*
SCPC Subsystem 16 channel units	165,000*
Power Equipment	130,000
Communication Shelter	35,000
On-Site Integration	100,000
Maintenance Test Equipment & Tools	85,000*
Spares	30,000
Civil Works	120,000
Shipping, Insurance, and Taxes	110,000
Vendor Project Management, Engineering, Documentation	100,000
In-House Costs	105,000
Vehicles, Office Supplies, etc.	25,000
Contingency	140,000
Total Earth Station Investment	$1,710,000

Source: COMSAT's FCC Filing

national capitals throughout the South Pacific, they would require modification. Additional equipment would have to be fitted to accommodate added traffic.

3.6 Sources of Earth Stations

A growing interest in the Pacific among equipment designers, manufacturers and supplers has been identified. It is anticipated from preliminary discussions that these companies would consider Pacific-based assembly of equipment.

Appendix B provides a listing of United States-based suppliers of earth stations and earth station components.

3.7 Applying Information

This parametric analysis of the number, distribution, size and cost of earth stations for the Pacific islands will complement results that Pacific governments receive from other studies. Together, these data should assist them in making upcoming planning decisions.

4. ECONOMIC CONSIDERATIONS AND FORECASTS FOR IMPROVED TELECOMMUNICATIONS IN THE PACIFIC REGION

In our first year's report, PSSC maintained that regional cooperation is a prerequisite for the economic development prospects of the Pacific island nations. Establishment of the South Pacific Bureau for Economic Cooperation (SPEC) a decade ago attests to a commitment among island leaders to cooperate (See Section 1.5.2). By mandate of the thirteen South Pacific prime ministers who make up the South Pacific Forum, SPEC takes primary responsibility for fostering the development of such regional economic efforts as shipping, air transport and telecommunications.

Our earlier work revealed that a good telecommunications system is a necessary but not sufficient condition for economic development in the region. Economic constraints limit the utilization and adoption of improved telecommunications in the Pacific, and yet, without the extension of a reliable telecommunications system to the rural areas and outer islands, economic development is unlikely to take place. Because of the impact of these factors, the second year's effort places primary emphasis on economic considerations.

In his report, "Structural Changes, Trade Dynamics and Telecommunications in the South Pacific Island Nations," prepared under contract to the PSSC, Dr. Neil Karunaratne first analyzed Pacific national planning objectives on a country-by-country basis. His descriptions of each plan appear here in Appendix C, along with tables on export/import commodities and markets extracted from his original report. Dr. Karunaratne explored telecommunications, trade and economic correlations, projecting long and short term demand scenarios, and undertook extensive econometric modeling.

Karunaratne posed these hypotheses: (1) that telecommunications supply would increase with increasing commodity export diversification and export market diversification; (2) that telecommunications demand would increase with increasing commodity import diversification and increasing market diversification; and (3) that telecommunications supply and demand would increase with growth in Gross Domestic Product or Gross National Product (GDP/GNP).[4] Only selected sections from Karunaratne's report are included; however, the entire document will be made available to economists and the more tenacious lay readers of econometrics. Abridged interpretations of Dr. Karunaratne's findings are found in Sections 4.1 and 4.2 of this report.

4.1 Economic Development and Telecommunications

4.1.1 Distance and Dependency: The Issue of Regionalism

The devleopment of the Pacific island nations is severely constrained by the isolation that comes with vast physical distance and the islands' limited economically significant resource base. While these constraints serve to retard the quest for the kind of economic development that is self-sustained, rising expectations, political awareness and nationalism in these nations place a heavy premium in the goal of self-reliance.

Although in terms of per capita income, the average of A$892[5] for Pacific islands is above that of developing Afro-Asian economies, the

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[4]Take GDP and add income accruing from abroad to domestic residents or abroad and subtract income earned in domestic market investment that that accrues to foreigners.

[5]The Australian dollar equals US$1.0056 (July, 1982).

dependency on aid, trade and technology of metropolitan[6] neighbors is noticeably high. Aid accounts for, on the average, 21 percent of the average per capita income of Pacific island nations. For some smaller economies, per capita aid exceeds 100 percent of per capita income. Besides, the recurrent trade deficits as a proportion of GDP/GNP on the average exceeded 30 percent in 1979. For the region as a whole, the trade deficit measured in per capita terms nearly doubled from A$101 in 1970 to A$204 in 1980. (See Table 4.1.)

The poor prospects for primary agriculture and mineral exports from Pacific islands and the rising of consumer imports will further aggravate the growing indebtedness of the region. The flagging support for aid in the inflation and unemployment-ravaged donor countries, however, does not augur well for increased aid to the Pacific nations in the future. In the past, the metropolitan donors continued to provide substantial aid to their former colonies well after the islands' independence.

4.1.2 Development and Collective Self-Reliance

A cursory view of the operating constraints and economic indicators of the Pacific island nations reveals that these countries will most likely continue to depend on metropolitan donors for their well being. The pursuit of planned economic development might even reinforce dependency in the island nations on metropolitan powers. Some have suggested that the island economies sould pursue zero growth strategies based on a mixed subsistence-plantation mode, thereby preserving the fragile ecology and stable life that can be destroyed by rapid development. [Ward and Hau'ofa 1979:44].

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[6] Metropolitan countries are those with former colonial ties to these island states.

TABLE 4.1: ECONOMIC, DEMOGRAPHIC & SIZE CHARACTERISTICS OF THE PACIFIC ISLAND NATIONS

COUNTRY	Per Capita GDP/GNP (most recent Est.) $A (1)	Population Mid-1979 ('000) (2)	Land Area (km^2) (3)	Density Population/ Land Area (4)	Sea Area millions (km^2) (5)	AAGR of Pop. last 5 years (6)	Per Capita Aid ($A) (% of GDP/GNP) (7)	Trade Surplus(+) Trade Deficit(-) as % of GDP/GNP 1979 (9)
1. American Samoa	4097	31.4	197	159	0.39	1.5	903 (22.0)	+ 24.26
2. Cook Islands	941	18.5	240	77	1.83	-0.7	362 (38.4)	- 98.51
3. Fiji	1455	619.0	18272	34	1.29	1.8	45 (0.03)	- 21.17
4. French Polynesia	4784	144.6	3265	44	5.03	2.2	889 (18.5)	- 57.32
5. Guam	4125	100.0	541	185		0.6	857 (20.7)	- 87.25
6. Kiribati	578	57.3	690	83	3.55	1.6	140 (24.22)	+ 17.13
7. Nauru	15000	7.3	21	348	0.32	0.8	0 (0.0)	+ 51.79
8. New Caledonia	6699	139.0	19103	7	1.74	1.2	955 (14.2)	- 0.0
9. Niue	774	3.6	259	14	0.39	-2.1	1222 (157.88)	- 56.46
10. Papua New Guinea	519	2944.0	462243	6	3.120	1.9	82 (15.8)	+ 10.40
11. Solomon Islands	536	217.7	28530	8	1.34	3.1	105 (19.5)	+ 3.58
12. Tokelau	560	1.6	10	160	0.29	0	1000 (178.57)	- 30.36
13. Tonga	398	95.8	699	137	0.70	1.7	219 (55.02)	- 50.7
14. T T P I	705	132.5	1832	72	6.20	2.3	752 (106.67)	–
15. Tuvalu	504	7.4	26	72	0.90	4.6	541 (107.34)	- 42.65
16. Vanuatu	452	114.5	11880	285	0.68	4.4	297 (65.71)	- 35.84
17. Wallis and Futuna	870	10.2	255	40	0.30	3.2	676 (77.70)	- 67.82
18. Western Samoa	304	155.0	2935	53	0.12	0.8	174 (57.24)	- 107.95
TOTAL/AVERAGE	892.2	4799.4	550999	9	28.19	1.9	187 (20.96)	- 30.19

Sources: Karunaratne, 1982, Table 2, Appendix C:1 and Table 4.2, South Pacific Economies, 1979: Statistical Summary, SPC, Noumea, New Caledonia, April, 1981.

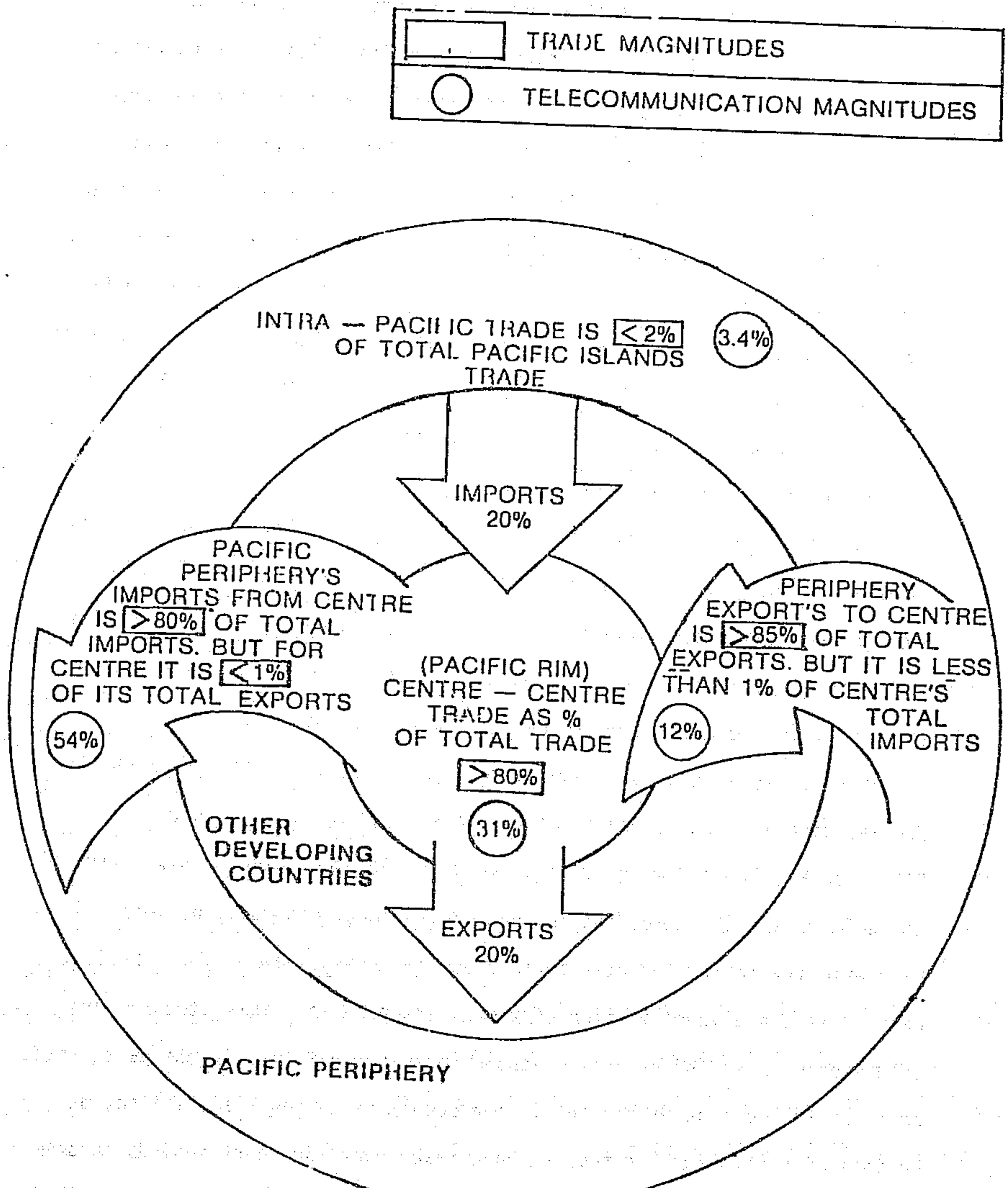
But, the penetration of the money economy and the attainment of political independence have led to inexorable change in the Pacific island nations. Regardless of the admonitions of the traditional leaders and the more benign expatriates, Pacific island populations envision a better lifestyle based on improved health, education, housing, employment and a more varied and exotic diet. Voting with their feet, villagers flock to urban centers; and voting with their mouths, they demand more and varied imported goods.

Development planning cannot ignore the preferences of the vast majority of people who are from the rural areas and outer islands of these developing countries. The objectives articulated in current development plans have captured the prevailing mood of people. The implementation of such plans requires resources and technological inputs. A survey of impending structural changes in these macro economies, particularly their trade patterns, is, therefore, warranted. The following sections focus on these issues of trade and structural change.

Reservations have been expressed about the prospects of increasing intra-regional trade among the island economies. Pacific island nations are heavily dependent on their metropolitan partners for most of their trade, and the island trade is only a minute fraction of the total metropolitan trade. One might expect that trade among the islands and metropolitan countries would take place on the basis of cost or resource endowment differences. But, available evidence reveals that metropolitan countries trade more among themselves because of the similarity of their structures [Linder, 1961].

This Linder thesis in trade is also mirrored in telecommunications. Metro-metro telecommunications is much higher than metro-periphery telecommunications (for trade relations, see Diagram I). However, the fact

DIAGRAM I CENTRE-PERIPHERY TRADE AND TELECOMMUNICATIONS.



that there is little inter-peripheral and inter-regional trade and telecommunications is not sufficient reason to reach pessimistic conclusions on intra-regional trade prospects for the islands. One cannot conclude, without adequate examination of industrial possibilities and such resources as marine, mineral, agriculture and manpower, that the trading prospects of Pacific island nations are gloomy. Dynamic perspectives of Pacific islands trade and industrialization are by far more relevant than orthodox theory for development policy-making in the region. Historically, exports, commissioned by governments but undertaken by expatriates (outside professionals), ignored the political will of island leaders to develop rapidly through trade and industrialization. Such reports typically propound policy prescriptions on the basis of text-book theories that were not pursued in the development of metropolitan countries.

Pacific island nations are far from their metropolitan trading partners and from the pulse of the world economy. In the 1980s when the tyranny of distance and the constraints of insularity are pitted against the revolution of "rising expectations" within the island nations, massive pressures for structural change will be generated within the islands' economies.

Pacific islands are, by and large, 'small primary oriented' economies specializing in a narrow range of products for export. Such exports as Fiji's sugar, Papua New Guinea's copper, the Solomon Islands' copra are susceptable to price fluctuation in the international commodity markets. A high priority in the recently formulated development plans of the Pacific nations is the diversification of the export base increasing the numbers of different kinds of exports. According to Karunaratne, in the past, trade acted as the 'engine of growth' in the countries. When trade failed, new engines of growth such as tourism have taken over for short periods in some countries such as Fiji. Induced growth and development can accentuate center-periphery, one-way dependence if leakages (e.g., through imports) exceed linkages (e.g., induced developments elsewhere in one economy). Nevertheless, if linkages exceed leakages there could be positive spread-effects as shown by the success story of Singapore and other newly industrialized countries.

4.1.3 Collective Self-Reliance and the Creation of Regionalism

One long-term solution to the malaise caused by external metropolitan dependence may lie in the fostering of collective self-reliance among Pacific island nations. Collective self-reliance would mean the framing of a concerted plan for economic integration or regional economic development by pooling the markets and the meager resource endowments of the Pacific nations. Among the dimensions of a strategy of development through collective self-reliance are the coordination of transport, shipping, communications and particularly the bargaining powers of island nations in their dealings with the rest of the world. There are garbled indications that new institutional mechanisms such as the Forum, its secretariat SPEC (South Pacific Bureau for Economic Cooperation), PIDP (Pacific Island Development Program), USP (The University of the South Pacific) and SPC (South Pacific Commission), will promote Pacific regionalism. Such developments could steer the island economies of the Pacific away from the present unequal partnership and dependency on the center countries to a future of collective self-reliance and mutual interdependence.

4.1.4 Regional Agreements

New regional cooperation agreements such as PATCRA (Papua New Guinea Australia Trade and Commercial Relations Agreement) and SPARTECA (South Pacific Regional Trade and Economic Cooperation Agreement) are now in operation and will hopefully foster more trade links between island nations and Australia and New Zealand. The spirit of these agreements should signify a new relationship on the basis of benign mutual gains.

SPARTECA is a non-reciprocal effort by Australia and New Zealand at liberalizing trade with the Pacific islands. These metropolitan countries desire to open their markets to products of Pacific islands that have more than 50 percent local content when measured in terms of factory costs. The SPARTECA agreement specifically aims at the rapid removal of tariff and non-tariff barriers on a non-reciprocal basis to facilitate unrestricted access to Australian and New Zealand markets. The range of exports, the quantum of export earnings and foreign exchange earnings are all expected to increase. SPARTECA also encourages joint ventures between the metropolitan countries and the Pacific island nations promoting the transfer of much needed know-how and technology to the Pacific islands.

Eventually, the plans of some island nations to establish Export Processing Zones (EPZs) will also be stimulated by the provisions of SPARTECA [EDB,1982]. These agreements on regional economic cooperation indicate that in the 1980s and beyond, the Pacific islands, embarking on trade oriented development strategies, will forge stronger links between the periphery and the center on the premise of mutuality rather than unequal dependence.

4.2 The Role of Trade and Telecommunications

Clearly, the Pacific island nations have yet to harness their intra-regional development prospects fully through economic cooperation. Trade and communications hold the key to the evolution of a viable strategy of collective self-reliance in the Pacific island nations. Such a strategy will ensure that decision-making in vital economic matters will emanate from sources within the islands rather than from sources in the metropolitan centers. Only then will the development of island economies become truly self-generating and less vulnerable to the cyclical booms, slumps, stagflation and other disturbances transmitted from the center countries.

4.2.1 Trade-Oriented Development Strategies

In the 1980s one option to island planners in the Pacific island nations is to pursue vigorously trade oriented development strategies. Such strategies can contain the pressures unleashed by the "revolution of rising expectations" by exporting on the basis of comparative advantage to pay for imports. But, concurrently such development strategies will have to prevent the economies from falling into a trap of unequal dominance-dependence on the center. The pursuit of collective self-reliance through intra-regional economic cooperation in trade and the gamut of other economic activities, shows the way out of the dependency dilemma The Pacific island nations have yet to exploit fully the prospects of industrial "complementation schemes" and the "package deals" for the allocation of private small-scale and public sector large-scale industrial projects for development as done in the case of the Association of South East Asian Nations (ASEAN). Also the pursuit of common agricultural policies based on the tenets of collective security as in the European Economic Community (Common Market) and more rationally on the premise of dynamic comparative advantage in international trade, has yet to be explored and implemented.

The Pacific island nations will have to evolve strategies that combine trade oriented growth paths and inward-focused collective self-reliance strategies. For them, import-substituting industrialization geared to a regional common market or free trade area has to be carefully planned and harnessed. Unlike any other developing economies, the limitations imposed by distance make a strong case for import substitution in certain bulky raw-material based economies. Paradoxically, some benefit can be derived from huge distances. Isolation obliges the islands to promote infant industries to cater for a regional market. The details of such marketing would have to be carefully designed and programmed.

4.2.2 Double Dualism and Basic Needs Strategy

There is no guarantee that the pursuit of export-led growth simultaneously with collective self-reliance is going to bridge the ever widening gap between the center and peripheral island states. Although the island nations grew dramatically during the 1970s, they lag significantly behind the metropolitan countries. The per capita income gap between average Pacific island nations and the Pacific metropolitan rim countries (Australia, New Zealand, Japan, U.S.A.) in 1979 was about 1:10 and is poised to widen in the 1980s. This phenomenon of widening international dualism is not peculiar to the center periphery configuration in the Pacific. There are forebodings worldwide that the economic gap between the rich and the developing nations will widen.

During the 1970s in many developing countries including the island nations of the Pacific, the rich became richer while the poor became poorer. The dualism was noticeable not only between communities (socially), but also between town and country (spatially). Further, ethnic tensions were exacerbated in Papua New Guinea, New Caledonia and, to lesser extent, in Fiji. Rural dwellers migrated in increasing numbers to towns and cities.

Since over 70 percent of the population of the Pacific nations lives in the rural hinterland, the provision of basic needs geared to integrated rural development is an articulated objective in the development plans of many countries in the Pacific region. Most development plans formulated in the emerging island states since the mid-1970s explicitly focus on redistributionist goals and the implementation of basic needs strategies (BNS).

The provision of basic needs such as education, medical care, transport, community and cultural centers and employment is a clearly specified goal in the current development plans of the island nations. But, the building of schools, hospitals, roads and other infrastructural projects requires large capital investment and protracted gestation lags. The risk exists that financial and capital resource constraints may reduce these planning goals to utopian dreams in the dependent island economies of the Pacific. Sophisticated, capital-intensive telecommunications technology may provide breakthroughs for salvaging planning goals that may not be viable due to lack of finance. Therefore, an incisive analysis of planning objectives designed to provide basic needs (particularly to the rural populace) and the role of telecommunications is needed.

4.2.3 Planning Objectives and Development Strategies

Many of the Pacific island nations have formulated development plans in which development objectives are meticulously articulated. Countries such as Fiji, Kiribati, the Solomon Islands and Tuvalu have official planning documents. Papua New Guinea, on the other hand, details its expenditure commitments according to an announced strategy in its expenditure plan. Most Pacific island nations wish for planned development to achieve equitable income growth with minimal disruption of traditional mores.

Appendix C reveals that these countries are poised for rapid economic change in the 1980s. Their planning objectives aim at rapid growth and equitable distribution of the benefits on the widespread population and to the most remote areas of their national boundaries. The rural hinterlands--which in most of these countries missed the opportunity that accompanied post-independence growth--are explicitly taken into account in the development targets of the plans.

Most Pacific island nations look to two principal strategies, export diversification and import substitution, to widen their economic base and lessen their vulnerability to events in their metropolitan trading partners. It is thought by varying the kinds of goods exported, the islands can reduce their dependency on a few primary exports. Further, through small-scale industrialization, they can substitute locally-made/grown commodities for goods which have until now been imported.

The plans of the larger island states underscore the need for rural development, and specifically, for reducing the gap between the rate and quality of development in urban areas in the rural environment. The desire to replace expatriate skills with local skills (a kind of import substitution) through human resource development, and the wish to have more local influence in key sectors of the economy are clearly stated in the development objectives examined in Appendix C. The plans discuss the problems of cultural domination from the outside, the need for financial self-reliance and the importance of sovereignty. The most recent iterations of long-term development plans show increased emphasis on international relations and a more clearly described interest in successful regional cooperation. Appendix C includes a table that depicts the variety of objectives of the development plans formulated by government planning departments throughout the Pacific.

4.2.4 Trade Orientation of the Pacific Island Nations

In the period since World War II, the Pacific island nations have been transformed rapidly from traditional subsistence-oriented economies to "open economies." Today, many of them could be classified as small, primary-oriented economies. The trade orientation of these nations varies considerably. One means of illustrating these differences is by determining the export and import ratios--the percentage of total supply that imports and exports constitute. The average export and import trade orientation ratios for Pacific island nations is higher among economies such as Nauru, Kiribati and Papua New Guinea that specialize in the production of minerals. Tiny coral-based nations, e.g., Niue and the atolls of Tuvalu and the Tokelau, have very low export orientation ratios because, with such meager resource bases, they simply have little to export.

The range of export orientation varies from 56 percent in Nauru to 1.6 percent in Tokelau. The islands' dependence on the outside world for manufactured goods, fuel and food is illustrated by the fact that import orientation ratios in the region on the average exceed export orientation ratios by more than 25 percent. The import orientation ratio is the highest for Western Samoa with an index of 61 percent and is the lowest for Nauru with an index of nearly nine percent (see Table 4.2).

An analysis of the composition of imports shows that the Pacific island nations are primary producing exporting economies. Many of the larger nations specialize in the production of a few primary products for export, and these export earnings account for a substantial proportion of the GDP/GNP. In the absence of reliable national income statistics, the composition of exports of Pacific island nations provides valuable insight into the structures of the economies.

TABLE 4.2: "OPENNESS" OF PACIFIC ISLAND ECONOMIES

COUNTRY	(1) GDP/GNP ($A'000) (MRE)*	(2) % of Total GNP/GDP	(3) Imports 1979 (A$'000)	(4) Total Supply (4)=(1)+(3)	(5) Exports 1979 ($A'000)	(6) Exports as % of total supply	(7) Imports % of total supply
American Samoa	126603	2.7	80613	207222	111804	54.0	38.9
Cook Islands	17400	3.8	20604	38004	3466	9.1	54.2
Fiji	900937	19.6	422388	1323829	231225	17.5	31.9
French Polynesia	675532	14.7	421892	1097424	25454	23.2	38.4
Kiribati	33134	0.0	15545	48679	21209	43.6	31.9
Nauru	109500	2.4	10559	120059	67270	56.0	8.8
New Caledonia	931103	2.0	319438	1250541	319557	25.6	25.5
Niue	2787	0.0	1915	4702	342	7.3	40.7
Papua New Guinea	1551200	33.8	701944	2253144	858605	38.1	31.2
Solomon Islands	11666[illegible]	2.5	52681	169348	62692	37.0	31.1
Tokelau	779	0.0	288	1007	16	1.6	28.6
Tonga	38167	0.0	26210	64379	6854	10.6	40.7
Tuvalu	3732	0.0	1851	5583	257	4.6	33.2
Vanuatu	43500	0.0	55530	99030	37017	37.4	56.1
Western Samoa	43500	0.0	66974	110474	16463	14.9	60.6
Total/Average	4594549		2198432	6792981	1762501	Av = 25.9	Av = 32.4

*MRE: Most recent estimate

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The most prosperous island nations according to per capita measures are the mineral exporters, e.g., phosphate-rich Nauru and Kiribati, nickel-rich New Caledonia and copper-rich Papua New Guinea. But do to the depressed world market for copper, and Papua New Guinea's large population base of nearly three million, that particular country does not occupy a high rung on the per capita income ladder. Mineral exports account for nearly 42 percent of the total exports from the Pacific islands and, in value terms, they are expanding their share in the total exports from the Pacific region at a rate above the annual average of 38 percent.

Next to minerals, the beverage froup (coffee, tea, cocoa) and spices dominate the composition of exports from the Pacific islands. Beverages and spices account for about 14 percent of the total exports from the region and are increasing although the rate of increase has slowed down in recent years. The main exporters of beverages are Papua New Guinea, Western Samoa and finally Fiji, which exports mainly spices.

Fish and seafoods as a category account for ten percent of the total export value throughout the Pacific and are produced mainly by Western Samoa, Papua New Guinea, Solomon Islands, Fiji and Vanuatu. The traditional copra (dried coconut) and coconut oil exports from the Pacific islands account for 9.4 percent of the total exports. Palm oil from Papua New Guinea and the Solomon Islands is making an increasing contribution to total export earnings. Wood and wood by products are recording spectacular increases as a non-traditional export mainly from Papua New Guinea, the Solomons and Fiji. Most of the sugar from the region comes from Fiji. It constitutes seven percent of total exports. The Pacific islands are predominantly exporters of unprocessed minerals and other raw materials to metropolitan markets. The trade configuration developed by the colonial antecedants still dominates the Pacific islands' post-independence trade patterns. There is still little inter-island trade. Routes form in spokes from capitals of island nations to and from metropolitan centers. Recently (August 1982), encouraging signs for inter-island trade came about with the Forum's decision to shore up the foundering Pacific Forum line. This decision commits US$12.6 million to support continued shipping service to the region and will ensure thin route coverage to small, underserved island areas.[7]

The import orientation of most of the island nations exceeds the export orientation. The trends of imports indicate that most Pacific island nations are becoming increasingly dependent on the outside world for a variety of consumer durables and foodstuffs. On the merchandise account, recurrent deficits have expanded at a rapid rate. For the South Pacific region as a whole, the trade deficit has increased from A$4.8 million in 1975 to A$7.9 million in 1979. The latter figure is about 16 percent of the GDP/GNP of the region. The Polynesian islands seemed to be more import-dependent than some of the Melanesian islands. For example, the Cook Islands, Western Samoa, American Samoa and French Polynesia have higher import orientation ratios compared to the Melanesian countries. Papua New Guinea, the Solomons and New Caledonia have comparatively lower import orientation ratios. Nevertheless, the Pacific islands are highly import oriented and show an increasing trend towards more import dependence in the future. The imports, according to 1979 import values from Pacific island nations, in descending order of importance were: machinery and transport equipment (23 percent), manufactured goods (20 percent), food (17 percent) and mineral fuels (15 percent).

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[7] Thirteenth South Pacific Forum, "Forum Communique," Rotorua, New Zealand, 9-10 August 1982.

Manufacturing

The high import dependency of the Pacific islands is a reflection of the small manufacturing base that exists in many of the countries of the region. The manufacturing activity in the Pacific islands is sketched here: American Samoa has fish canneries and formerly operated both a wristwatch assembly and garment manufacturing firm; the Cook Islands has processing plants for fruit juice, vegetables and fish products, which are targeted at New Zealand. French Polynesia and New Caledonia have food manufacturing, clothing, building and metal fabrication firms to satisfy domestic demand.

Fiji has the most diversified industrial resource-based industries such as sugar processing, coconut oil producing and saw milling for export. A larger number of small-scale industries in food, textiles, paper, chemicals, metal and non-metallic fabrication sectors cater to the local market. Papua New Guinea has a large market potential in terms of GDP/GNP per capita and population. But, Papua New Guinea markets are fragmented by the lack of effective communications. Consequently, provincial markets fail to integrate into a sizeable national market. Despite this limitation, a wide range of consumer and service industries are produced in Papua New Guinea in the food, textile, wood paper, non-metallic, metal and engineering sectors. These industries provide employment to over 15,000 people, while Fiji's manufacturing sector employs about 10,000 [Commonwealth Secretariat/SPEC, 1978:22]

4.2.5 Trade Patterns and Diversification Trends

This analysis can be extended by a detailed examination of both commodity and market concentration ratios for both exports and imports. Karunaratne carried out a cross-country comparison to indicate trade performance of one country relative to another, and studied trade patterns over a period of time in an attempt to reveal trends of concentration or diversification in the commodity and market mix.

Karunaratne found that imports are more diversified than exports throughout the island nations. In each island nation, it seems, there is a preference for a modern or Western lifestyle and, consequently, a demand for imported goods. Exports, on the other hand, vary according to such factors as a country's resource base and comparative trading advantage. The trend in exports seems to be toward diversification. In fact, the number of different kinds of exports is growing faster than the number of markets to which these exports are sent; however, the prospects for commodity diversification in exports (but not market diversification) are likely to change quite dramatically with the implementation of long-term planning objectives in the 1980s.

Diversification in imports is growing, particularly in the larger economies, but the Pacific nations appear to be importing the same kinds of things. Both the types of goods that are imported and the number of import markets are approaching a stable level.

4.2.6 Trade Prospects and Protectionist Policies

The trade prospects of Pacific island nations in the 1980s will be determined by a number of external and internal factors such as the prospects of an upturn in the world economy in the 1980s and the success of regional economic cooperation agreements (SPARTECA and PATCRA) with metropolitan neighbors. Besides, the benefits from the Generalized System of Preferences (GSP) and Lome (ACP-EEC Convention of Lome II) agreements will offer the island nations considerable gains from trade liberalization and consequent trade expansion.

Because the Pacific islands plan to restructure their economies in the 1980s through import substitution and export promotion in their industrial and agricultural activities, the present pattern of low tariff and non-tariff barriers that exists in the islands may change. The islands' policies are not so self-protective as those of their metropolitan neighbors, Australia and New Zealand. It is likely that as the island nations continue to industrialize, they will move toward diversification in their economic bases and they will resort to greater use of protectionist policies in the near future.

The comparatively low protection that prevails in Pacific islands becomes apparent from a brief survey of the tariff and licensing policies of some selected countries in the region. Papua New Guinea maintains a single column tariff of five to ten percent and levies tariffs mainly for revenue purposes on a series of non-essential imports such as liquor (30 percent), cars (45 percent) and radios (50 percent). Protective duties are levied on competitive imports such as chemical products (17 percent), paper bags (20 percent), nails (27 percent), barbed wire (35 percent). Fiji maintains a two-column fiscal and customs duty. The latter ranges from zero to seven percent. High tariffs ranging from 35-70 percent are levied on some consumer durables. Protective duties ranging from 25-70 percent are imposed in a large range of consumer durables (toothpaste, soaps, detergents, garments, suitcases, paper products, wire, nails and bolts). Among the range of items that are produced locally and require a license to import are certain cooking utensils, cements and foam materials.

The Solomon Islands impose high tariffs of 110 percent on non-essential imports such as saccharine, fireworks, ammunition and jewelry (80 percent). Automobiles carry a duty range of 42-70 percent. Relatively low tariffs, 20-30 percent, are levied on foodstuffs, bakery products and small goods. Western Samoa imposes a duty of 42 percent on a wide variety of products. Lower rates prevail on basic foodstuffs and agricultural imports. Automobiles carry high duties ranging from 115-135 percent. Tonga operates a two column tariff which permits imports from Commonwealth partners at a duty of 15 percent and from other sources at a duty of 33 percent. Foodstuffs and agricultural imports are allowed in Tonga at nominal duties. Cars carry duties of 46 percent [Commonwealth Secretariat/SPEC 1978:28-30].

The prospects for export and for the industrialization that accompanies import substitution in some of the larger island nations will depend on the judicious implementation of the projects identified in the development plans. Several agro-based resources processing industries such as palm oil, rice, copra and coffee in the Solomon Islands and Papua New Guinea could generate both employment and surpluses for export. This is true, too, for the exploitation of marine resources, especially fisheries, in many of the islands.

In countries such as Fiji, Tonga and Western Samoa, there appears to be more latitude for the establishment of small-scale manufacturing industries on the basis of a regional import/substitution strategy. There are a number of infrastructural and entrepreneurial constraints in some of the islands. Any such industrial scheme would require cheap power, good roads, adequate water supplies and skilled personnel. Besides natural resources, these nations have the advantage of inexpensive labor.

The Papua New Guinea/Fiji:Australia wage differential is in the range of 1:6. The differential is wider for smaller island nations (See Table 4.3). The prospects for establishing labor intensive, footloose, or standard

TABLE 4.3: HOURLY WAGE RATE IN MANUFACTURING

(male - unskilled)

	COUNTRY	US$
1.	American Samoa	1.00
2.	Cook Islands	0.40
3.	Fiji	0.80
4.	Niue	0.55
5.	New Caledonia	1.45
6.	Papua New Guinea	0.90
7.	Solomon Islands	0.25
8.	Tonga	0.30
9.	Vanuatu	0.45
10.	Western Samoa	0.30
11.	New Zealand	3.40
12.	Australia	5.15

Source: Industrial Development Profile of the Island Developing Countries of the South Pacific Region. (Prepared by the Center for International Studies) UNIDO/ICIS, 147, February, 1980:325.

ized technology industries in the islands, with Australian and New Zealand private investors' collaboration, appear promising. The incentive policies evolved by island governments in the 1980s and the effective implementation of the provision of the regional economic cooperation agreements will determine the inflow of private foreign investments to the Pacific. There are strong indications that private foreign investment will play a primary role in the trading prospects for the Pacific islands in the 1980's.

4.2.7 Hypothesis for Telecommunications

In order to examine telecommunications supply and demand for the region it is assumed that the supply of telecommunications in most developing economies is stimulated mainly by the export of primary products from the developing, peripheral country to the metropolitan or center countries. The supply and infrastructural investment in telecommunications in the post-colonial era has continued to be influenced by the colonial legacy of trade. The patterns of contact have changed with the post-independence restructuring of the islands' economies, partly due to the demand for a diversified menu of imports to meet a variety of both investment and consumption needs. It is likely, but not yet proven, that demand factors will dominate telecommunications establishment in the future. The trends of both export and import concentration ratios of many Pacific islands substantiate the thesis that demand dynamics from within, rather than external supply dynamics (as in the colonial period), will push telecommunications development in the future.

A number of variables are suitable candidates for explaining telecommunications supply and demand. Besides the concentration ratios, populations and income qualify for consideration. Because complete information on per capita telephones and telex machines was unavailable, Karunaratne used per capita telecommunications expenditure estimates. The supply and demand for telecommunications in his model were derived from a sample of data on total spending on international telecommunications per capita, a composite of telephone, telex and telegram expenditure. [ITU, 1980:3], (see Table 4.4).

Karunaratne's modeling of the situation implied that the supply and demand for telecommunications would increase with both growth of GDP/GNP per capita and increasing commodity and market diversification of both exports and imports. His analysis, based on the available cross-sectional data for the islands, confirms the overriding importance of the link between telecommunication supply and demand on the one hand, and GDP per capita and exports on the other.

Contrary to the hypothesized relationships, export diversification effects on telecommunications supply were more important than import diversification effects on telecommunications demand.[8]

Karunaratne cautions that because his analysis is based on cross-sectional data, it fails to capture the dynamics of the Pacific islands development. If sufficient data were available to conduct a time-series or pooled time-series/cross sectional analysis, it would support the hypothesis that commodity and market diversification of both imports and exports could further telecommunications expansion. Consulting economists and engineering planners also maintained that although firm statistical links could not be drawn, and the data refuted Karunaratne's hypotheses in one case, for the most part, his original hypotheses should be confirmed as the economies and telecommunications capability develop in the Pacific island nations.

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[8] The relationship between telecommunications demand and export diversification and telecommunications supply and import diversification, were not studied.

TABLE 4.4: TELECOMMUNICATIONS-TRADE DATA BASE

	COUNTRY	DOLLAR	TELEPHONY	TELEX	TELEGRAPHY
1.	American Samoa	42.5	33.7	5.6	3.2
2.	Cook Islands	11.0	6.5	3.2	1.3
3.	Fiji	7.6	4.8	2.1	0.7
4.	French Polynesia	20.0	34.5	5.2	2.0
5.	Kiribati	3.4	0.7	0.0	2.7
6.	New Caledonia	46.8	39.5	5.6	1.6
7.	Nauru	69.0	52.0	12.6	4.4
8.	Niue	20.0	11.0	0.0	9.0
9.	Papua New Guinea	7.5	6.1	1.2	0.2
10.	Solomon Islands	3.6	1.9	1.4	0.3
11.	Tonga	4.3	2.5	1.1	0.6
12.	Tuvalu	7.4	1.0	0.0	6.4
13.	Vanuatu	9.5	5.1	3.8	0.6
14.	Western Samoa	3.7	2.1	1.0	0.6

Dollar : Total expenditure on international telecommunications per capita in (A$)

Telephony : Per capita expenditure on telephony (A$)

Telex : Per capita expenditure on telex (A$)

Telegraphy : Per capita expenditure on telegraphy (A$)

Karunaratne postulates that in developing island nations, import substitution and export promotion strategies will activate telecommunications expansion further through commodity diversification than through market diversification. One possibility offered by Karunaratne is that further market diversification may not move development or increase telecommunications because it is likely that island nations are already exporting to the best possible markets.

4.2.8 The Necessity of Planning for a Balanced Telecommunications Infrastructure

If the pattern of telecommunications development in the Pacific islands were to continue to follow traditional trade network routes, the urban/rural dichotomy between the islands and the metropolitan centers would perpetuate dualism and dependency. The planning strategies of these island nations, without exception, emphasize the need to cater to the rural population--more than 70 percent of the total--in the growth process. The period from 1978 through 1980 witnessed annual rates of growth of island international telecommunications demand of 30 percent (see Table 4.5, Column 3).

As trade and economic development are fueled by rising expectations among island peoples, international telecommunications and inter-urban growth will continue to gather momentum. However, unless concerted planning is undertaken to upgrade and deliver telecommunications to the 70 percent of the population in rural environments, the present pattern of telecommunications growth will be counter developmental. This pattern will exacerbate rural/urban, rich/poor disparities and increase political instability. Among Pacific island decision-makers there is widespread appreciation of the role an appropriate telecommunications infrastructure can play in ameliorating the quality of rural life by igniting the process of rural economic develop-

TABLE 4.5: PROJECTED PER CAPITA TOTAL & RURAL TELECOMMUNICATIONS USAGE IN THE SHORT- AND LONG RUN (in millions of paid minutes)

YEAR / COUNTRY	(1) Actual Usage Per Capita (1980) (TT_t)	(2) Observed % change 1978 to 1980 (t)	(3) AAGR (%) (r)	(4) Total Usage Per Capita 1985 (TT_{1985})	(5) Total Usage Per Capita 2000 (TT_{2000})	(6) % Urban Population (1985)	(7) % Urban Population (2000)
1. American Samoa	11.4	67	29	47.8	219.31	50	55
2. Cook Islands	4.3	158	60	45.06	70.38	30	35
3. Fiji	2.3	37	17	5.04	37.64	48	45
4. French Polynesia	12.6	76	33	52.42	206.22	61	65
5. Guam	5.8*	68*	30*	21.52*	94.92	93	95
6. Kiribati	0.3	13	06	0.40	4.90	38	40
7. Nauru	22.3	23	10	35.90	364.97	100	100
8. New Caledonia	15.6	63	28	53.90	255.32	63	65
9. Niue	7.0	38	17	15.33	114.56	25	30
10. Papua New Guinea	2.8	20	09	4.28	45.82	13	20
11. Solomon Islands	0.9	435	82	17.96	14.72	14	20
12. Tokelau	1.4	68*	30*	21.52*	22.91	27	30
13. Tonga	1.4	206	74	22.32	22.91*	28	30
14. T T P I	5.8*	68*	30*	21.52*	94.92	48	50
15. Tuvalu	0.8	106	43	34.4	13.09	20	25
16. Vanuatu	3.3	211	76	55.70	54.00	32	35
17. Wallis & Futuna	5.8*	68*	30*	21.52*	94.92	28	30
18. Western Samoa	2.4	61	27	7.92	39.28	24	28
TOTAL AVERAGE	5.8	68	30	21.52	94.92	28	30

Sources and Notes:

Col. 1 ITU (1982) RTD. International Traffic Data Base 1980, Karunaratne, Appendix C:1.
Col. 2 ITU (1982) RTD. International Traffic Data Base 1980, Karunaratne, Table 4.1.
Col. 3 Compund Annual Average Growth Rate (AAGR) based on Column 2.
Col. 4 Projected on the basis of observed AAGR of Col. 3 Base = 1979.
Col. 5 Projected on the basis of observed AAGR using base = 1979
*indicates average growth rate of 30% is used in projections instead of observed.
Col. 3 $TT_{1985}=TT_{80}\ (1+.0r)^5$ where TT_t is given on Column 1 and r-AAGR in Col. 3.
Col. 4 $TT_{2000}=TT_{80}\ (1.5)^{20}$ i.e. for projections of year 2000 a 15% AAGR is assumed.

ment and providing the delivery of basic needs to rural communities. Efficient telecommunications has resounding effects on the macro-economy. Karunaratne has classified the benefits according to sector. They are catalogued in Table 4.6.

The geographical and climatic factors that operate in the Pacific islands pose several challenges to the development of an optimal telecommunications system. In 1980, the prime ministers of the Pacific nations, Australia and New Zealand formalized their recognition of the fact that the provision of modern, affordable, maintenance-simple, durable and efficient telecommunications facilities would result in massive savings in terms of opportunity costs. In their annual meeting, the Pacific Forum, the prime ministers renewed their call for upgrading telecommunications and urged collaboration with a "suitable consortium for national satellite telecommunications." As discussed in Section 3 of this report, the call--more specific this time--was reiterated at the 1982 Forum in Rotorua, New Zealand. The Forum has authorized SPEC, its secretariat, to request further information on the availibility of appropriate capacity on the United States' Tracking and Data Relay Satellite System due for launch within the next year. A speedy solution is imperative and will certainly promote integrated rural development and facilitate the implementation of development strategies to meet basic human needs and enhance economic development.

In Section 2 on the satellite options, PSSC consulting engineers noted that PALAPA (Indonesia), SAKURA (Japan) and military satellites such as FLTSATCOM and LEASAT (United States) are not viable options because they are inappropriately configured or designed and their use would possibly entail "leasing arrangements that would imply a dependency which South Pacific nations may be unwilling to accept." [Hurd, 1982:62]

TABLE 4.6 : SOME TYPICAL USERS AND BENEFITS OF TELECOMMUNICATIONS — A SECTOR ANALYSIS WITH A RURAL FOCUS

SECTOR USER	USAGE	USER BENEFIT	RURAL BENEFIT
1. Agriculture (Small holders)	Market information	Average price increase	Higher agricultural efficiency and output
2. Forest (Fire prevention agencies)	Fire warnings	Co-ordination of fire fighting	Higher forest output and employment
3. Fishing (Coastal operators)	Contact between boats and shore facilities	Contact with suppliers	Cheaper fish prices and increased nutrition & welfare
4. Mining (Small producers)	Offices and manager contact	Improved transport co-ordination	Improved rural jobs and services
5. Manufacturing (Handicrafts & traditional products)	Contact with buyers	Co-ordination of supply delivery	Expansion of production and increase employment and income
6. Infrastructure (Energy & Power)	Rapid damage or service reports	Improved supply administration	Incentive to locate activities in rural areas
7. Financial Services (Rural banks)	Rapid authorisation of rural loans	Enlarged access to funds	Increase of rural saving and investment
8. Transport (Road hauliers	Liasion between vehicles and central dispatchers	Improved utilisation of fleet	Greater rural utilisation of national transport capacity
9. Commerce (Retailers	Liasion with suppliers and customers	Reduced inventories	Lower inventory finance commitments
10. Tourism (Hotels & Lodges)	Reservations and order handling	Optimisation of occupancy rates	Expansion of tourist related rural industry and services
11. Education (Primary-Secondary)	Improved education by direct remote broadcast services	Pooling of scarce profess-ional resources through remote delivery	Improved literacy, skills, participation.
12. Private sector/ Households (Individual & PCOS)	Emergency social contact	Quicker & effective decisions and labour saving	Transport cost saving & improved quality of rural life
13. Health & Social Services	Contact between rural hospital & Specialists centres	Pooling of scarce profess-ional resources & effective use of paramedics	Improved standards of rural health and medication & preven tion & control of disease
14. Administration (Development projects)	Contact between project & central planners	Improved co-ordination & implementation	Training of rural personnel in decision making. Benefits of learning by doing

Source: Adapted from Annex A, ITU (1981)op.cit.

Because most of the island nations, acting on their own, cannot hope to meet even the capital costs of the space segment (without the terrestrial adjuncts) which earlier investigation estimated at about US$136 million [(PSSC, Vol. I, 1981, Ex. 8)], a joint approach is imperative for working out the financial modalities and bargaining strategies to purchase modern satellite technology. The advanced countries are all engaged in rapid satellite telecommunications expansion. However, the island nations must be well versed and articulate about their requirements in order to ensure appropriate consideration from metropolitan countries who otherwise might dismiss islands' needs through benign default.

Section 3 elaborates on plans to expand such existing systems as INTELSAT and INMARSAT. Also, new systems will be established in the 1980s. For example, the planned TDRSS, mentioned above, could be retrofitted to re-orient the C-band antenna on its satellite at 171°W longitude for coverage of island nations. The second generation of the Australian Domestic Satellite (AUSSAT), 1991-1993, may offer other possibilities. YURI (Japanese) and STATIONAR (Soviet) offer additional bargaining leverage. Unless modern communication technologies are tapped judiciously in concert with effective planning and regional cooperation and integration, the island economies will not make the quantum leaps in growth or provide the "critical mass" required to effectively implement integrated rural and urban planning strategies. Further, the impending technological leaps, particularly in communications, are most widely known in Western countries and are freely available from several sources.

The next section is taken from Karunaratne's analysis of potential telecommunications demands of Pacific island nations. It provides the basis for the techno-economic planning of a viable telecommunications infrastructure in these countries.

4.2.9 Projecting Short-Term (1985) and Long-Term (2000) Demand Scenarios

A short-term (1985) and long-term (2000) demand scenario is projected for urban to urban, international and rural traffic. In projecting international traffic flows, the following procedure was adopted: the annual average growth rates (AAGR) were calculated on the basis of observed percentage change in traffic flows between 1978-80 as revealed by the ITU regional data base 1980 [ITU, 1982]. The short-term demand scenario (i.e., up to 1985) for international traffic was estimated in millions of paid minutes by extrapolating the observed annual average growth rate of different island nations (see Tables 4.5, 4.8 and 4.9). It is important to acknowledge that the observed growth rate based on 1978-80 data is based on the "traffic explosion" which accompanied the introduction of quality satellite communications through the establishment of the INTELSAT international and inter-urban network.

An observed annual average growth rate (AAGR) for Pacific island nations of about 30 percent was used in the short-term demand projection (up to the year 1985). It is assumed that the spectacular 30 percent growth rate will lose some of its steam and grow at a stable rate of about half or 15 percent post-1985 up to the year 2000. Thus, on the basis of 15 percent AAGR, the aggregate international traffic demand is anticipated to increase from 23.11 million paid units to 155.88 million units or nearly a fivefold increase during the period 1985-2000.

Rural demand projections will depend on basic needs planning with primary attention devoted to basic two-way telephony and radio broadcasting. On this premise, it has been assumed that per capita telecommunications in the rural section will be 1.5 units in the short-term up to 1985 and thereafter will double to 3.0 units per capita up to the year 2000. On this basis, total potential demand for rural telecommunications will be approximately 7.07 million paid units in 1985, increasing to almost double that figure, or 15.47 million paid minutes, by the year 2000 (see Table 4.9 and summary Table 4.7).

Projected per capita telecommunications are multiplied by urban and rural populations to estimate demand (see Table 4.9). To derive short- and long-term international demand scenarios, projected international usage per capita has been multiplied by projected urban population only, while rural per capita usage has been multiplied by estimated rural population to derive the short and long-run rural demand scenarios.

The projections of international and intra-urban telecommunications demand are based on external determinants such as trade, and these are anticipated to contribute to the trend of high telecommunications growth rates in the future. However, in the rural hinterland, the realization of projected demand in the short- and long-term scenarios is contingent on careful planning and provision of an adequate rural telecommunications infrastructure. If such an infrastructure is not established, the current skewed distribution of telecommunications in the island nations will prevail, and the benefits of modern telecommunications and its multiplier effects will continue to elude the vast majority of the population. It should be reiterated that a rural telecommunications infrastructure is a cost-effective mechanism for the delivery of such basic needs as medical care, education and social services to the rural areas and outer islands.

At present, it is estimated that only ten percent of the rural community of the Pacific islands, often adjacent to commercial plantations, has even a modicum of access to basic telephony and telegraphy. Availability, however, is usually narrowly confined to the plantation-based

TABLE 4.7: TELECOMMUNCATIONS DEMAND PROJECTIONS

ITEM	YEAR					
	International 1985	International 2000	Rural 1985	Rural 2000	TOTAL 1985	TOTAL 2000
Telecommunications demand (millions of paid minutes)	23.11	155.88	7.07	15.47	30.18	171.35
Population (millions)	1.5	2.1	3.9	5.2	5.4	7.3
Per capita usage	15.4	74.2	1.8	3.0	5.6	23.5

Sources: Tables 4.8 and 4.9 Statistical Appendix

TABLE 4.8: PROJECTED PER CAPITA TOTAL & RURAL TELECOMMUNICATIONS USAGE IN THE SHORT- & LONG-RUN SCENARIOS

COUNTRY	(1) Estimated Population 1979 (millions)	(2) Observed AARG (%) based on last 5 years	(3) Projected Population 1985 (millions)	(4) Projected Population 2000 (millions)	(5) Estimated Rural Population (% Rural population) 1979 (millions)	(6) Projected Rural (% Rural of total) 1985 (millions)	(7) Projected Rural (% Rural of total) 2000 (millions)
1. American Samoa	0.0314	1.5	0.0343	0.0429	0.0146 (57)	0.0172 (50)	0.0193 (45)
2. Cook Islands	0.285	-0.7	0.0173	0.0173	0.0135 (73)	0.0121 (70)	0.1120 (65)
3. Fiji	0.6190	1.8	0.6889	0.9003	0.3900 (63)	0.0413 (60)	0.4952 (55)
4. French Polynesia	0.1446	2.2	0.1648	0.2283	0.0590 (41)	0.0064 (39)	0.0791 (35)
5. Guam	0.1000	0.6	0.1036	0.1133	0.0009 (9)	0.0072 (7)	0.0057 (5)
6. Kiribati	0.0573	1.6	0.0602	0.0808	0.0367 (64)	0.0037 (62)	0.0485 (60,
7. Nauru	0.0073	0.8	0.0076	0.0086	0.0000 (0)	0.0000 (0)	0.0000 (0)
8. New Caledonia	0.1390	1.2	0.1493	0.1785	0.0542 (39)	0.0552 (37)	0.0625 (35)
9. Niue	0.0036	-2.1	0.0033	0.0023	0.0020 (79)	0.0026 (75)	0.0016 (70)
10. Papua New Guinea	2.9940	1.9	3.3519	4.4453	2.6647 (89)	2.9161 (87)	3.5562 (80)
11. Solomon Islands	0.2177	3.1	0.2614	0.4133	0.1991 (91)	0.2248 (86)	0.3306 (80)
12. Tokelau	0.0016	0.0	0.0016	0.0016	0.0012 (75)	0.0012 (73)	0.0011 (70,
13. Tonga	0.0958	1.7	0.1060	0.1364	0.0709 (74)	0.0763 (72)	0.0955 (70)
14. T T P I	0.1325	2.3	0.1519	0.2135	0.0716 (54)	0.0790 (52)	0.1068 (50)
15. Tuvalu	0.0074	4.6	0.0098	0.0190	0.0061 (82)	0.0070 (80)	0.0142 (75)
16. Vanuatu	0.1145	4.4	0.1482	0.2828	0.0799 (70)	0.1008 (68)	0.1838 (65)
17. Wallis & Futuna	0.0102	3.3	0.0124	0.0201	0.0077 (75)	0.0089 (72)	0.0141 (70)
18. Western Samoa	0.1550	0.8	0.1626	0.1832	0.1224 (79)	0.1236 (76)	0.1319 (72)
TOTAL	4.8494	1.9	5.4341	7.2875	3.8027 (78)	3.9221 (72)	5.1645 (70)

Sources: Karunaratne, 1982, Table 16

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TABLE 4.9: PROJECTED INTERNATIONAL RURAL & TOTAL TELECOMMUNICATIONS DEMAND SCENARIOS IN 1985 AND 2000 (in millions of paid minutes)

YEAR / COUNTRY	International (Urban & Peri-Urban)		Rural		Total Demand	
	(1) D^I_{1985}	(2) D^I_{2000}	(3) D^R_{1985}	(4) D^R_{2000}	(5) ΣD_{1985}	(6) ΣD_{2000}
1. American Samoa	0.8198	5.1746	0.0260	0.0580	0.8458	5.2326
2. Cook Islands	0.2338	0.4261	0.0180	0.0340	0.2518	0.4601
3. Fiji	1.3888	15.1492	0.6200	1.4860	2.0088	16.7352
4. French Polynesia	5.3848	30.6020	0.9600	0.2370	6.3448	30.8390
5. Guam	2.0734	10.2167	0.0110	0.0170	2.0844	10.2337
6. Kiribati	0.0091	0.1583	0.0560	0.1460	0.0651	0.3043
7. Nauru	0.2728	3.1387	0.0000	0.0000	0.2728	3.1387
8. New Caledonia	5.9698	29.6235	0.0083	0.1880	5.1528	29.8115
9. Niue	0.0130	0.0790	0.0040	0.0050	0.0170	0.0840
10. Papua New Guinea	1.8649	40.7367	4.3740	10.6690	6.2383	51.4057
11. Solomon Islands	0.6572	1.2168	0.3370	0.9920	0.9942	2.2095
12. Tokelau	0.0060	0.0110	0.0020	0.0020	0.0080	0.0130
13. Tonga	0.6624	0.9374	0.1140	0.2860	0.7764	1.2234
14. T T P I	1.5690	10.1327	0.1180	0.3200	1.6870	10.4527
15. Tuvalu	0.0605	0.2487	0.0010	0.0420	0.0615	0.2907
16. Vanuatu	2.6415	5.3449	0.1520	0.5510	2.7935	5.8959
17. Wallis & Futuna	0.0747	0.5724	0.0130	0.0440	0.0877	0.6164
18. Western Samoa	0.3091	2.0105	0.1850	0.3940	0.4941	2.4045
TOTAL	23.11	155.88	7.07	15.47	30.18	171.35

Notes: $D_t = (TT_t)\ (U_t \text{ or } R_t)\ (P_t)$ where:

D_t = Projected Demand in year t

t = 1985, 2000

U_t = Percentage urban population in year t

R_t = Percentage rural population in year t

P_t = Projected population in year t

Column (1) = $D^{International}_{1985}$ $= (TT_{1985}) \times (U_{1985}) \times (P_{1985})$

(Column (1) Table 13)x(Column (6) Table (13 Karunaratne, 1982xColumn (3) Table (14).

The other columns have been analogously, *mutatis mutandis*.

larger economies of such countries as Papua New Guinea, the Solomon Islands and Fiji. The projected short-term and long-term scenarios for rural areas are modest, involving the generation of capacity to meet a demand of 7.07 million paid minutes in 1985 and 15.47 million paid minutes in the year 2000. Therefore, in relative terms, even in the year 2000 the rural telecommunications economy, or "teleconomy," demands would be less than ten percent of the total projected demand of over 171 million paid minutes. But, notwithstanding the small magnitudes, the catalytic role of rural telecommunications in integrated rural development has to be emphasized.

Beyond the short-term, the growth of the island nations will be propelled by the export-oriented, resource-based agro-industrial processing of timber, minerals, fish products (mainly tuna) and cash crops such as palm oil, coffee, cocoa, tea and spices. International telecommunications will provide some of the required support and stimuli.

In the 21st century the exploitation of marine resources, tuna fisheries and mining of polymetallic nodules could generate a bonanza for the Pacific islands which could reap tremendous benefits from the demarcation of the 200 mile economic zone. However, the benefits of a marine resources boom in the 21st century can be a chimera--an unrealistic dream--if rural populations are not integrated into the national and international telecommunications networks from the outset of planning.

Some of the technological problems that have to be solved to design an appropriate telecommunications network for the Pacific islands are quite challenging. In the next section an attempt will be made to generate some techno-economic parameters that will be useful for optimal system design and manufacture.

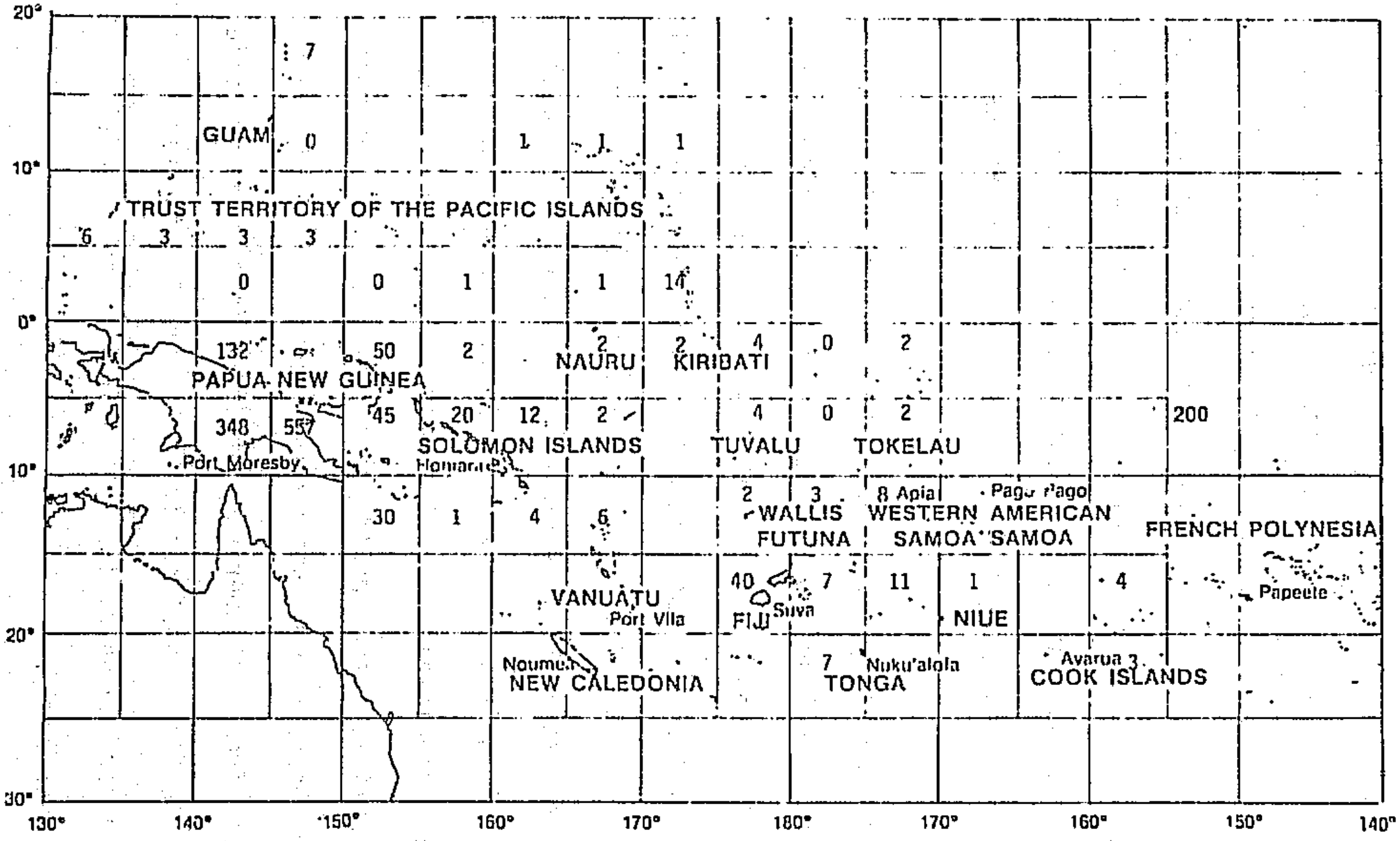
4.2.10 Techno-Economic Parameters for Systems Planning

The Pacific island nations are dispersed over 135 squares (each five degrees square) in a grid extending between 20° N to 25° S latitude and 135° W to 155° E longitude (see Map I). However, only 40 squares of the 135 squares grid would be of direct importance to "people-oriented" telecommunications planning.

The grid squares are sequentially numbered 1 through 35, and French Polynesia is assigned the code number 200 (see Map I). Each of the 5° by 5° squares, because of their geographic location, account for approximately 308.265 square kilometers. However, land covers only two percent of the total area of squares, and an even smaller fraction of this area is populated. Therefore, approaching the techno-economic planning using the grid as if planning for a spatially contiguous area would lead to serious design errors and misallocation of effort and resources. The grid's most useful function is for the computerized planning of numbers of earth stations per given population and the placement of those earth stations. These considerations are described fully in Section 3.

Clearly, the spacial dispersion of the island nations poses severe challenges to cost-minimizing or optimal telecommunications systems design. The low volume of traffic generated by archipelagic nation states that are geographically far-flung immediately lends itself to distance insensitive satellite telecommunication rather than terrestrial telecommunication. Eventually, by the turn of the century, sufficient demand would be generated in the Pacific islands to make the satellite option financially viable and politically imperative. Perhaps in the context of known technology, the option of a dedicated geosynchronous satellite with a Single Channel Per Carrier (SCPC), Demand Assignment Multiple Access (DAMA) appears feasible.

MAP I PACIFIC ISLAND NATION (5° GRID)



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Engineering expertise available to Karunaratne has indicated that a multi-beam illumination design with some loss of interconnectivity, rather than a single beam, may be inevitable. The whole telecommunications system would have to be managed as a regional organization so that island nations can benefit from economies of scale of operation and spreading of capital costs of overhead. The regional telecommunications managing organization could be one of the following: (1) a consortium, (2) a private corporation, (3) an existing regional institution or (4) a country manager appointed to represent and operate for all the Pacific island nations [PSSC, 1981: 193-195].

A noteworthy feature that future system designs may have to take into account is the land area and demography of the biggest Pacific island nation, Papua New Guinea. Papua New Guinea accounts for 85 percent of the 1/2 million km^2 total land and 60 percent of the total five million population of the Pacific island nations. Whether or not Papua New Guinea decides to use AUSSAT, PALAPA or foster a regional satellite league with other Pacific island states, the decision will result in dramatic variations in design specifications. In the long-term scenario (year 2000), an integrated optimal system would justify the satellite approach purely on the basis of observed impressive demand trends of the islands. Also, extrapolations from the experience of other developing economies and the prognostications about growth of the information sector as a whole justify planning for the satellite option in the long term (i.e., before the end of the year 2000).

The demand projections based on telecommunications and demographic growth rate trends for individual nation states, excluding special users, indicated a growth of up to 30 million paid minutes in 1985, rising by nearly six-fold to 171 million paid minutes in the year 2000. This demand expansion when disaggregated on the basis of countries can be translated to the hardware or infrastructure installations required to satisfy the anticipated demand. In the short-term scenario (up to 1985), the option of leasing transponders from existing satellites such as INTELSAT or INMARSAT, or future satellites such as TDRS, has been suggested and described fully in Section 3. It is estimated that the satisfaction of the projected demand for telecommunications traffic in 1985 would require the deployment of over 1,904 circuits of which 37 percent would cater to rural needs. The balance would be used for international and inter-urban traffic. On the basis of current norms (thick and thin route) and the state of technology, this implies that island nations will have to lease out three transponders of which one will cater to rural needs.

The potential demand when translated to hardware requirements does not favor a dedicated satellite option in the short term but rather shared use of on-the-shelf satellite space segment. The earth station requirements associated with the short-term scenario, distributed by country when aggregated, yield 306 urban and 404 rural stations. In the long-run scenario, traffic demand would require the installation of over 9,600 circuits or the equivalent of 16 transponders. Currently, the majority of twelve transponder domestic satellites at C-band have been replaced by satellites with 24 transponders. Therefore, in the long term, the demand for telecommunications in Pacific islands makes dedicated satellite communications an eminently plausible option (see Table 4.10).

A contiguous map (Map II) shows the land area of the decision-making political entities as a percentage of each 5° square and the number of estimated earth stations for the year 2000. The information in Map II and the matrix of physical distances (see Table 4.11) between various

TABLE 4.10: PROJECTIONS OF CIRCUITS AND EARTH STATIONS

COUNTRY	Short-Term Scenario (1985)		Long-Term Scenario (2000)		Total	Total	Short-Term Scenario (1985)		Long-Term Scenario (2000)		Total Earth Stations
	International & Urban (1985)	Rural (1985)	International & Urban (2000)	Rural (2000)	(1985)	(2000)	International & Urban (1985)	Rural (1985)	International & Urban (2000)	Rural (2000)	(2000)
1. American Samoa	41	3	259	6	44	265	10	2	65	5	70
2. Cook Islands	12	2	21	3	14	24	3	2	6	2	8
3. Fiji	70	62	758	149	132	907	18	47	190	112	302
4. French Polynesia	269	96	1830	24	365	1854	67	72	456	18	474
5. Guam	104	1	511	2	105	513	26	1	128	2	130
6. Kiribati	1	6	8	15	7	23	1	5	2	11	13
7. Nauru	14	0	157	0	14	157	6	0	39	0	39
8. New Caledonia	299	1	1481	19	300	1500	75	1	370	14	384
9. Niue	1	0	4	1	1	5	1	0	1	1	2
10. Papua New Guinea	94	437	2037	1067	531	3104	24	328	509	800	1309
11. Solomon Islands	33	34	61	99	67	160	8	26	15	74	89
12. Tokelau	1	0	1	0	1	1	1	0	1	0	1
13. Tonga	33	11	47	29	44	76	8	8	12	30	42
14. T T P I	78	12	507	32	90	539	20	9	152	24	176
15. Tuvalu	3	0	12	4	3	15	1	0	3	3	6
16. Vanuatu	132	15	267	55	147	322	33	11	67	41	108
17. Wallis & Futuna	4	1	29	4	5	33	1	1	7	3	10
18. Western Samoa	15	19	101	39	34	140	4	14	25	29	54
Total Circuits	1204	700	8091	1548	1904	9639	306	404	2048	1169	3217
Number of Transponders	2	1	14	2	3	16					

Norms: Assumed in Circuit and Transponder projections: 1 Satellite = 12 Transponders; 1 Transponder = 600 circuits; 600 Circuits = 1200 SCPC at 30 KHz intervals; 1200 SCPC = 500 Trunks at 1% Blockage | Source: ITU, 1981: 34 |; 1 Circuit = 20,000 Paid minute (Thick Route/International); 1 Circuit = 10,000 Paid minutes (Thin Route/Rural)

Norms: Assumed in Earth Station projection: 1 Earth Station = 0.25 Circuits (THICK ROUTE)
= 0.75 Circuits (THIN ROUTE)

Source: Table 4.9

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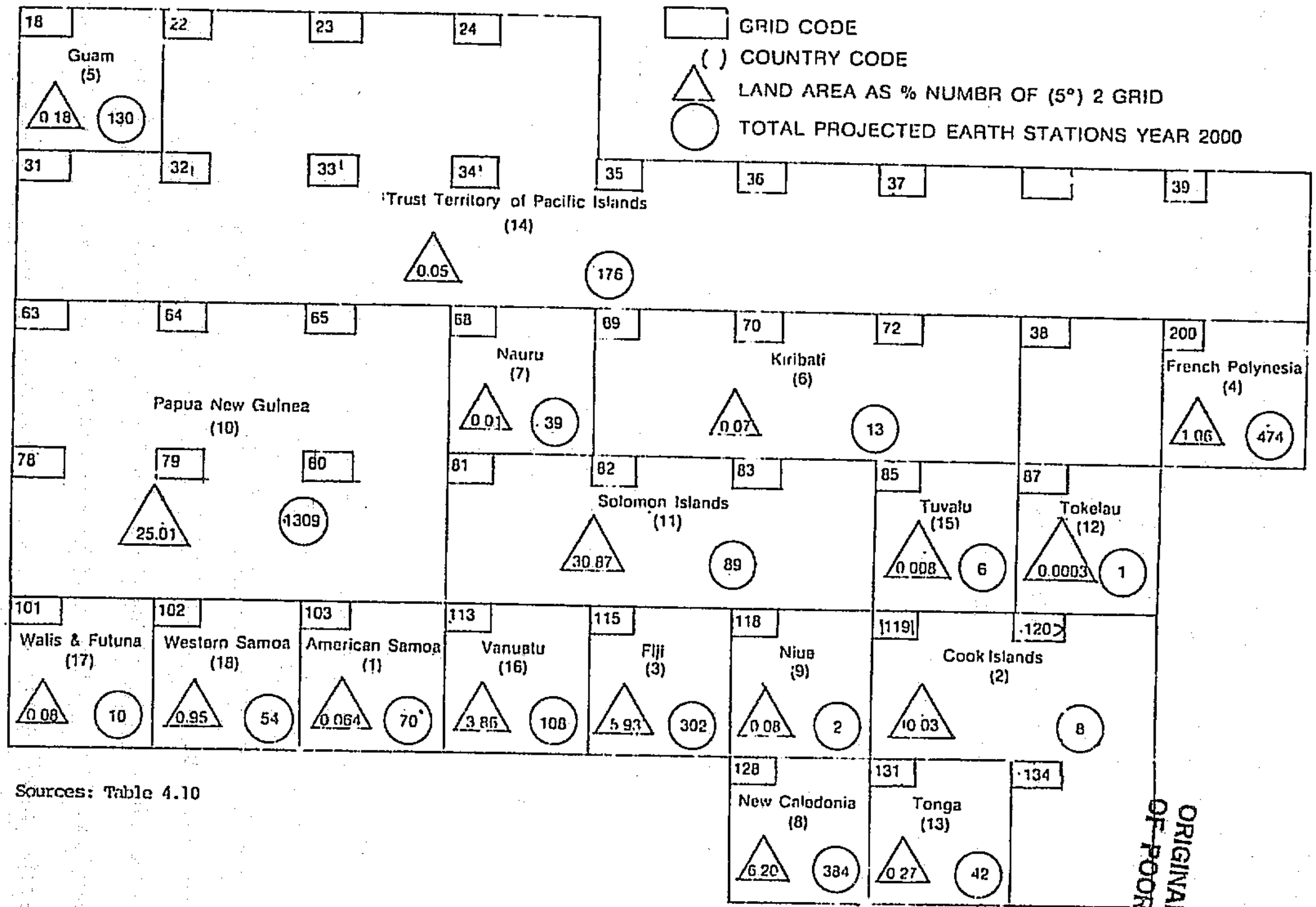
MAP II A: CONTIGUOUS MAPPING OF THE PACIFIC ISLAND NATIONS 5° SQUARE GRID



Sources: Table 4.10

capitals (or the identified location of each island nation) provides further planning data. Such information may be useful for designing an optimal antenna configuration of a multi-beam dedicated satellite, which, on the basis of demand projections, will be a viable option for the region by the year 2000. (See Table 4.11)

The techno-economic norms that have been used in the projection of circuits and earth stations are best estimates based on available technical information and have been verified by experts from the regional ITU office. These norms are recapitulated below:

1 Satellite	=	12 Transponders
1 Transponder	=	600 Full Circuits
600 Circuits	=	1200 Single Channel Per Carrier (SCPC Half Circuits Spaced at 30KHz Intervals)
1 Full Circuit	=	20,000 Paid Minutes (Thick Route)
1 Full Circuit	=	10,000 Paid Minutes (Thin Route)
1 Earth Station	=	4 Full Circuits (Thick Route)
1 Earth Station	=	1.330 Full Circuits (Thin Route)

4.2.11 Multi-Objective Reconciliation and Design Optimization

Designing an integrated telecommunications network to attain several divergent planning goals is a complex task. Although in design the central focus would be on the commercial profitability of the system, in the context of developing economies the ultimate political acceptability and development impact will depend on satisfying objectives beyond narrow commercial profitability.

In this section, some of the broader objectives of optimal systems design are investigated in a quantitative manner. Depending on the planning

TABLE 4.11: INTER-ISLAND PHYSICAL DISTANCES (KILOMETERS AND MILES)

COUNTRY (MAIN CITY)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. American Samoa (Pago Pago)	--	1448 899	1279 794	2316 1438	5743 3566	2413 1498	2781 1727	2654 1648	513 318	4923 3057	3258 2023	531 330	9410 5843	5743 3566	1279 794	2316 1438	1962 1218	1699 1055
2. Cook Islands (Avarua)		--	2413 1498	1182 734	7167 4450	3837 2382	4295 2667	3668 2277	1158 719	6250 3881	4609 2862	1834 1138	1689 1048	7191 4466	2727 1693	3499 2172	2148 1334	1568 974
3. Fiji (Suva)			--	3499 2173	5043 3131	2148 1333	2292 1423	1375 853	1279 794	3813 2368	2220 1379	1472 914	772 472	5091 3161	1062 659	1086 674	555 344	1182 734
4. French Polynesia (Pareete)				--	7939 4930	4561 2832	5091 3161	4802 2982	2220 1379	7263 4510	5574 3461	2534 1574	2823 1753	7939 4930	3547 2203	4585 2847	3137 1948	2461 1528
5. Guam					--	3378 2097	2871 1782	4585 2847	6105 3791	2485 1543	2992 1858	5405 3356	5791 3596	217 135	4440 2757	4272 2652	5067 3147	5599 3476
6. Kiribati (Tarawa)						--	700 435	2678 1663	2871 1783	3306 2053	1810 1124	2027 1258	2751 1708	3354 2082	1231 764	2099 1303	1930 1198	2075 1288
7. Nauru							--	2389 1483	3233 2008	2630 1633	1231 764	2558 1588	2992 1858	2871 1782	1593 989	1882 1168	2220 1379	2727 1693
8. New Caledonia (Noumea)								--	2582 1603	2823 1753	1617 1004	2823 1753	1979 1228	4705 2922	2051 1273	555 345	1906 1183	2534 1573
9. Niue (Alofi)									--	5091 3167	3451 2143	1086 674	627 389	6129 3806	1665 1034	2365 1468	1038 645	603 374
0. Papua New Guinea (Port Moresby)										--	1689 1049	4826 2996	4585 2847	2485 1543	3764 2337	2775 1723	4126 2562	4802 2982
11. Solomon Islands (Honiara)											--	3137 1948	3016 1872	3089 1918	2099 1303	1303 809	2461 1528	3113 1933
12. Tokelau												--	1375 854	5381 3341	1038 644	2389 1483	917 569	507 315
13. Tonga (Nuku'alofa)													--	5839 3626	1544 959	1810 1125	820 509	893 554
14. TIPI														--	4464 2772	4343 2697	5116 3177	5622 3491
15. Tuvalu (Funafuti)															--	1544 959	700 434	1158 719
16. Vanuatu (Vila)																--	1520 943	2196 1363
17. Wallis and Futuna																	--	700 435
18. Western Samoa (Apia)																		--

Notes: Measured from Map I

and political context, these broader objectives can be weighted and ranked to take account of trade offs and priorities. However, in this discussion uniform weights for the different objectives are given throughout. Moreover, some of the salient objectives of a telecommunications infrastructure will also be identified. An operational procedure follows to provide systems designers with guidelines to facilitate decision-making in the context of conflicting objectives.

Three of the major objectives an optimal telecommunications infrastructure must satisfy are: (1) user accessibility (2) user willingness and (3) the capacity of the system to meet basic needs requirements. Karunaratne has quantified the importance of each goal by constructing a composition index for each specified goal on the basis of related variables and compiling an economic data base as a prelude to the quantification of the various indicators in a "demonstration multi-objective reconciliation procedure" (see Tables 4.12 and 4.13 for the data base).

Accessibility of telecommunications to prospective users is a crucial economic and operational requirement for the construction of a viable telecommunications system. Accessibility depends on such factors as population density, urbanization and the size of the population in any specified geographic area. (See Tables 4.14, 4.15 and 4.16, which present cardinal and ordinal scores calculated on the basis of cross country data).

Accessibility without the backing of effective demand or purchasing power can lead to a non-viable design. Therefore, ability or willingness to pay for the telecommunications infrastructure use has to be evaluated in any optimization procedure. A country's ability to pay will be directly related to per capita income. Income is derived from trade, and the level of trade will be inversely related to its aid dependency.

TABLE 4.12: DATA BASE FOR TECHNO-ECONOMIC INDICATORS

COUNTRY	(1) Grid Code	(2) Land Area Km^2	(3) Land Area per 5^o square in grid	(4) Population density per Km^2	(5) % Urban in Total Population (MRE)	(6) Income: GNP/GDP $Amill. (1979)	(7) Trade: Exports per capita (A$) (1979)	(8) Aid per capita (A$) (1979)	(9) Dependency Ratio	(10) Life Expectancy Yrs (MRF)	(11) Infant Mortality rate (MRF)	(12) Persons per Doctor
1. American Samoa	103 (1)	197	0.064	159	43	126.609	3561	903	90.9	67	20	1180
2. Cook Islands	119-20, 134(3)	240	0.03	77	27	17.4	187	362	116.1	61	33	950
3. Fiji	115 (1)	18272	5.93	34	37	900.937	374	45	77.3	62	46	2070
4. French Polynesia	200 (1)	3265	1.06	44	59	675.532	176	889	81.6	61	63	1479
5. Guam	18 (1)	541	0.18	185	91	396.004	381	857	70.6	76	22	1030
6. Kiribati	69,70,72(3)	690	0.07	83	36	33.134	371	140	75.8	52	87	3070
7. Nauru	68 (1)	21	0.01	348	100	109.500	9215	0	85.1	56*	54*	700
8. New Caledonia	128 (1)	19103	6.20	7	61	931.03	2299	955	73.4	64	25	1050
9. Niue	118 (1)	259	0.08	14	18	2.787	95	1222	111.4	62	33	3910
10. Papua New Guinea	63-65,78-80(6)	462243	25.01	6	11	1551.200	292	82	87.8	49	125	1093
11. Solomon Islands	81,82,83(3)	28530	30.87	8	9	166.667	288	105	105.2	54	46	11920
12. Tokelau	87 (1)	10	0.0003	160	25	11.667	10	1000	116.6	56*	54*	2973
13. Tonga	131 (1)	699	0.27	137	26	38.167	72	219	91.4	58*	60	3460
14. T T PI	31-39 (12)	1832	0.05	72	46	[illegible].70	161	752	101.3	61	59	2230
15. Tuvalu	85 (1)	26	0.008	285	30	7.732	35	541	61.7	59	42	[illegible]00
16. Vanuatu	113 (1)	11880	3.86	10	21	43.50	323	297	93.2	55	102	3910
17. Wallis & Futuna	101 (1)	255	0.08	40	25	8.696	0	676	99.3	56	54	2500
18. Western Samoa	102 (1)	2935	0.95	53	21	43.50	106	174	104.7	62	36	2920

Notes: Column (1) See Map I for Grid numbers
Column (3) Column (2) ÷ Area of Number of 5^o square grid. N.B.: Area per 1^o square grid ≈ 111 km^2.
Source: Table 20, Karunaratne, 1982.

Sources: Table 2 Karunaratne, 1982, Tables 4.2, 4.4, 4.6, 4.8 and 4.9

South Pacific Economies 1979: Statistical Summary, SPC (1981)

TABLE 4.13: DATA BASE: PERCENTAGE SCOPES FOR TECHNO-ECONOMIC PARAMETERS

COUNTRY	(1) Land Area as % total	(2) Population Density per km^2	(3) Urban Population as % of total Population	(4) Population as % of total	(5) GDP/GNP as % of total	(6) Exports per capita as % of total	(7) Aid per capita as % of total	(8) Life expectation in years as % of total	(9) Infant Mortality as % of total	(10) Dependency ratio	(11) Doctors per person
1. American Samoa	0.04	9.23	6.27	6.5	11.05	19.84	9.79	6.25	2.07	5.53	2.43
2. Cook Islands	0.04	4.47	3.93	3.8	2.54	1.04	3.93	5.69	3.41	7.06	1.96
3. Fiji	3.32	1.97	5.39	12.76	3.93	2.08	0.49	5.78	4.76	4.70	4.27
4. French Polynesia	0.59	2.56	8.60	2.98	12.91	0.98	9.64	5.69	7.03	4.96	3.03
5. Guam	0.10	10.74	13.26	2.06	11.13	2.12	9.30	7.09	2.27	4.29	2.12
6. Kiribati	0.12	4.82	5.25	1.18	1.56	2.07	1.52	4.85	9.00	4.60	6.34
7. Nauru	0.004	20.21	14.58	0.15	40.48	51.35	0.00	5.22	5.59	5.17	1.44
8. New Caledonia	3.47	0.41	8.89	2.87	1.22	12.81	10.36	5.97	2.58	4.46	2.16
9. Niue	0.05	0.81	2.62	0.07	2.09	0.53	13.26	5.78	3.41	6.77	[illegible]
10. Papua New Guinea	83.89	0.35	1.60	61.74	1.40	1.63	0.89	4.57	12.93	5.34	2.05
11. Solomon Islands	5.18	0.46	1.31	4.49	1.45	1.60	1.14	5.04	4.76	6.40	24.56
12. Tokelau	.004	9.29	3.64*	0.03	1.31	0.06	10.85	5.22	5.59	7.09	6.14
13. Tonga	0.13	7.96	3.79	1.98	1.07	0.46	2.38	5.41	6.21	5.56	7.14
14. T T P I	0.33	4.18	6.70	2.73	1.91	0.91	8.16	5.69	6.10	6.16	4.60
15. Tuvalu	0.005	16.55	4.37	0.15	1.36	0.20	5.87	5.50	4.34	3.75	4.13
16. Vanuatu	2.16	0.58	3.06	2.36	11.22	1.80	3.22	5.13	10.55	5.67	8.07
17. Wallis and Futuna	0.05	2.32	3.64*	0.21	2.35	0.0	7.33	5.22	5.59	6.04	5.16
18. Western Samoa	0.53	3.08	3.06	3.20	0.82	0.59	1.89	5.78	3.72	6.37	6.03

TABLE 4.14: CARDINAL SCORE AND RANKING OF ACCESSIBILITY INDEX

COUNTRY	Density Score (d_i) (1)	Rank	Urbanization Score (b_i) (2)	Rank	Population Score (p_i) (3)	Rank	Composite Score (4)	
1. American Samoa	0.0923	(5)	0.0627	(6)	0.0065	(12)	0.0528	(8)
2. Cook Islands	0.0447	(8)	0.0393	(13)	0.0038	(13)	0.0293	(14)
3. Fiji	0.0197	(13)	0.0539	(7)	0.1276	(2)	0.1161	(3)
4. French Polynesia	0.0256	(11)	0.0860	(4)	0.0298	(4)	0.0671	(6)
5. Guam	0.1074	(3)	0.1326	(2)	0.0206	(9)	0.0869	(4)
6. Kiribati	0.0482	(7)	0.0525	(8)	0.0118	(11)	0.0375	(12)
7. Nauru	0.2021	(1)	0.1458	(1)	0.0015	(16)	0.1165	(2)
8. New Caledonia	0.0041	(17)	0.0889	(3)	0.0287	(6)	0.0406	(11)
9. Niue	0.0081	(14)	0.0262	(16)	0.0007	(17)	0.0117	(18)
10. Papua New Guinea	0.0035	(18)	0.0160	(17)	0.6174	(1)	0.2123	(1)
11. Solomon Islands	0.0046	(16)	0.0131	(18)	0.0449	(3)	0.0208	(17)
12. Tokelau	0.0929	(4)	0.0364	(15)	0.0003	(18)	0.0432	(10)
13. Tonga	0.0796	(6)	0.0379	(14)	0.0198	(10)	0.0595	(7)
14. T T P I	0.0418	(9)	0.0670	(5)	0.0273	(7)	0.0454	(9)
15. Tuvalu	0.1655	(2)	0.0437	(9)	0.0015	(15)	0.0702	(5)
16. Vanuatu	0.0058	(15)	0.0306	(12)	0.0236	(8)	0.0200	(15)
17. Wallis and Futuna	0.0232	(12)	0.0364	(10)	0.0021	(14)	0.0206	(16)
18. Western Samoa	0.0308	(10)	0.0306	(11)	0.0320	(5)	0.0311	(13)

Notes: Column (1) $d_i = \dfrac{\dfrac{(\text{Population})_i}{(\text{Land Area})_i}}{\sum_{i=1}^{n} \dfrac{(\text{Population})_i}{(\text{Land Area})_i}}$ Column (2) $d_i = \dfrac{\dfrac{(\text{Urbanites})_i}{(\text{Population})_i}}{\sum_{i=1}^{n} \dfrac{(\text{Urbantes})_i}{(\text{Population})_i}}$

Column (3) $p_i = \dfrac{(\text{Population})_i}{\sum_{i=1}^{n} (\text{Population})}$

Column (4) Composite score Accessibility Index $c_i = \left[\dfrac{d_i + b_i + p_i}{3}\right]$

TABLE 4.15: CARDINAL SCORES AMD RANKING ABILITY TO PAY INDEX

COUNTRY	(1) Income Score (X_i)	Rank	(2) Trade Score (Y_i)	Rank	(3) Aid Score (Z_i)	Rank	(4) Composite Accessibility Index	Rank
1. American Samoa	0.1105	(2)	0.1984	(2)	0.0059	(15)	0.1049	(2)
2. Cook Islands	0.0254	(6)	0.0104	(10)	0.0148	(9)	0.0084	(18)
3. Fiji	0.0393	(5)	0.0208	(5)	0.1185	(2)	0.0464	(5)
4. French Polynesia	0.1291	(3)	0.0098	(11)	0.0060	(14)	0.483	(4)
5. Guam	0.1113	(4)	0.0212	(4)	0.0062	(12)	0.0462	(6)
6. Kiribati	0.0156	(10)	0.0207	(6)	0.0382	(5)	0.0196	(9)
7. Nauru	0.4048	(1)	0.5135	(1)	0.5641	(1)	0.4913	(1)
8. New Caledonia	0.0122	(14)	0.1281	(3)	0.0056	(16)	0.0486	(3)
9. Niue	0.0209	(8)	0.0053	(14)	0.0047	(18)	0.0103	(16)
10. Papua New Guinea	0.0140	(13)	0.0163	(8)	0.0652	(3)	0.0318	(7)
11. Solomon Islands	0.0145	(12)	0.0160	(9)	0.0509	(4)	0.0271	(8)
12. Tokelau	0.0151	(11)	0.0006	(17)	0.0058	(17)	0.0072	(17)
13. Tonga	0.0107	(17)	0.0046	(15)	0.0244	(7)	0.0132	(12)
14. T T P I	0.0191	(9)	0.0091	(12)	0.0099	(11)	0.0127	(13)
15. Tuvalu	0.0136	(15)	0.0020	(16)	0.0183	(10)	0.0113	(14)
16. Vanuatu	0.0122	(16)	0.0180	(7)	0.0180	(8)	0.0161	(10)
17. Wallis and Futuna	0.0235	(7)	0.000	(18)	0.0079	(12)	0.0105	(15)
18. Western Samoa	0.0082	(18)	0.0059	(13)	0.0307	(6)	0.0149	(11)
TOTAL	3.0		1.000		1.000		1.0	

Notes: Column (1) Income Score $X_i = \dfrac{GNP_i/Population_i}{\sum_{i=1}^{n} (GNP_i/Population_i)}$

Column (2) Trade Score $Y_i = \dfrac{Exports_i/Population_i}{\sum_{i=1}^{n} (Exports_i/Population_i)}$

Column (3) Aid Score $Z_i = \dfrac{Aid_i/Population_i}{\sum_{i=1}^{n} (Aid_i/Population_i)}$

Column (4) Composite Ability to pay score $W_i = \left[\dfrac{X_i + Y_i + Z_i}{}\right]$

Sources: Tables 4.10 and 4.12

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TABLE 4.16: BASIC NEEDS REQUIREMENTS INDEX

COUNTRY	(1) Dependency (d_i)	(2) Life Expectancy (e_i)	(3) Mortality (f_i)	(4) Medi-care (g_i)	(5) Composite Basic needs index (n_i)	Rank
1. American Samoa	.0553	.0489	.0207	.0243	0.0389	(13)
2. Cook Islands	.0706	.0538	.0341	.0196	0.0349	(17)
3. Fiji	.0470	.0528	.0476	.0427	0.0516	(10)
4. French Polynesia	.0496	.0535	.0703	.0303	0.0434	(12)
5. Guam	.0492	.0430	.0227	.0212	0.0363	(15)
6. Kiribati	.0460	.0630	.0900	.0634	0.0628	(5)
7. Nauru	.0517	.0584	.0559	.0144	0.0300	(18)
8. New Caledonia	.0446	.0512	.0258	.0216	0.0367	(14)
9. Niue	.0677	.0528	.0341	.0807	0.0709	(3)
10. Papua New Guinea	.0534	.0669	.1293	.0206	0.0358	(16)
11. Solomon Islands	.640	.0607	.0476	.2956	0.1357	(1)
12. Tokelau	.0709	.0584	.0559	.0614	0.0618	(6)
13. Tonga	.0556	.0564	.0621	.0714	0.0667	(4)
14. T T P I	.0616	.0535	.0610	.0460	0.0535	(9)
15. Tuvalu	.0375	.0554	.0434	.0413	0.0507	(11)
16. Vanuatu	.0567	.0594	.1055	.0807	0.0709	(2)
17. Wallis & Futuna	.0604	.0584	.0559	.0516	0.0578	(8)
18. Western Samoa	.0637	.0528	.0372	.0603	0.0613	(7)

Notes:

$$e_i = \frac{\frac{1}{\text{Life Expectancy}_i}}{\sum_{i=1}^{n} \left(\frac{1}{\text{Life Expectancy}_i}\right)} \qquad d_i = \frac{\text{Dependency ratio}_i}{\sum_{i=1}^{n} \text{Dependency ratio}_i}$$

$$f_i = \frac{\text{Infant mortality rate}_i}{\sum_{i=1}^{n} \text{Infant mortality rate}_i} \qquad g_i = \frac{(\text{Doctors}/\text{Population})_i}{\sum_{i=1}^{n} (\text{Doctors}/\text{Population})_i}$$

$$n_i = \frac{\sqrt[4]{(d_i, e_i, f_i, g_i)}}{\sum_{i=1}^{n} \sqrt[4]{[d_i, e_i, f_i, g_i]}}$$

The empirical validation of basic needs requirements which telecommunications are designed to service can be quantified by using physical quality of life (PQLI) measures as proxies. Data are available for such PQLI as dependency ratios, life expectancy and infant mortality rates. Karunaratne has combined this information to provide a measure of the basic needs requirements of any locality.

When planning objectives are not compatible with systems goals, trade-offs have to be recognized, and choices have to be made. Karunaratne shows that of the three indicators investigated in this study, "accessibility" and "willingness to pay" may be compatible, but both may conflict with the objective of "providing basic needs." None of the countries in his demonstration case study satisfy the three objectives simultaneously. This is demonstrated by the tabulation of the five top ranking countries according to the three objectives:

Diagram II:
Ranking of Countries According to Telecommunications Planning

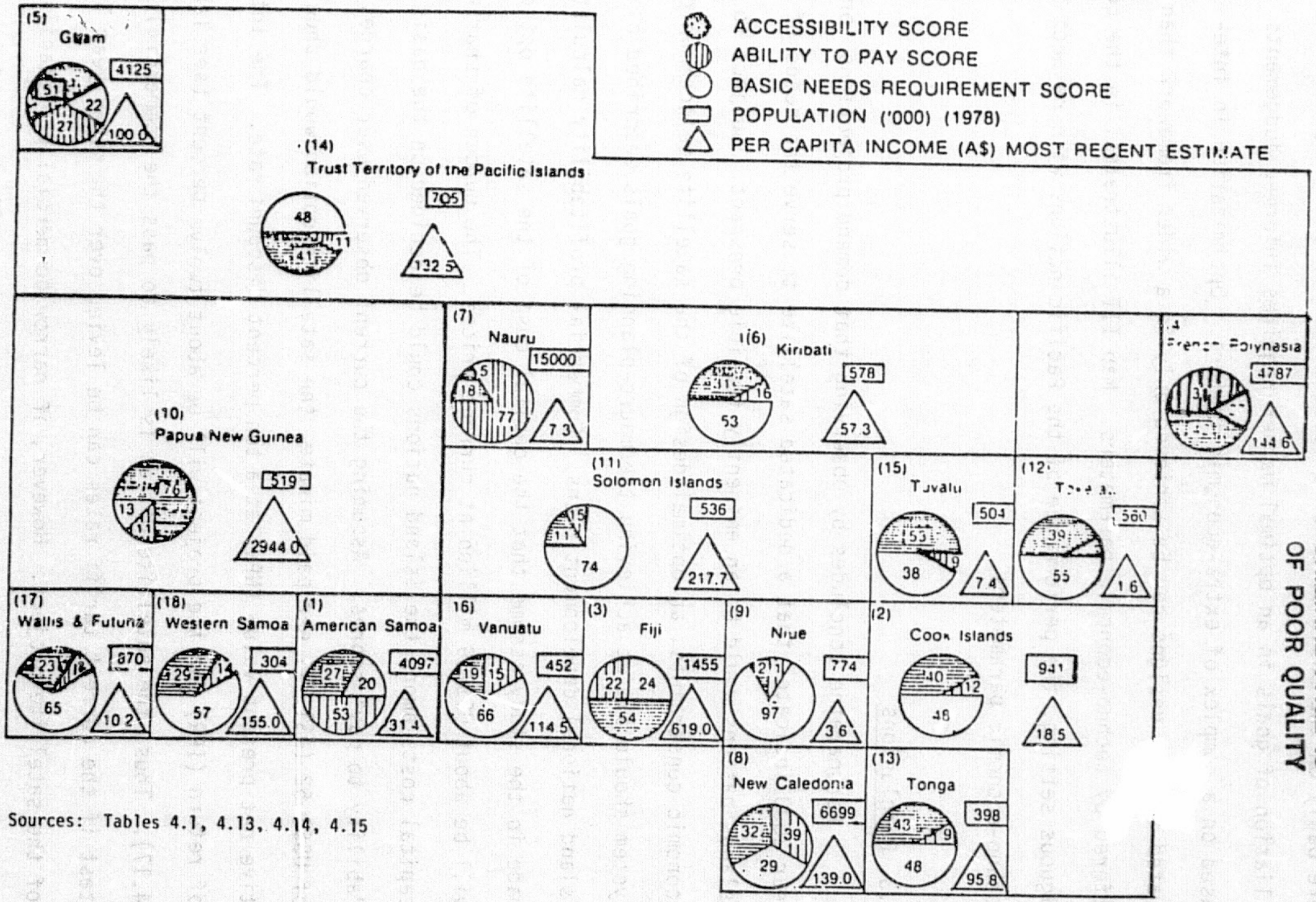
Objective Rank	Accessibility	Ability to Pay	Basic Needs Requi-ments
1	P. New Guinea	Nauru	Solomon Islands
2	Nauru	American Samoa	Vanuatu
3	Fiji	New Caledonia	Niue
4	Guam	French Polynesia	Tonga
5	Tuvalu	Fiji	Kiribati

Diagram II clearly shows that Nauru and Fiji jointly satisfy "accessibility" and "ability to pay" criteria. The intersection set of all three criteria is empty in Diagram II, as no country satisfies simultaneously all three objectives. The countries such as the Solomon Islands and Vanuatu, that rank highly according to basic needs requirements, also fare badly on the basis of other criteria. In systems design, reconciliation of goals in an optimal manner requires informed judgements based on a complex of extra-economic factors. Optimization in integrated systems designs can be achieved only in a wider framework than that offered by techno-economic parameters. Map III illustrates, in the contiguous setting, the performance of the Pacific nations with respect to techno-economic parameters.

4.3 Conclusions

Karunaratne concludes by observing that demand projections for the year 2000 indicate that a dedicated satellite to serve the needs of Pacific islands nations would be an eminently feasible prospect. Subject to techno-economic constraints, an optimal design of the satellite telecommunications system should aim at achieving the macro-planning goals described by Pacific island national development plans. Commercial profitability calculations made in the study assume that the capital cost of the satellite options will be about US$739 million at current prices. The burden of sharing the capital costs among the island nations could be decided on the basis of the "ability to pay" scores. Assuming the current observed user charges (1980) of US$1.52 (A$1.71) per paid minute, the satellite option would show a positive net present value (NPV) at a ten percent discount rate. The internal rate of return (IRR) for the project will be about twelve percent (see Table 4.17). Thus, the satellite option is likely to pass the commercial viability test if the current tariff rates can be levied over the seven year life span of the satellite project. However, if narrow commercial profitability is transcended and if the rural and macro-multiplier effects are taken into account, the social profitability of the satellite option will undoubtedly exceed the commercial profitability. And, of course, to be politically

MAP III RELATIVE IMPORTANCE (IN PERCENTAGE TERMS) OF SOME TECHNO-ECONOMIC PARAMETERS



Sources: Tables 4.1, 4.13, 4.14, 4.15

TABLE 4.17: A COMMERICAL PROFITABILITY ANALYSIS OF THE SATELLITE OPTION

a. Capital Costs

Space segment (satellite plus spare)	136
Earth Stations (3217 x US$0.025)	80
Public Call Offices (0.5 million km^2 x US$0.01)	200
Other ground segment adjuncts (networks, switching: 2.5 x (2)	200
Risk premia and contingencies, etc.	123
Sub-Total	739

b. Revenue

Capacity demand in year 2000 is 171 million paid minutes. 1980 observed cost per paid minute in Pacific island nations is US$1.52 (A$1.71). 260

DISCOUNTED CASH FLOW ANALYSIS (US$ million)

(Assumed life-span 7 years)

Year	0	1	2	3	4	5	6	7
Capital Cost	-739							
Operating Costs		-19	-55	-74	-74	-74	-74	-74
Capacity Use (%)		(25)	(75)	(100)	(100)	(100)	(100)	(100)
Revenue		+65	+195	+260	+260	+260	+260	+260
Net Cash Flow	-739	+46	+140	+186	+186	+186	+186	+186
DCF (Discounted Cash Flow) 10%	-739	41.8	115.7	139.7	177.6	139		
NPV (Net present value)	+144							
IRR (Internal Rate of Return)	i = 12% Assuming a salvage value of US$127.							

Sources: Tables 4.9-4.10, ITU, (1981), ITU, (1982), PSSC, (1981).

acceptable, any new telecommunications system must show potential social profitability.

4.4 Recommendations

The satellite option presents the only means of delivering basic needs to the rural areas in a timely and cost-effective manner. A comprehensive exercise to determine more precisely the commercial and social profitability of the satellite option is, therefore, the first recommendation of this study. Because of the costly capital investment required to install modern satellite telecommunications, it is imperative that the Pacific islands pursue a regional or joint approach to finance the capital investment and operations of the project. Only such an approach to share the costs and benefits of the network, according to capacity to pay initially, can make the satellite option an operational reality. A regional approach will also provide leverage to a regional managerial body to bargain with equipment suppliers for the best possible deal for on-the-shelf or future space and ground segment hardware. The second recommendation, then, is that the nations should establish a regional body to manage the operation of the proposed integrated satellite telecommunications system and then to negotiate for equipment to best utilize the capital investment.

A third recommendation is that the Pacific islands or their spokesperson should explore the non-Pacific funding alternatives. Metropolitan countries could be persuaded to provide a Pacific island footprint on a planned satellite at a marginal cost to them. As pointed out at UNISPACE '82 by representatives of third world nations, the issues of world domination and militaristic and strategic goals cause superpowers to lose sight of the benign role modern technology can play in contributing to the development of mankind. The use of satellite communications is likely to accele ate in the coming decades, and there is bound to be much capacity that can be turned to humanitarian and benevolent purposes. A coordinated approach needs to be pursued by Pacific island representatives in international forums to persuade metropolitan powers to translate rhetorical concern for the third world into deeds. Telecommunications provides such an opportunity.

In order to negotiate efficiently with technology suppliers, the Pacific islands need to marshall their facts and monitor closely the rapid developments that are occurring in the field. Pacific nations' central planning offices should be committed to compiling the required information to ensure successful implementation and maintenance of telecommunications projects. Fourthly, it is recommended that in the island context, prospective telecommunications planning should be declared a priority area.

Fifthly, it is recommended that manpower training programs should be undertaken well in advance. Although modern satellite telecommunications technology is designed for low maintenance, skills are required to manage and operate the sophisticated systems efficiently. Manpower training should, therefore, be undertaken well in advance to localize, as far as possible, the technical and managerial operations of the proposed regional telecommunications project.

The lack of adequate information on the appropriateness of modern telecommunications technology and the absence of technical expertise can cause developing Pacific island nations to be victims of predatory dumping. Pacific island nations must not act in haste to accept new technology, as they may be accepting obsolescent hardware. Adequate information on appropriate technology and technical expertise is necessary to safeguard against this danger. Suppliers, experts and consultants now perform these functions. In the long-run, the Pacific island nations will have to develop the capacity to safeguard their interests as technology buyers. In the short-run, the Pacific islands will depend on the goodwill of the technology suppliers to ensure a fair deal. Thus, sixthly, it is recommended that supplier credentials be carefully examined before developing economies commit themselves to consultancies or award tenders for economic development of this nature.

The focus of the present study has been mainly on the delivery of basic voice and message services via satellite to the Pacific islands. There are, in addition, other potential growth areas such as television, mobile telecommunications and remote sensing, which must be considered as advances in the technology become available and closely monitored for appropriate application in the Pacific island nations.

5. ECONOMIC, FINANCIAL AND INSTITUTIONAL ASPECTS OF A COMMUNICATIONS SATELLITE SYSTEM FOR THE PACIFIC

Considerations of an economic, financial and institutional nature related to the establishment of an interim and a permanent system for commercial communication by satellite, both domestic and international, within the Pacific basin countries, islands and territories, have been outlined by Dr. Marcellus Snow in a report prepared under contract to PSSC (see Section 1.9).

Most of Dr. Snow's consulting report, "Economic, Financial and Institutional Aspects of a Communications Satellite System for the Pacific Basin," has been incorporated into Section 5. A section of his report, which addresses econometric modeling, is deleted from the text and is presented in its entirety as Appendix D.

As with Dr. Karunaratne's work, constraints of time and other resources have necessitated compromises in the ideally desirable research agenda and procedure. Nearly all data and analysis have been carried out on a macroeconomic or aggregative level, rather than on a country-by-country basis. In most cases, however, traffic is disaggregated into international/urban and domestic/rural categories. Also, a number of findings and suggestions have remained at the qualitative level. Rigorously quantitative analysis is undertaken of the INTELSAT and INMARSAT options for the interim Pacific Basin system.

The report provides an additional degree of disaggregation by both including and excluding French Polynesia and New Caledonia in most statistical tables. On the one hand, these two areas were included in all the projections of Dr. Karunaratne's work, from which Snow's input data are based, and it seemed unwise to neglect totally the data on those areas. French Polynesia and New Caledonia are unique among the 18 entities considered here in that they are integral parts of metropolitan France. Although they have to date not been included in the telecommunications planning of the International Telecommunication Union regional project, the share of total anticipated traffic of these two areas is considerable, and it was worthwhile to show all traffic, facilities and financial figures for the cases both including and excluding French Polynesia and New Caledonia, abbreviated here as FP/NC.

Section 5.1 projects traffic requirements in terms of paid minutes, circuits, earth stations and transponders for the period 1985-1991. This seven-year period is selected for illustration of the INTELSAT and INMARSAT scenarios to satisfy the anticipated traffic. Seven years is the present lifetime of satellites by most engineering and accounting standards; in addition, 1985 seems the earliest likely date for beginning operation using either of these interim systems.

Section 5.2 presents the INTELSAT option in considerable detail, including costs for transponders, earth stations, salaries, depreciation, interest and miscellaneous overhead. Appendix D examines various charging options and projects revenue and operating surplus or loss for each such option. The concept of price elasticity of demand and the theory of inverse elasticity and marginal cost pricing are also set forth in that Appendix, where three tariff scenarios are examined on the basis of a four-equation system which provides for inverse-elasticity pricing, recovery of operating costs by revenue and projection of demand on the basis of assumed price changes and elasticities of demand.

Section 5.3, in somewhat less detail, discusses the INMARSAT option and contrasts it with INTELSAT. In Section 5.4, based on Karunaratne's findings, is a discussion of the implications of trade, economic growth, strucutural change and tariff policy for telecommunications traffic and revenue. The sketch of a business plan for a permanent Pacific Basin satellite system during the period 1992-2000 is given in Section 5.5, and Section 5.6 examines a number of vital institutional questions which arise when a regional satellite system is considered for the Pacific Basin. Section 5.7 provides a summary and conclusions. Tables have been inserted following relevant text.

5.1 Projection of Paid Minutes, Circuits, Earth Stations and Transponders for the Period 1985-1991

5.1.1 Paid Minutes

Table 5.1 reproduces input projections from Karunaratne (1982) for international/urban and domestic/rural traffic in paid minutes. The average annual growth rate over the period 1985-2000 is then inferred and used to project annual figures for the seven year period 1985-1991 in both traffic categories and both including and excluding FP/NC.

In Section 4, Karunaratne disregarded any effects prices have on demand. While this flies in the face of economic reality by assuming that users are not sensitive to the price of services they are purchasing, such an assumption is an often necessary evil in early stages of telecommunications studies, for a number of reasons. First, almost no studies are extant on the price sensitivity or ability to pay--price elasticity (responsiveness to changes in price) of demand, a concept used in Appendix D--for telecommunications services in developing regions. Second, one must make assumptions regarding the tariff struc-

TABLE 5.1: PAID MINUTES OF TRAFFIC, 1985-91 AND 2000

	Paid Minutes (000,000)					
	Including FP/NC			Excluding FP/NC		
Year	Int'l/ Urban	Domestic/ Rural	Total	Int'l/ Urban	Domestic/ Rural	Total
1985	23.11	7.07	30.18	11.76	6.03	17.79
2000	155.88	15.47	171.35	95.66	15.03	110.70
Average Annual Growth Rate (%)	13.6	5.4	12.3	15.0	6.3	13.0
Projections for 1985-91 at growth rates indicated:						
1985	23.11	7.07	30.18	11.76	6.03	17.79
1986	26.25	7.45	33.89	13.52	6.41	19.93
1987	29.82	7.85	37.67	15.55	6.81	22.36
1988	33.88	8.28	42.16	17.89	7.24	25.13
1989	38.49	8.73	47.22	20.57	7.70	28.27
1990	43.72	9.20	52.92	23.65	8.18	31.83
1991	49.67	9.69	59.36	27.20	8.70	35.90

Source (1985 and 2000 only): Karunaratne (1982)

tures that will be used. In addition, there is an undeniably strong "autonomous" growth component in telecommunications figures that reflects national and world economic and other conditions generally above and beyond any sensitivity to the price of services. Finally, it might well be that price sensitivity (elasticity of demand) is so low (inelastic) in the range of present and projected future prices that price can be legitimately ignored as a first approximation. For these reasons, Snow follows Karunaratne in ignoring price effects. In Appendix D, however, the question of ability to pay will be looked at in several different scenarios.

5.1.2 Circuits

Table 5.2 derives equivalent telephone-grade circuits based on the paid minutes indicated in Table 5.1. Karunaratne's figures for earth stations in 1985 and 2000 are used to calculate an average annual growth rate over that fifteen-year period. Those growth rates are then used to project circuit requirements for the period 1985-1991. For simplicity, all traffic in this report is converted to equivalent voice-grade (telephone) circuits.

The original circuit projections were based on the following equivalencies:

1 circuit = 10,000 paid minutes annually
(domestic/rural thin route)

1 circuit = 20,000 paid minutes annually
(international/urban thick route)

These are best guesses at the true ratios. While approximate, they are based on the estimates and experience of senior ITU officials and

TABLE 5.2: VOICE-GRADE CIRCUITS, 1985-91 AND 2000

	Voice-Grade Circuits					
	Including FP/NC			Excluding FP/NC		
Year	Int'l/ Urban	Domestic/ Rural	Total	Int'l/ Urban	Domestic/ Rural	Total
1985	1204	700	1904	636	603	1239
2000	8091	1548	9639	4780	1505	6285
Average Annual Growth Rate (%)	13.5	5.4	11.4	14.4	6.3	11.4
Projections for 1985-91 at growth rates indicated:						
1985	1204	700	1904	636	603	1239
1986	1367	738	2105	728	641	1369
1987	1551	778	2329	832	681	1513
1988	1760	820	2580	952	724	1676
1989	1998	864	2862	1089	770	1859
1990	2268	911	3179	1246	818	2064
1991	2574	960	3534	1426	870	2296

Source (1985 and 2000 only): Karunaratne (1982)

others. Nevertheless, these equivalencies offer considerable leeway for more intensive use of existing capacity, since there are 525,600 minutes in a 365-day year.

5.1.3 Earth Stations

Karunaratne calculated earth station requirements according to the following ratios:

1.33 circuits = 1 earth station (domestic/rural thin route)

4.0 circuits = 1 earth station (international/urban thick route)

Again, while highly approximative, these assumed estimates are in accord with the experience of telecommunications engineers and traffic experts. The ratios differ by a factor of three as between thick and thin routes.

In Table 5.3, the previously calculated earth station requirements in all categories for the years 1985 and 2000 are converted into average annual growth rates. This time, however, figures are calculated only for the year 1991 based on those growth rates because the interim system to be discussed below in various cost and pricing scenarios is assumed to cover the seven-year period 1985-91, and the complement of earth stations to be acquired and installed in 1985 will be set so as to satisfy 1991 traffic levels. This is once more in accord with usual telecommunications facilities planning. Slippage of earth station completion dates in the past has been a major factor in inhibiting the growth of satellite circuit usage. In addition, some redundancy is desirable in case of outages of earth stations or faster than anticipated traffic growth. For these and other reasons, all 1985-1991 interim scenarios assume 1985 installation of earth stations

TABLE 5.3: EARTH STATIONS, 1985, 1991 AND 2000

	Earth Stations					
	Including FP/NC			Excluding FP/NC		
Year	Int'l/ Urban	Domestic/ Rural	Total	Int'l/ Urban	Domestic/ Rural	Total
1985	306	404	710	164	331	495
2000	2048	1169	3217	1222	1137	2359
Average Annual Growth Rate (%)	13.5	7.3	10.6	14.3	8.6	11.0
Projections for 1991 at growth rates indicated:						
1991	654	617	1271	366	543	909

Source (1985 and 2000 only): Karunaratne (1982)

sufficient to accommodate traffic at 1991 levels.

5.1.4 Transponders

Transponders are the basic modular components of a communications satellite. Many satellites of the present generation are equipped with twelve transponders. For a variety of technical and other reasons it is often convenient to reckon communications capacity in terms of transponders as well as circuits. INTELSAT, for example, leases whole, half and quarter transponders for domestic usage.

Like the other equivalencies used above, the ratio of circuits to transponders is indefinite. Nevertheless, the figure of 600 circuits per transponder found approval among the satellite engineering experts consulted, and is used in this report. Since this figure is particularly subject to variation, however, it will be assumed that 600 to 700 circuits can be derived from one transponder, perhaps with some degradation of signal quality but at a level still basically acceptable in the setting under discussion. Thus, in Table 5.4, which projects transponder levels for 1985-91, figures superscripted with a "+" sign mean that up to 700 circuits per transponder are assumed. The total figure of three plus transponders for 1985, for example, (including FP/NC) means that more than 600 but less than 700 circuits per transponder are needed to derive the 1,904 circuits from three transponders.

5.2 The INTELSAT Option--Costs and Tariff Scenarios, 1985-1991

At this point, the study becomes sensitive to assumptions regarding how the described traffic will be met. This will affect costs and possible tariff scenarios. This section discusses the option of leasing transponders from INTELSAT. Since INTELSAT satellites have a particular power,

TABLE 5.4: TRANSPONDERS, 1985-91

	Transponders					
	Including FP/NC			Excluding FP/NC		
Year	Int'l/ Urban	Domestic/ Rural	Total	Int'l/ Urban	Domestic/ Rural	Total
1985	2+	1+	3+	1+	1+	2+
1986	2+	2	4+	2	1+	3+
1987	3	2	5	2	1+	3+
1988	3	2	5	2	2	4
1989	4	2	6	2	2	4
1990	4	2	6	2+	2	4+
1991	5	2	7	3	2	5

Source: Circuit figures from Table 5.2, using ratio of 600 circuits per transponder.

Note: "+" means based on 600 to 700 circuits per transponder.

this has implications for the size, power and cost of earth stations. These costs, in turn, have implications for the structure and level of tariffs applied.

Since 1973, INTELSAT has leased whole, half and quarter transponders for domestic usage. The annual rate was originally $1,000,000 per transponder, which since has been reduced to $800,000 (global beam). The current rate of $800,000 is also assumed for the 1985-1991 time period, although by then (if it follows the pattern of other INTELSAT rates) it may well be substantially lower. Thus, using the $800,000 rate builds an element of conservatism into the INTELSAT scenario outcome, although it will be seen that space segment costs (in the form of transponder leasing charges) constitute only a small part of overall costs, which are dominated by earth station and operating costs.

Another consideration for the INTELSAT case is the requirement by INTELSAT that leased transponder capacity be used for domestic purposes only. This requirement was based on the fear that leased transponders, if used for international traffic, could drain traffic and revenue away from the more profitable international leased circuits on which INTELSAT tariffs and traffic are traditionally based.

The INTELSAT scenario assumes that transponders leased from INTELSAT can and will be used for some international traffic, e.g., from Fiji to Papua New Guinea or from Tonga to Western Samoa. To enable such traffic to be carried on leased INTELSAT transponders, in turn, requires the assumption that INTELSAT could be successfully approached and requested to allow an exception to its "domestic only" requirement for leased transponders. The institutional considerations in obtaining such an exception will be discussed in Section 5.6 below. For present purposes we assume that such an exception has been granted.

One final aspect of cost figures is that they are presented in current (nominal) U.S. dollars. In other words, no attempt has been made to discount to indicate the effects of inflation or the difference between a dollar spent today as opposed to several years in the future. Time discounting always presents the difficulty of choosing appropriate discount rates. This is particularly difficult in an area of rapid technological development such as telecommunications, where new processes and products emerge regularly. All cost figures presented in this study are undiscounted because the fall in costs and prices of such telecommunications hardware as earth stations and satellites due to technological progress is roughly equal to the rate of international inflation, at least as a first approximation.

5.2.1 Transponder Costs

Table 5.5 shows costs of INTELSAT transponder leasing at the rate of $800,000 per transponder. There is no disaggregation as to type of traffic (international/urban vs. domestic/rural), but the distinction between inclusion and exclusion of FP/NC is maintained.

5.2.2 Earth Stations

Under the INTELSAT option it is assumed that each of the 16 or 18 Pacific Basin areas must maintain a "base" earth station at an international gateway to maintain interconnectivity with the rest of its earth stations. This is in lieu of the less realistic assumption that demand assignment would be extensively used to remove the need for such interconnectivity.

Estimation of earth station costs is in many ways difficult, par-

TABLE 5.5: TRANSPONDER LEASING COSTS (INTELSAT OPTION)

	Including FP/NC		Excluding FP/NC	
Year	No. of Transponders	Cost ($000)	No. of Transponders	Cost ($000)
1985	3+	2400	2+	1600
1986	4+	3200	3+	2400
1987	5	4000	3+	2400
1988	5	4000	4	3200
1989	6	4800	4	3200
1990	6	4800	4+	3200
1991	7	5600	5	4000

Source: Transponder figures from Table 5.2.
Transponders @ $800,000.

ticularly when one deals, as in the present case, with earth stations destined for 1985 acquisition and installation at a level sufficient to satisfy demand through 1991. Nevertheless, consultation with senior ITU financial and engineering advisors provided realistic and plausible estimates. Specifically, base earth stations (one per entity) are assumed to cost $1 million each, and the remaining ("hinterland") earth stations are assumed to cost $120,000 each. The base earth stations would be slightly smaller and less expensive than the INTELSAT Standard B models, and would have dishes with diameters of approximately eight meters. The hinterland stations, providing ten watts per channel, would require 6.5 meter dishes. Further assumptions regarding the earth stations will be made in calculating operating costs. Table 5.6 summarizes earth station acquisition costs.

5.2.3 Operating, Maintenance and Management (OMM) Costs

An extensive ITU paper (1978) is used as a guide for calculating OMM costs associated with the ground segment of the INTELSAT option. These are classified as follows, with results as indicated in Table 5.7.

Expatriates (Foreign Personnel)

It is assumed that one expatriate will be required at each base earth station. ITU (1978) lists an expatriate's salary at $17,500 annually for 1979. It is assumed that this grows at ten percent annually, reaching the levels indicated in Table 5.7 for the years 1985-1991.

Senior Technicians (Local Personnel)

It is assumed that one senior technician will be required at each base earth station and at each hinterland earth station. ITU (1978)

TABLE 5.6: EARTH STATION ACQUISITION COSTS (INTELSAT OPTION)

INCLUDING FP/NC	($000)
18 base ES @ $1,000,000	18,000
1271 - 18= 1253 hinterland ES @ $120,000	150,360
Total ES Cost	168,360
EXCLUDING FP/NC	
16 base ES @ $1,000,000	16,000
909 - 16= 893 hinterland ES @ $120,000	107,160
Total ES Cost	123,160

Source: Earth station figures from Table 5.3.

TABLE 5.7: OMM EXPENSE (INTELSAT OPTION)

Year	($) * Expatriate Salary	# of ** Expatriates	($000) Total Expatriate Salary	($) Senior * Technician Salary	# of ** Senior Technicians	($000) Total Senior Technician Salary	($000) Misc. *** Overhead	($000) Total OMM
				INCLUDING FP/NC				
1985	31002	18	558	10629	1271	13509	9520	23587
1986	34103	18	614	11692	1271	14861	10525	26000
1987	37513	18	675	12861	1271	16346	11645	28666
1988	41264	18	743	14175	1271	18016	12900	31659
1989	45390	18	817	15562	1271	19779	14310	34906
1990	49930	18	899	17119	1271	21758	15895	38552
1991	54922	18	989	18831	1271	23934	17670	42593
				EXCLUDING FP/NC				
1985	31002	16	496	10629	909	9662	6195	16353
1986	34103	16	546	11692	909	10628	6845	18019
1987	37513	16	600	12861	909	11691	7565	19856
1988	41264	16	660	14175	909	12885	8380	21925
1989	45390	16	726	15562	909	14146	9295	24167
1990	49930	16	799	17119	909	15561	10320	26680
1991	54922	16	879	18831	909	17117	11480	29476

Source: Tables 5.2 and 5.3.
*Grown at ten percent annually from levels in ITU (1978), Annex 2.
**One expatriate per base earth station; one senior technician per base and hinterland earth station.
***$5,000 per circuit.

lists a senior technician's salary at $6,000 annually for 1979. It is assumed that this grows at ten percent annually, reaching levels indicated in Table 5.7 for the years 1985-1991.

Miscellaneous Overhead

This particularly difficult estimate is needed to aggregate all indirect and overhead costs associated with the provision of service under the INTELSAT option. ITU (1978) provides detailed insight into the types of expenses this involves, including such diverse matters as earth station power, land lines from the earth station to local distribution networks, allocated overhead fro the national and international PTT administrations, secretarial and other backup support and so on. The overhead cost of $5,000 per circuit to be assumed for the INTELSAT option is admittedly arbitrary, but it is consistent with previous studies by Snow (1975, 1976) of communications satellite system costs.

It should be noted that this figure is the most truly traffic-sensitive cost. As such it comes close to being a short-run marginal cost in the economic sense, and will be important in projecting tariff scenarios to be detailed in Appendix D.

Table 5.7 marshalls cost data for OMM expenses under the INTELSAT option.

5.2.4 Depreciation and Interest

In Table 5.8, the earth station acquisition costs incurred in 1985 are depreciated over a 15-year period. This is normal for an earth station according to ITU and other accepted accounting practices [ITU (1978)] and reflects the expected useful lifetime of an earth station. This means, of course, that depreciation and usage of the

TABLE 5.8: DEPRECIATION AND INTEREST (INTELSAT OPTION)

	Including FP/NC		Excluding FP/NC	
Year	($000) Depreciation *	($000) Interest **	($000) Depreciation *	($000) Interest **
1985	11224	13253	8211	9695
1986	11224	12747	8211	9324
1987	11224	12203	8211	8927
1988	11224	11613	8211	8496
1989	11224	10972	8211	8026
1990	11224	10273	8211	7515
1991	11224	9529	8211	6971

Source: Table 5.6.
*1/15 of annual earth station acquisition cost.
**Based on eight percent loan over 15 years earth station acquisition.

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earth stations acquired in 1985 would continue until 1999, i.e., eight years beyond the terminal year of 1991 used for the interim scenarios. Depreciation is on a straight-line basis.

In addition, Table 5.8 shows interest payments on an assumed 15-year loan at 8 percent. Like the depreciation allowances, loan payments would continue eight years beyond the end of the interim period 1985-91. Although eight percent is probably only about half the commercial world rate that would have to be paid by a telecommunications authority in the developing world, it reflects, at least as an order of magnitude, the subsidized loan rate which would be available via multilateral development lending agencies such as the IBRD (World Bank).

5.2.5 Total Costs, Costs per Paid Minute and Costs per Circuit

Costs for the INTELSAT option are summarized in Table 5.9, which reproduces and aggregates the cost categories developed up to this point. Additional columns report costs on a per paid minute and per circuit basis.

5.2.6 Interpretation of INTELSAT Option Total Costs

As Table 5.9 indicates, total annual costs of the INTELSAT option would grow from $50.5 million in 1985 to $68.9 million in 1991 if FP/NC traffic is included, and from $35.9 million to $48.7 million otherwise. Perhaps more instructive are the costs per circuit and per paid minute. Per circuit costs would fall over the same period from $26,504 to $19,509 if FP/NC traffic is included, and from $28,942 to $21,193 otherwise. The costs per paid minute allow the most direct comparison with current published tariffs in the South Pacific region.

TABLE 5.9: TOTAL COSTS, COSTS PER PAID MINUTE AND COSTS PER CIRCUIT (INTELSAT OPTION)

Year	($000) Transponder Leasing	($000) Omm	($000) Depreciation	($000) Interest	($000) Total Cost	($) Cost Per Circuit	($) Cost Per Paid Minute
			INCLUDING FP/NC				
1985	2400	23587	11224	13253	50464	26504	1.67
1986	3200	26000	11224	12747	53171	25259	1.57
1987	4000	28666	11224	12203	56093	24085	1.49
1988	4000	31659	11224	11613	58496	22673	1.39
1989	4800	34906	11224	10972	61902	21629	1.31
1990	4800	38552	11224	10273	64849	20399	1.23
1991	5600	42539	11224	9529	68946	19509	1.16
			EXCLUDING FP/NC				
1985	1600	16353	8211	9695	35859	28942	2.02
1986	2400	18019	8211	9324	37954	27724	1.90
1987	2400	19856	8211	8927	39394	26037	1.76
1988	3200	21925	8211	8426	41832	24959	1.66
1989	3200	24167	8211	8026	43604	23456	1.54
1990	3200	26680	8211	7515	45606	22096	1.43
1991	4000	29476	8211	6971	48658	21193	1.36

Sources: Tables 5.2, 5.5, 5.6, 5.7, 5.8.

Per minute costs would decline from $1.67 to $1.16 from 1985 to 1991 if FP/NC traffic is included, and from $2.02 to $1.36 otherwise.

Table 5.10 summarizes the latest available equivalent per-minute tariffs for various types of telephone service within and among selected South Pacific areas. This allows comparison with the costs of an interim INTELSAT system for the period 1985-1991, which were just estimated.

The tariffs most likely to reflect costs are those for international service. Indeed, they may be somewhat above costs, since it is normal PTT practice to subsidize domestic service with international traffic, which is less price elastic. Thus, international but intra-regional tariffs such as from Fiji ($1.69 per minute), Nauru ($2.00 per minute), the Solomon Islands ($1.71 per minute) and Western Samoa ($1.27 per minute) offer what is arguably an upper limit on costs, since such service is very unlikely to be tariffed below cost. Domestic tariffs, on the other hand, are probably priced at well below cost and are not as reliable an indicator of the costs they intend to recover.

Even the lowest of these international tariffs--that of $1.27 per minute--exceeds the anticipated 1990 and 1991 cost under the INTELSAT option that included FP/NC traffic. In general, the per-minute costs of either INTELSAT option are of the same order of magnitude as international, intra-Pacific tariffs now in effect. Assuming that these tariffs are roughly reflective of underlying costs, it can be concluded that either INTELSAT option (with or without FP/NC traffic) would have costs in the 1985-91 period roughly the same as those today, with more important additional benefit that the system would be vastly more inclusive of the rural and domestic areas of the Pacific island countries, and would make higher quality and more dependable links available.

TABLE 5.10: QUOTED AND EQUIVALENT PER-MINUTE TARIFFS FOR TELEPHONE SERVICE IN SELECTED SOUTH PACIFIC COUNTRIES

Country	Type of Service	Date of Tariff	($) Quoted Rates*	($) Equivalent Per-Minute Rate *
Fiji	All Pacific Islands	1981-82	5.06 for 3 mins	1.69
	UHF radio telephone (intra-and inter-island)	1981-82	0.47 for 3 mins	0.16
	HF radio telephone	1981-82	0.63 for 3 mins	0.21
	Suva to Nadi	1981-82	0.06 for 12 secs	0.30
Nauru	All Pacific area	1980	2.00 per min	2.00
Northern Marianas	Tinian to Guam	1980	3.75 for 3 mins	1.25
Papua New Guinea	To Australia (ISD)	1976	1.50 per min	1.50
Solomon Islands	All Pacific area	1975	1.71 per min	1.71
Tonga	To Australia, New Zealand	1976	1.63 per min	1.63
	To Fiji, Pago Pago		1.09 per min	1.09
	Radio telephone (inland)		0.26 per min	0.26
Vanuatu	Domestic	1981	0.30 per min	0.30
Western Samoa	To American Samoa	1980	0.42 per min	0.42
	To Australia, Nauru, New Zealand, Papua New Guinea, Tonga		1.27 per min	1.27

Source: ITU Regional Development Project Archives, Suva Fiji.
*Conversion into U.S. dollars using rates of July 1, 1982.

5.2.7 Concluding Remarks Regarding the INTELSAT Option

Although the INTELSAT option has been found to offer costs roughly equivalent to presumed costs of the much less extensive intra-regional Pacific Basin system now in operation, some surprise might be registered that the introduction of so much new technology will not lower costs by an order of magnitude or more.

The answer to such a query is that the INTELSAT option outlined above, as derived from the input parameters supplied by Karunaratne (1982), is a much more extensive system, one which will supply international-grade telecommunications services to remote island villages which in the past have had to depend on HF radio to the extent service was available at all. Costs of such communication had in the past been prohibitive, and it is significant that the option outlined above can make communication available at costs and prices currently in effect by combining profitable "thick" international/urban routes with the "thin" domestic/rural routes that are either non-existent or poorly served in today's Pacific Basin.

One might inquire whether a less elaborate, less comprehensive and less earth station-intensive system might supply at least some of the domestic/rural circuits at a significantly lower cost while still using transponders leased from INTELSAT space segment capacity. In this vein, a recent article by Pelton (1982) is instructive. He argues that much of the cost of all-satellite systems in rural areas arises because of the so-called "last mile problem," and suggests that more cost-effective systems might make use of centrally located earth stations that transmit terrestrially into surrounding areas of several hundred square kilometers. Specifically:

> As long as . . . spare satellite capacity is available from INTELSAT for $800,000 . . . per year, and as long as VHF

radio telephone service provides acceptable, cost-effective service to rural villages that otherwise would have no service, then the economics of high-power satellites operating to three-meter dishes in every village and hamlet remains questionable for at least another five to ten years. (Pelton (1982), p. 29)

. . .

The critical aspects in the availability of telecommunications seem to be whether the areas served are urban or rural. Further, a number of powerful economic and practical reasons will continue to make this so for some years to come.

Rural telecommunications can indeed be cost effectively offered by a happy combination of conventional satellite technology, terrestrial networks and new terminal and exchange equipment, particularly if investment in space segment facilities can be minimized.

A dedicated satellite system designed for global rural communications services directly to the villages would be uneconomic and several times more expensive than a hybrid satellite/terrestrial network. (Pelton (1982), p. 32)

It should be noted, finally, that INTELSAT itself has been active, although with mixed success, in cooperating with international industry to find less costly earth stations capable of utilizing its very reasonably priced space segment capacity. A senior INTELSAT official has theorized that earth stations capable of accessing INTELSAT global beam transponders might be available for approximately $50,000 over the next few years.

These two factors (the possibility of VHF for the most remote areas and lower earth station costs) have not been considered in estimating the costs of the INTELSAT scenario developed in this report. As a result, the INTELSAT cost figures are extremely conservative and probably do not present the INTELSAT option to its full advantage. Assumptions of earth station cost are particularly important in any INTELSAT scenario, since, given the relatively low space segment expense, earth stations make up the bulk of system expenditures.

5.3 The INMARSAT Option, 1985-1991

This section sketches costs of an interim Pacific Basin satellite system during the seven-year period 1985-1991 for which INMARSAT (International Maritime Satellite Organization, headquartered in London) is assumed to provide space segment capacity.

One very severe and immediate drawback of even considering the INMARSAT system is that it currently prohibits the use of its satellites for communication from one land (shore) position to another. In other words, as a maritime system, it provides communication only from ship to shore, shore to ship or ship to ship. Various officials of INMARSAT and COMSAT, the U.S. Signatory, have been approached informally, and none has expressed an interest, official or otherwise, in making INMARSAT capacity available for shore-to-shore communications. This is in the face of anecdotal evidence presently mounting that INMARSAT capacity is presently being or has already been used, on an informal and episodic basis, for shore-to-shore links, usually from small portable earth stations. The question of how, if at all, INMARSAT can be induced to allow usage of its considerable excess capacity for shore-to-shore links in the envisaged interim Pacific Basin system is addressed below in Section 5.6. Making the particular leap of faith involved, the following subsections develop the cost data for the INMARSAT option on the assumption that such capacity will be forthcoming.

5.3.1 Earth Stations

By using higher-powered and more expensive satellites than INTELSAT, INMARSAT allows cost savings in earth stations, which can be smaller and less expensive and have lower power. Furthermore, INMARSAT capacity is provided and tariffed on a demand assignment basis, meaning that links are established on an as-needed basis, in lieu of rented circuits between pairs of member administrations.

The same number of "regular" earth stations as generated in the INTELSAT scenario using Karunaratne (1982) is assumed, i.e., 1,271 including FP/NC and 909 excluding FP/NC. These will satisfy projected 1991 traffic. In addition, five large "regional" earth stations (four if FP/NC are excluded) are assumed.

According to telecommunications engineering advice consulted, the following factors affect the price of the "regular" earth stations in the INMARSAT land-based option. On-board ship earth stations presently operating in the INMARSAT system cost between $50,000 and $80,000 assuming one voice circuit only. These, however, require tracking equipment and must be extremely rugged since they are usually in motion and exposed to the elements. A land-based earth station with one voice circuit designed for INMARSAT usage, having an antenna diameter in the neighborhood of 1.3 meters, could be designed for $30,000 to $35,000. Additional circuits would increase the cost somewhat. Two to three voice channels would require $50,000, and four to five channels would cost $55,000.

It seems prudent both to design land stations for more than one channel and to assume costs toward the upper end of the spectrum for conservatism. Therefore, $50,000 per earth station is assumed. The large regional stations, as in the INTELSAT option, are assumed to cost $1,000,000 each. These 1982 figures are expected to change little by 1985. Table 5.11 summarizes earth station acquisition costs and shows how they are depreciated assuming a 15-year straight-line period. In addition, a 15-year subsidized loan at 8 percent is once more assumed to derive interest costs.

TABLE 5.11: EARTH STATION COSTS (INMARSAT OPTION)

Including FP/NC:

5 regional ES @ $1,000,000 =	$ 5,000,000
1271 regular ES @ $50,000 =	63,550,000
Total	$68,550,000

Excluding FP/NC:

4 regional ES @ $1,000,000 =	$ 4,000,000
909 regular ES @ $50,000 =	45,450,000
Total	$49,450,000

($000)

	Including FP/NC		Excluding FP/NC	
Year	Depreciation*	Interest**	Depreciation*	Interest**
1985	4570	5396	3297	3893
1986	4570	5190	3297	3744
1987	4570	4969	3297	3584
1988	4570	4729	3297	3411
1989	4570	4467	3297	3223
1990	4570	4183	3297	3017
1991	4570	3880	3297	2799

*1/15 annually of acquisition cost.
**Assumes a 15-year loan at eight percent interest.

5.3.2 Operating Costs

As before, one expatriate per large regional earth station is assumed, at the same salary level as for INTELSAT. Since the "regular" earth stations are smaller and simpler to operate and maintain, however, it appears justified to assume less than the one senior technician per earth station required in the INTELSAT option. Since the INMARSAT earth stations are roughly three times less expensive, it is assumed that one senior technician per three earth stations will now suffice, which keeps the number of senior technicians per dollar's worth of earth station roughly constant. Again, the simplicity of the earth stations justifies the assumption of a smaller per-circuit allocation of miscellaneous overhead. Somewhat arbitrarily, to be sure, $3,000 per circuit is now assumed, as against $5,000 per circuit in the INTELSAT case.

Table 5.12 summarizes OMM costs arising from personnel and miscellaneous overhead costs.

5.3.3 Space Segment Costs

INMARSAT currently charges $5.25 per minute to its member administrations on a demand-assigned basis for a voice-grade circuit. This is an order of magnitude above the INTELSAT annual voice-grade half-circuit lease charge, which is now $4,680 annually. Taking two such leases to form a circuit and dividing by 10,000 minutes of traffic annually, one obtains an equivalent charge of $0.94 per minute; that figure drops to $0.47 per minute if 20,000 minutes of traffic annually per circuit are assumed. The differential is much greater if the more advantageous INTELSAT transponder leasing rate is considered.

Of course, the services are not comparable, since the INMARSAT signal

TABLE 5.12: OMM EXPENSE (INMARSAT OPTION)

Year	($) Expatriate Salary*	# of Expatriates**	($000) Total Expatriate Salary	($) Senior Technician Salary*	# of Senior Technicians***	($) Total Senior Technician Salary	($000) Misc. Overhead****	($000) Total OMM
				INCLUDING FP/NC				
1985	31002	5	155	10629	424	4507	5712	10374
1986	34103	5	171	11692	424	4957	6315	11443
1987	37513	5	188	12861	424	5453	6987	12628
1988	41264	5	206	14175	424	6010	7740	13956
1989	45390	5	227	15562	424	6598	8586	15411
1990	49930	5	250	17119	424	7258	9537	17045
1991	54922	5	274	18831	424	7984	10602	18860
				EXCLUDING FP/NC				
1985	31002	4	124	10629	303	3221	3717	7062
1986	34103	4	136	11692	303	3573	4107	7786
1987	37513	4	150	12861	303	3897	4539	8586
1988	41264	4	165	14175	303	4295	5028	9488
1989	45390	4	182	15562	303	4715	5577	10474
1990	49930	4	200	17119	303	5187	6192	11597
1991	54922	4	220	18831	303	5705	6888	12813

* Grown at ten percent annually from 1979 figures.
** One per regional earth station.
*** Three per regular earth station.
**** $3,000 per circuit.

is of higher power, permitting the use of lower-cost earth stations. The question in the present context is whether the Pacific Basin interim system envisaged has enough earth stations to make INMARSAT preferable to INTELSAT. Clearly, there is some break-even point at which cheaper earth stations would overcome the cost penalty of more expensive space segment capacity.

The assumption of how much INMARSAT would charge for usage of its space segment capacity is crucial. INTELSAT, as noted previously, was persuaded in 1973 to offer a "promotional" transponder rate for domestic usage only which was considerably less expensive than its full-time lease rate for international links. Today, the $9,360 required for a full circuit of INTELSAT capacity (two half-circuits) contrasts with the $800,000 annual transponder charge, which, assuming 600 circuits per transponder, comes out to only $1,333 per circuit, which is less than $9,360 by a factor of seven.

It seems highly unlikely that even if INMARSAT is persuaded to offer its space segment capacity to an extensive land-based system, it would reduce its charges so considerably, even if (as appears likely) it were anxious to market some of its excess capacity. For purposes of illustrating the INMARSAT option, we assume two different per-minute INMARSAT prices for a voice-grade circuit: $2.00 (reflecting a reduction on the order of a factor of 2.625), and $1.00 (a reduction on the order of a factor of 5.25). These are the best that could conceivably be hoped for by the 1985-91 time frame and are probably overoptimistic.

Under the alternative assumptions of $2.00 and $1.00 per minute INMARSAT charges, Table 5.13 indicates total costs, costs per circuit and costs per minute of the INMARSAT option.

TABLE 5.13: TOTAL COSTS, COSTS PER CIRCUIT AND COSTS PER MINUTE (INMARSAT OPTION)

				SS Cost = $2.00/min.				SS Cost = $1.00/min.			
Year	($000) Interest	($000) Depreciation	($000) OMM	($000) SS Cost	($000) Total Cost	($) Cost per Minute	($) Cost per Circuit	($000) SS Cost	($000) Total Cost	($) Cost per Minute	($) Cost per Circuit
INCLUDING FP/NC											
1985	5396	4570	10374	60360	80700	2.67	42384	30180	50520	1.67	26534
1986	5190	4570	11443	67780	88983	2.63	42272	33890	55093	1.63	26172
1987	4969	4570	12628	75340	97507	2.59	41866	37670	59837	1.59	25692
1988	4729	4570	13956	84320	107575	2.55	41696	42160	65415	1.55	25355
1989	4467	4570	15411	94440	118888	2.51	41540	47220	71668	1.52	25041
1990	4183	4570	17045	105840	131638	2.49	41408	52920	78718	1.49	24762
1991	3880	4570	18860	118720	146030	2.46	41321	59360	86670	1.46	24524
EXCLUDING FP/NC											
1985	3893	3297	7062	35580	49832	2.80	40220	17790	32042	1.80	25861
1986	3744	3297	7786	39860	54687	2.74	39947	19930	34757	1.74	25389
1987	3584	3297	8586	44720	60187	2.69	39780	22360	37827	1.69	25001
1988	3411	3297	9488	50260	66456	2.64	39652	25130	41326	1.64	24658
1989	3223	3297	10474	56540	73534	2.60	39556	28270	45264	1.60	24349
1990	3017	3297	11597	63660	81571	2.56	39608	31830	49741	1.56	24099
1991	2799	3297	12813	71800	90709	2.53	39073	35900	54809	1.53	23437

Source: Tables 5.1, 5.11, 5.12

5.3.4 Comparison of INTELSAT and INMARSAT Options

The ratio of INMARSAT to INTELSAT costs is presented in Table 5.14. Naturally, that ratio is the same whether calculated on a dollar basis, total cost, dollar per minute or dollar per circuit basis.

As Table 5.14 indicates, the INTELSAT option is unambiguously more favorable than the INMARSAT option when an INMARSAT space segment charge of $2.00 per minute is assumed. When $1.00 per minute is assumed, INTELSAT still emerges as the less costly solution when FP/NC traffic is included. Only in the case of the $1.00 per minute charge with FP/NC traffic excluded are there some years (1985-88) in which the INMARSAT option shows a modest cost advantage. Even there, INTELSAT gains the upper hand by the end of the interim period, showing a 12.6 percent cost advantage by 1991.

It bears repeating here that the INTELSAT option was presented using very conservative cost figures, and it seems fair to say that the INMARSAT case has been less conservatively set forth. This is particularly true of the $1.00 per minute space segment assumption, which seems well beyond what could be hoped for given today's institutional realities. In addition, assumptions regarding earth station costs, senior technicians per earth station and miscellaneous overhead per circuit seem, if anything, at the low end of the spectrum.

As a result, it can be concluded that the INTELSAT option is definitely preferable on a cost basis to INMARSAT although the results appear to fall in the same order of magnitude. When institutional factors are considered, the case for INTELSAT becomes strengthened again. Such factors will be reviewed in Section 5.4.

5.4 Implications for Trade, Economic Growth, Structural Change and Tariff Policy for Telecommunications Traffic and Revenue

TABLE 5.14: COMPARISON OF INTELSAT AND INMARSAT COSTS FOR PACIFIC BASIN INTERIM SATELLITE SYSTEM

INMARSAT Total Cost as Percentage of INTELSAT Total Cost

Year	Including FP/NC: SS Cost = $2.00/min	Including FP/NC: SS Cost = $1.00/min	Excluding FP/NC: SS Cost = $2.00/min	Excluding FP/NC: SS Cost = $1.00/min
1985	159.9	100.1	139.0	89.4
1986	167.4	103.6	144.1	91.6
1987	173.8	106.7	152.8	96.0
1988	183.9	111.8	158.9	98.8
1989	192.1	115.8	168.6	103.8
1990	203.0	121.4	178.9	109.1
1991	211.8	125.7	186.8	112.6

Sources: Tables 5.9, 5.13

5.4.1 Telecommunications, Infrastructure and Economic Development

This necessarily qualitative section will begin with a summary of what economic theory has to say about the interrelationship of telecommunications with economic development. The answer is: very little that is either useful or insightful.

Despite extensive bibliographies on the subject, most development economists consider the relationship between telecommunications and economics as one too narrow to be usefully examined. At best, telecommunications is subsumed in the mainstream development literature with other forms of "infrastructure" or "social overhead capital"--roads, harbors, railways, airports, schools and public health systems, for example. Even in this more macroeconomic setting, economic science is far from clear as to whether infrastructure is more a prerequisite for economic development or a result of it. To assume or to require that the causality is unambiguously in one direction or the other, furthermore, is simplistic. Both directions of causality can be accommodated, for example, in an econometric system of simultaneous equations, and the concept of bidirectional causality between infrastructure and development causes no theoretical difficulties either.

Nevertheless, policy makers and telecommunications planners in the Pacific Basin and other developing regions of the world feel with some justification that they are taking a calculated risk whenever several hundred million dollars are committed for a new satellite system, even with the success of Indonesia's PALAPA, for example, as past history. Should planners wait for economic growth to make expansion of the telecommunications system a virtual necessity for further economic progress--letting it become something of a bottleneck or constraint--or should the bolder course be taken of building ahead of demand, in the hope or expectation that a high-quality, dense and reliable telecommunications system will attract economic growth and development that would not otherwise materialize?

The virtually exponential growth of world telecommunications traffic since the introduction of the first commercial satellites in the mid-1960s--and particularly today's continued rapid traffic growth in an economic setting of worldwide recession--argue for some degree of boldness and optimism. Experience--more than anecdotal though less than empirically verified--of telecommunications experts confirms that availability of practically any new telecommunications systems causes an immediate "impulse jump" of usage. While extrapolation from this impulse jump alone would lead to dangerous overoptimism about future traffic prospects, experience nevertheless bears out the contention that (given appropriate tariff structures) newly constructed telecommunications capacity can be filled at a rate sufficiently rapid to pay operating, interest and depreciation costs.

Furthermore, in the rural and isolated islands of the Pacific Basin, fast and dependable access to accurate information is an absolute requirement for marketization or access to the market economy. Banks, airlines, tourist facilities, department stores, financial institutions--all require the kinds of information flows that can only be provided by high-quality telecommunications of the kind described in the scenarios above. And economic development, conceived in its crudest form as a sustained rise in per capita national income, certainly depends on the expansion of markets and of the market economy, whether the "markets" involved are acted in by private individuals, private companies or government agencies. Thus, at least in the setting of the Pacific Basin, there seems little doubt that improved telecommunications is vital to continued economic development of the region.

5.4.2 Structural Change and Telecommunications

Not only growth, but rearrangement or structural change of an economy might be a cause or a result (or both) of improved telecommunications. Karunaratne (1982) examines time series of concentration ratios of commodity imports and exports, as well as of import and export markets, and relates them econometrically to economic growth and telecommunications demand via a simultaneous equation model. He shows that the level of telecommunications usage is positively influenced by a rise in export commodity diversification. According to this result, for example, a country even with no economic growth undergoing a diversification of its exports (say from a single plantation-type crop such as sugar or pineapple to diversified agriculture) could predict an increase in its level of telecommunications consumption. On the other hand, he found that increases in the import commodity concentration ratio, _ceteris paribus_, led to declines in both telecommunications usage and in per capita income, based on 1971-78 data from the 18 Pacific Basin countries although these two relationships were qualitative only and not statistically significant.

Other examples of structural change are demographic in nature. For example, migration from country to country, or from the countryside to urban centers within a given country, are common in developing areas, and these certainly can be expected to have an effect, most probably positive, on telecommunications demand.

5.4.3 Tariffs, Traffic and Revenues

Appendix D provides three tariff scenarios for the INTELSAT option. It illustrates the considerable flexibility available to policy makers in designing charging structures which are fair, easily administered, promote overall economic welfare and which fulfill the objective in question, whether it be recovery of costs, subsidization of telecommunications for purposes of economic development or generation of an operating surplus to be used to subsidize other public enterprises--perhaps other telecommunications projects, such as improving the domestic telephone system. The crucial question involves price elasticities of demand and, in more refined analysis, cross-elasticities of demand, which measure how demand for one service (say telex) reacts when the price of another (say broadband data transmission) increases or decreases. Unfortunately, little or no economic research has been conducted to determine plausible ranges of such elasticities for telecommunications demand in developing areas. This is a vital area for future research.

5.4.4 Stimulation of Industry Investment Interest

How do prospects for economic growth, telecommunications demand, structural change and tariff policy interact with respect to attracting the telecommunications industry (and, more broadly, industry in general) to a developing area such as the Pacific Basin? Once more, a dependable quantitative answer does not yet exist and to find one would require a major commitment of intellectual and other resources in the subdisciplines of econometrics and economic development. Nevertheless, a few preliminary and qualitative conclusions can be hazarded on the basis of experience to date.

The seven-year period of the interim system, from 1985 through 1991, should be considered a time of testing and information gathering. Although substantial outlays will be involved for earth stations and doubtless a large debt will be incurred with an international lending institution, these risks seem well worth taking given the great need for improved telecommunications in the Pacific Basin and the potential for traffic stimulation when such an improvement is undertaken. The following can be anticipated as the primary sources of local industry and economic stimulation attributable to the inauguration of the interim system in 1985:

(1) Earth Station Construction--If they wish, the Pacific entities can insist that some segment, however modest, of earth station construction take place in the Pacific island countries. It might be argued from a cost standpoint that this would increase the cost of the ground segment. This would doubtless be true from a purely static viewpoint. But it would also introduce the necessity for increased levels of training, quality control and technical sophistication which would begin to build a solid base for more cost-competitive activities in the region. An analogy with the INTELSAT IV series of satellites is instructive. Despite significantly increased costs, European administrations in INTELSAT insisted that there be a substantial European content in the INTELSAT IV subcontracting. The experience gained from that subcontracting helped to make the European aerospace industry the sophisticated and competitive entity that it is today. More to the point, it should be noted that all of the 3,000 small earth stations used in the INSAT experiment in India were completely assembled in India.

(2) Earth Station Maintenance and Technical Training--The INTELSAT option assumes one senior technician per earth station, and the INMARSAT option assumes one senior technician per three earth stations. Recruiting, training and employing approximately 1,000 individuals to operate and monitor spaceage equipment will certainly have beneficial effects in a number or areas, some of them difficult to anticipate. Yet it is clear that the introduction of these individuals will bring about a permanent upward shift in the sophistication of the labor force. In addition, there will be the usual economic multiplier effects from their relatively high salaries and from the salaries of those who train them.

(3) Cost Savings of Industry Already Located in the Pacific Basin--Before major complements of new industry are attracted by improved telecommunications ability, it appears likely that industry already in the region will be able to enjoy cost savings of various kinds, and thereby, if export-oriented, to increase the foreign trade level and perhaps the export diversity of each country. For example, more adequate information makes it possible to carry lower inventories. Inter-island travel for deliveries, to gather orders and information and so on, would be significantly reduced. For first-hand details of such savings, see Young and Hurd (1981) passim.

Nevertheless, it may well be that major commitments of new industry in the Pacific Basin area are not forthcoming until after the interim period is over. In the most optimistic scenario, however, such commitments during the interim period may well assure that there will be enough traffic to justify a permanent system by 1992 that will pay for itself without difficulty. In any event, the best way to achieve sustained economic growth via the introduction of new industry will be to introduce a reliable, high-quality, high-coverage interim satellite system by 1985. An imaginative and carefully designed tariff structure will assure that the ability of different user groups to pay is adequately taken into account. This will in turn have the effect of maximizing traffic and system usage consistent with the recovery of system costs according to schedule.

5.5 Business Plan for a Permanent Pacific Basin Satellite System, 1992-2000

A follow-on permanent system for the nine-year period 1992-2000 to replace the interim system designed for use during 1985-91 will last into the twenty-first century. This section presents some notions about design and cost figures of such a permanent system for the Pacific Basin although not in the detail in which the interim INTELSAT and INMARSAT options have been outlined.

5.5.1 System Design

While the interim system, due to time constraints and other factors, must essentially be a conventional one for public domestic and international telecommunications, greater imagination can be used in designing the follow-on system, given the ten-year lead time at the disposition of planners.

Following the ideas given in the preceding section, it might be appropriate to repeat the notion that telecommunications is a necessary but not sufficient condition for economic development. By designing the permanent system as a multi-purpose one, it will be possible to allow telecommunications to participate intimately in the process of development.

Non-telecommunications possibilities for such a satellite system include the following uses:

(1) earth resource surveys (forestry, fisheries, minerals, agriculture);

(2) meteorology;

(3) navigation and aeronautics;

(4) health and education;

(5) public administration.

Designing a permanent system which is different both qualitatively and quantitatively from its predecessor interim system will have the following advantages:

(1) its multi-purpose features above will allow it greater flexibility in providing services directly related to the process of economic development over and above the provision of telecommunications itself; and

(2) sources of development assistance and subsidized loans (USAID, World Bank, etc.) will be more willing to help offset system costs if the Pacific Basin nations can demonstrate that the permanent system they wish to acquire is oriented toward development (as well as conventional telecommunications) in such a multi-faceted fashion.

Thus, it is recommended that the permanent system envisaged for the 1990s and beyond be one of dedicated multi-purpose high-power satellites, rather than simply one for the satisfaction of increasing levels of public telecommunications traffic.

5.5.2 System Configuration and Costs

Tables 5.2 and 5.3 indicate that by 2000, some 3,217 earth stations (2,359 excluding FP/NC) will be needed to accommodate the anticipated 9,639 circuits of traffic (6,285 excluding FP/NC). Assume that non-commercial, non-telecommunications, development-oriented use of the multi-purpose system will increase circuit demand by 50 percent or more, say to 15,000 circuits (including FP/NC) by 2000. With luck and careful planning, such an increase need not entail the acquisition of too many new earth stations. The ones envisaged for public telecommunications traffic could be used more efficiently and intensively and designed in a multi-use mode. A circuit level of 15,000 corresponds to 24 transponders at 625 circuits per transponder, corresponding in turn to two satellites at 12 transponders per satellite. An in-orbit spare should also be assumed. Very roughly, one could cost out three satellites of the INTELSAT VI type and technology, designed for multi-purpose usage, at about $30 million each in 1992 dollars. Launches via the U.S. space shuttle, including insurance or a risk premium, should be at or below $10 million each by that date (1981 dollars). Thus, satellite and launch acquisition costs might be approximately $120 million.

With respect to earth stations, it should be remembered that those installed in 1985 for the interim system can be anticipated to last through 2000, their design lifetime. Thus in 1992 there would be the acquisition of 3,217 - 1,271 = 1,946 earth stations, which will have useful lifetimes of 15 years and need be only three-fifths depreciated during the nine-year design time of the permanent system. The new earth stations, given the higher power levels of the dedicated satellites, economies of scale in earth station construction and increasing technological breakthroughs in earth station design, might be as small as one meter in diameter and cost no more than $20,000 each. Furthermore, the need for more expensive expatriate technical services might be obviated by the 1992-2000 period, and one senior technician might be able to care for ten such earth stations. Also, interconnectivity problems might be overcome by demand assignment or other means to eliminate the need for large "regional" earth stations.

This heady list of assumptions, following cost assumptions previously used about depreciation, interest and salary levels (and using $5,000 per circuit for miscellaneous expenditure) works out very roughly into the range of $7,000 to $10,000 per circuit by 2000, compared to per-circuit cost of roughly $19,000 to $26,000 per year for 1991, the end of the interim period. The evolution of costs shows that more and more of the total cost will be taken up by labor-intensive items such as miscellaneous overhead and technicians' salaries, and less and less will be assumed by the technology-intensive items in the earth and space segments.

5.5.3 Conclusions Regarding a Permanent System

One could certainly proceed with the alternative assumption that either leased space segment capacity or a dedicated but wholly telecommunications oriented system would provide traffic during the 1992-2000 period. To depend on world-wide commercial systems such as INTELSAT and INMARSAT into the 1990s and beyond, however, might be increasingly difficult if multi-purpose usage is desired since each system is somewhat specialized. Indeed, such specialization has helped to make possible the cost savings realized in each, particularly in INTELSAT. For much the same reasons, perhaps the worst solution would be to have the greater expense of a dedicated system which did not offer the possibility of multi-purpose usage for development purposes.

The introduction of multiple-use satellites during the 1990s would bring with it the need for greatly increased expertise in a number of complex and rapidly evolving areas, such as life sciences, geology and meteorology. Domiciling and training individuals with these skills in the rural Pacific Basin on a large scale would introduce considerations well beyond the scope of this report. It is fair to surmise, however, that many of these costs would be underwritten by industrialized nations and their multilateral lending institutions, whereas a system with only a commercial telecommunications orientation (despite citation of arguments about the alleged link between telecommunications and development) would be a less attractive target of such support.

5.6 Institutional Considerations

Subsection 5.6.1 outlines a number of problems involving the structure and regulations of the organizations that will be involved in Pacific Basin telecommunications during the interim and permanent periods. Subsection 5.6.2 outlines strategies for dealing with such challenges.

5.6.1 Challenges to be Anticipated

Use of Leased INTELSAT Transponders for International Traffic

It has been noted that INTELSAT allows leasing of whole, half and quarter transponders at the concessionary rate of $800,000 per year (global beam) for domestic usage only. In the INTELSAT option developed in Section 2 of this report, however, it is assumed that such capacity will also be used in part for intra-regional but international links.

Carriage of International Traffic by INTELSAT Signatories Over Non-INTELSAT Facilities

The business plan of the permanent system in Section 5.5 posits a dedicated satellite system beginning in 1992. This would presumably also include some intra-regional but international traffic, which would also contravene INTELSAT regulations. The INTELSAT permanent agreements, which are acceded to by all INTELSAT signatory administrations, require that INTELSAT members agree to carry all their public international satellite traffic on INTELSAT facilities. This would apply to Pacific Basin administrations such as Fiji which are also members of INTELSAT.

Use of INMARSAT Facilities for Land-Based Stations

As noted, the INMARSAT option developed in Section 3 assumes that INMARSAT could be induced to allow shore-to-shore communication on INMARSAT capacity, which its statutes dod not presently permit.

Granting of a Concessionary Space Segment Rate by INMARSAT

Even if INMARSAT is persuaded to allow shore-to-shore usage of its space segment capacity, the current rate of $5.25 per minute for a voice circuit is at least an order of magnitude too high to make it worth considering for an interim system. As noted in Section 3, it is assumed that INMARSAT agrees to allow the Pacific Basin users to access its space segment for \$2.00 (first case) or \$1.00 (second case) per minute. Negotiating this highly favorable rate will be even more challenging than obtaining permission for shore-to-shore usage.

Ownership Structure of the Interim and Permanent Systems

The question of system ownership, operation and management is a particularly difficult and pertinent one, given the transnational nature of the systems envisaged.

A number of possibilities present themselves:

(1) Ownership, operation and management by an outside entity, i.e., the PTT of New Zealand or Australia, or by Cable and Wireless, COMSAT, etc.;

(2) Ownership, operation and management vested in a single Pacific Basin country say Fiji or Papua New Guinea;

(3) Ownership vested by shares in all Pacific Basin countries, with operation and management contracted to an outside entity, such as Cable & Wireless or Comsat;

(4) Ownership vested in all Pacific Basin countries, with operation and management taken over by the PTT of an individual Pacific Basin country, say Fiji or Papua New Guinea.

Assuming that ownership by all user countries is desirable, the following ownership patterns come into question:

(1) Ownership or investment shares in strict agreement with system usage. This is the pattern of INTELSAT, which has the structure of an economic cooperative of owners and users;

(2) Ownership or investment shares predominantly in the hands of some of the larger Pacific Basin users, who then act as entrepreneurs with respect to other users with no ownership quotas less than their usage quotas;

(3) Ownership in equal shares, regardless of system usage.

Inclusion of French Polynesia and New Caledonia in the Interim and Permanent Systems

Because of their status as integral parts of a metropolitan country, FP/NC have remained understandably aloof from many of the transnational organizations and initiatives of the Pacific Basin region since most such organizations and initiatives are those of sovereign countries.

5.6.2 Toward the Solution of Institutional Challenges

Several of the institutional challenges described above involve the necessity of changing the rules, decisions or basic statutes of one of two specialized international organizations.

In particular, the approach to INTELSAT will require concerted action on the part of high-ranking telecommunications and other representatives of the Pacific Basin region. This should be an essentially diplomatic initiative rather than one at the level of telecommunications administrators or practitioners.

The INTELSAT Board of Governors is the executive organization of that body and would be the appropriate organ to (a) declare intra-regional traffic as "quasi-domestic" for the purpose of using leased INTELSAT transponder capacity, and (b) exempt INTELSAT members from their pledge to carry all public international satellite traffic on INTELSAT facilities. Several avenues of approach exist.

(1) An INTELSAT member, such as Fiji, could submit such a request. Since no Pacific Basin INTELSAT members are directly represented on the Board of Governors, a request would have to be submitted to the Chairman of the Board of Governors or to the Director General of INTELSAT, who would then submit it to the Board at a regular Board meeting.

(2) An INTELSAT member with Board of Governors representation and interest in the Pacific Basin area, such as Australia, New Zealand or the United States, could submit appropriate requests and suggestions at a Board meeting.

(3) All INTELSAT members in the Pacific Basin could submit a request to the board via the Board Chairman or the Director General on behalf of themselves and non-INTELSAT members in the Pacific Basin.

(4) High-ranking officials of international and regional organizations, such as the ITU and SPEC, could request the opportunity to appear before the Board to plead the case of the Pacific Basin countries. This could be done in lieu of, or in addition to, any of the other three avenues above.

If such exemptions are considered matters of fundamental policy import, the Board might, in accord with the INTELSAT definitive agreements, defer the decision to INTELSAT's Meeting of Signatories, a body that meets annually and consists of representatives of all INTELSAT's operating signatories (typically the national PTT administrations or satellite operating entities), each with equal voting power.

Since INMARSAT is consciously organized and administered along the lines of INTELSAT, much of the same strategy as that outlined above could also improve the chances of INMARSAT's deciding to allow shore-to-shore communications and to grant a concessionary rate for doing so. Since INMARSAT's operating mission is more narrow and involves the interests of a smaller number of countries, however, the breadth of interest in and representation of the developing world to be found in INTELSAT bodies (and particularly in the Meeting of Signatories and the Assembly of Parties) might not be expected in INMARSAT. Thus, the best strategy in approaching INMARSAT would be to appeal directly to that organization's economic interests--marketing chronic excess capacity that will not sell at $5.25 per minute--rather than to stress the interests of the developing world per se.

Regarding the question of system ownership, it is recommended that, following INTELSAT's highly successful experience, any regional satellite system be organized as an economic cooperative in which each member's ownership shares equal its usage shares. Balancing out the incentives of members as owners (investors) and users (customers) has, among other benefits, the result of (a) making debate over the appropriate rate of return on invested capital less of a burning issue, and (b) avoiding a split of members into two camps, one with net ownership exceeding net usage and therefore favoring high tariffs and a high rate of return, and the other with net usage exceeding net ownership and therefore favoring low tariffs and a low rate of return. Snow (1976) has discussed this matter in his book on INTELSAT.

The question of initial ownership shares and how they are to be financed is also important. Despite the high probability of outside financing, ownership of the system should be vested in the governments or operating agencies of the Pacific Basin countries themselves. Although foreign expertise might be sought and contracted for in the design or operation of the system, it should not be at the expense of ownership or policy-making powers. Furthermore, the considerable skewness of income and technical sophistication within the Pacific Basin should not be used as an excuse for some of the more advanced of those countries to seize ownership or policy-making prerogatives from the others--by, for example, making loans and owning more of the system than is reflected in usage levels.

Finally, the matter of French territories in the Pacific Basin, while difficult, need not be intractable. The 18 Pacific Basin entities in Karunaratne (1982), for example, include three--Trust Territories, Guam and American Samoa--which are not sovereign nations and which have close ties to the United States. Others--such as the Cook Islands and Niue--are nominally sovereign but have close ties to metropolitan powers such as New Zealand. The Pacific Forum and its secretariat, SPEC, are the foci to draw French Polynesia and New Caledonia into the planning process for an interim and a permanent satellite system in the Pacific Basin. The ITU, with diplomatic backup from its parent organization, the United Nations, might also be helpful in this process, as would diplomatic contacts from other metropolitan powers with interests in the region, such as the United States, Japan, Australia and New Zealand.

5.7 Summary and Conclusions

This final section summarizes findings and recommendations of the present report. It is hoped that the recommendations will be useful in stimulating consideration of issues relating to satellite communications in the Pacific Basin.

5.7.1 Need for Dependable Traffic Projections Based on Price Effects

The attempt to project traffic figures through 2000, without the use of assumptions regarding price, highlights the primitive state of the art in this area of investigation. Human and material resources would be well spent in telecommunications demand studies of developing areas. There are no conceptual or methodological obstacles to conducting such studies; such studies would provide reliable elasticity estimates that could be used for more accurate traffic forecasting.

5.7.2 Optimal Charging Policy

Tariff structures can be formulated to meet a wide variety of policy goals. Nearly all of the ones with desirable features, however, depend on segregating user groups by price elasticity of demand. Such a separation might be based on type of service, urban vs. rural, income, perceived ability to pay or some other criterion that is correlated with price elasticity. The use of a simultaneous equation approach such as that illustrated in Appendix B makes it possible to project demand for each user group given prices and to assure that revenue is equal to costs if that is also desired.

5.7.3 INTELSAT vs. INMARSAT Options

These two options, each considered for the seven-year interim period 1985-91, yielded quite different cost structures. INTELSAT emerged as the less costly of the two, as well as the one with fewer and less insuperable institutional challenges to its implementation. The INTELSAT cost figures are very sensitive to assumptions about earth station costs since the space segment is relatively cheap. The INMARSAT cost figures are very sensitive to assumptions about space segment costs since the earth stations are relatively cheap. Although the cost figures were of the same order of magnitude, the INTELSAT cost estimates were somewhat more conservatively formulated than were those for INMARSAT, and even so INTELSAT generally emerged as the less costly option.

5.7.4 Interaction of Telecommunications with Trade, Growth and Structural Change

While evidence mounts that telecommunications plays an important role in economic development, the directions of causality have not yet emerged clearly. It seems fair to posit as a working hypothesis that telecommunications is both a cause and a result of development; or, that it is a necessary but not sufficient condition for development to occur. This is also a very promising field for future research which would have to be conducted on a large scale to achieve the desired results. An econometric approach appears the most promising.

During the interim period from 1985 to 1991, evidence should begin to appear that improved telecommunications has stimulated growth to some degree or has laid the foundation for it to occur more rapidly and pervasively. The attraction of industry from the telecommunications sector and from the world economy more generally during that time frame should provide the political and financial consensus necessary to build the commitment for establishing a permanent, dedicated system in the early 1990s.

Structural changes in an economy, such as migrations from the countryside to urban centers or a diversification of exports and export markets, might themselves stimulate telecommunications demand and in turn be stimulated by improved and extended telecommunications facilities. Structural change in its various forms should thus also figure in the specification of a simultaneous equations econometric model to capture the relationship of telecommunications to economic development.

Once again, imaginative tariff structures which make use of economic theory to achieve goals reflecting a broad political consensus (total cost coverage by revenues, subsidization of telecommunications, use of telecommunications to subsidize other government activities, cross-subsidizing to reduce unequal distribution of income or wealth) can be used to maximize the chance that those goals will be realized. Although it is perceived as fair and administratively efficient, average cost pricing is generally an unsatisfactory tariff policy compared with the others illustrated here.

5.7.5 The Permanent System, 1992-2000

The most important point in the preliminary sketches of a business plan for the permanent system is that consideration be given to acquiring a multi-purpose dedicated system, owned by the Pacific Basin nations in investment shares reflecting recent past usage. By stressing development-oriented activities such as earth resources surveys, health, education and meteorology, in addition to conventional commercial telecommunications, the effects of enhanced telecommunications on economic development could be considerably increased. The ten-year planning period until 1992 will need to be used carefully if such a plan is implemented.

By the end of the century, per-circuit costs on the order of 1/2 to 1/3 of those experienced during the interim period can be anticipated. As time passes, labor-intensive costs can be expected to assume an increasing portion of total costs, as continued technological advances reduce capital outlays in the ground and space segments.

5.7.6 Institutional Considerations

To achieve the changes in INTELSAT or INMARSAT operating procedures and regulations necessary for an interim system, a concerted, unified diplomatic effort from across the Pacific Basin will be necessary at as high a level as possible. If it is deemed desirable for political and/or financial reasons to attract the Francophone Pacific territories into the interim and permanent systems, a similar initiative will be required perhaps enlisting the Pacific rim countries as well.

Ownership of the interim and especially of the permanent system should be vested in investment shares held by each Pacific Basin country or operating administration. Investment shares should be periodically revised to reflect recent past usage so that internal financial and other tensions are minimized.

Outside entities might well have their services contracted for but should not be allowed ownership or policy-making roles as payment for such services.

5.7.7 Further Studies

If it is deemed desirable to continue studies preparatory to the establishment of an interim system by the middle years of the 1980s, the conclusions summarized in Section 5.7 indicate the following topics as particularly worthy of consideration for funding:

(1) Price elasticities, demand, revenue and optimal charging regimes for telecommunications in developing areas;

(2) The relationship between telecommunications, economic development and structural change in developing areas;

(3) Institutional considerations incident to the establishment of an interim satellite communications system in the Pacific Basin;

(4) Computer-aided parametric generation of cost estimates for the interim and permanent Pacific Basin satellite systems based on detailed engineering, cost and demand projections.

6. CONCLUDING STATEMENTS

6.1 A Regional Approach to Meeting National Needs

It is widely acknowledged that a new spirit of self-determination has arisen among the island nations of the Pacific and that the region is neither monolithic in its outlook nor homogeneous in its cultural makeup and political/colonial history. However, the leadership of the region has determined that the most efficient and effective means of improving telecommunications and, thus, enhancing development, is a comprehensive region-wide system, extending both satellite and terrestrial technologies into remote areas. Such a system will meet unique, individual national needs while bolstering the solidarity and economic prospects for the region as a whole. As a result, a series of decisions ranging from political and technical to socio-economic must be made by each government concerned.

In order to implement a telecommunications system for the Pacific islands, certain key steps remain to be taken. A corporate structure for a Pacific islands telecommunications network must be developed. Such a structure must mesh neatly with existing telecommmunications authorities of the participating countries and must be appropriately integrated into existing legal structures, nationally, regionally and internationally.

Each of the political entities of the Pacific has long standing, highly individual traditions. Each has an existing body of law. In some instances the legal corpus stems from English Common Law, in others a deviation from the Napoleonic Code or, in some, United States law prevails. The effort of evolving a legally constituted body to serve as the management entity for telecommunications will, therefore, be a complex task.

The difficulties are compounded by the fact that the first entity to be developed must be a structure which will have policy-level control over the system to be implmeneted and will be obliged to interact with other political entities such as international regulatory agencies and transit carriers.

A broad base of support for the development of the ideal communications system ha, been identified. Interest in a regional system has been expressed and documented, and willingness to pay has been articulated. The actual contributions of each sovereign nation to a regional system must be determined. The Pacific islands' ability to pay, however, is constrained by the limitation of their national resources and the shrinking supply of both bilateral and multilateral aid worldwide. Progress is slow and costs are rising. It is imperative that both social and commercial profitability be criteria for telecommunications planning in the Pacific and that they be kept in perspective both nationally and regionally as decisions are made on the creation of a manageable, effective system.

The costly capital investment required to install modern satellite telecommunications makes it imperative that Pacific island nations pursue a regional approach to finance the capital investment and operations of the project. Only a regional approach to sharing the costs and benefits of the assets (initially based on ability to pay) can make the satellite option an operational reality. A regional approach will also provide leverage to the designated managerial body to negotiate with equipment suppliers for the best possible price for on-the-shelf or future space and ground segment hardware.

The political leadership in the Pacific, meeting at the prime ministerial level, has determined that the nations share a common need and are willing to take steps to achieve improved communications. A study of how the various sovereign rights and needs of each entity can best be incorporated into a manageable entity capably of operating and maintaining a complex satellite-based telecommunications system is absolutely necessary.

It is also necessary to create suitable legislation to enable each sovereign nation involved to take action and establish a regional body of law or practice for the purpose of this common effort.

6.2 The Creation of a Managerial Entity

The design of the management scheme is as critical to the success of the system as is the corporate organization. In financial terms, in terms of meeting the needs of its consumers and its ability to contribute to the economic development of the Pacific region, the managerial construct must be totally appropriate to the Pacific context. At the highest government level, decisions must be made on what entity (whether a national government, international organization or a newly created agency) will manage a system. Before the relationship between the system and outside entities such as transit carriers and international organizations is determined, it must first be made perfectly clear what authority will make these decisions.

No common management style has yet developed in the Pacific. Each nation has used its colonial forebearers as a model. However, the successful common activities of the South Pacific Bureau for Economic Cooperation (SPEC) and the South Pacific Commission (SPC) suggest that workable styles are emerging. Once the necessary legislative roadblocks have been cleared in each nation, considerable effort will have to be devoted to developing a telecommunications corporation or authority to which each of the member states will have to accede a certain degree of autonomous power. That body will have to be assured the right to act in a variety of situations once policies have been established.

6.3 Satellite Technology as a Mainstay for Future Development

The technology employed in the region is, by and large, outmoded and does not do the job required for integrated national development. Satellite communications stands out as the most effective means of providing an affordable, reliable medium for delivering emergency communications, basic health care, education and community care services to remote areas. One beneficial effect may be to stem the increasing rural to urban migration and rising urban unemployment.

6.3.1 INTELSAT and INMARSAT

INTELSAT has emerged as the most viable option for expanding the availability of telecommunications throughout the far-flung Pacific islands. It is recommended that the research and development efforts associated with appropriate, affordable, maintenance-simple earth stations for use with INTELSAT be accelerated. Diligent monitoring of the possible use of INMARSAT is also advised.

6.3.2 TDRSS

It is recommended that further investigation be conducted on the possibility of Pacific islands utilization of TDRS (171°W). Detailed information is required on the cost of modifying the C-band antenna on the spacecraft and on the contractual relationship between the island nations and the United States agency responsible for the C-band capacity.

6.3.3 The Australian Domestic Satellite

This study recommends that intergovernmental dialogue on the possible utilization of AUSSAT II for nations beyond AUSSAT I service to Papua New Guinea continue at the highest levels possible.

6.3.4 Training Considerations

Although satellite telecommunications is increasingly maintenance-simple, it will be necessary to train local personnel to manage and operate the sophisticated systems effectively. The United Nations International Telecommunication Union should be a major, integrating force in any training effort. Training should take place well in advance of implementation. Planning should focus on the regional telecommunications training center in Fiji as the location and source of appropriate training courses.

6.3.5 A Permanent System

By the turn of the century, it is projected that demand from the island nations will justify the lease or purchase of a dedicated satellite to cater exclusively to island needs. The permanent system should be jointly owned by the Pacific Basin entities themselves, in ownership shares which reflect their usage of the system. A cooperative approach is recommended to ensure optimal terms in satellite leasing arrangements and for sharing the burden of cost.

6.4 Pricing Structure

A tariff structure must be selected which will allow the system to become financially self-sufficient. Typically, the approach has been to charge a per-circuit price equal to the total cost divided by the number of circuits. While this average cost pricing is administratively simple and also seems fair, it has some disadvantages. One other approach would be to consider sub-groups of users who differ in their ability or willingness to pay for circuits, in other words, their sensitivity to price. Suggested criteria for separating users into groups of differing ability to pay include: location, per capita income, time of day and type of user (business or residential). It is shown that charging higher prices to users with high ability to pay and lower prices to users with low ability to pay often increases overall traffic to such an extent that all would benefit. Determining the criteria for separating user groups is a delicate process as is measuring ability to pay. They both must be addressed carefully. A multi-tiered pricing structure for a Pacific telecommunications system is desirable. The precise nature of the costing structure requires further study, best conducted in close coordination with the ITU in order to incorporate a suitable pricing structure into the Pacific Basin telecommunications management plan.

The economic analysis of this report suggests that Pacific island users are not overly concerned with price or tariff variations, and that the primary issue is not <u>if</u> a system will be profitable, but, rather, <u>when</u> it will become profitable. The overriding necessity is the establishment of a system at whatever cost per call or message. There is also growing evidence that in the Pacific context, once telecommunications becomes available, there is heavy, often unanticipated, utilization of service.

6.5 Ultimate Design

The two-year Pacific Basin Communications Study undertaken by PSSC was a planning effort and not a specific systems design. The ultimate design of an ideal telecommunications system will have to reflect the variety of objectives, sometimes conflicting, which are found in the real world of the Pacific islands. Basic decisions must be made in the technology to be employed and where to find it, how much it will cost and how to pay for it. It is now imperative to maintain momentum, mobilize dollars and designate authority for the accomplishment of the many complex tasks with which the Pacific is faced and which require action.

APPENDIX A

SPECIFIC COST SCENARIOS

The following is a scenario outlined by an ITU representative with a working appreciation for telecommunications in the Pacific Basin. The examples include communications (1) between Funafuti, Tuvalu and Fiji and (2) between the Tokelau Islands and Western Samoa.

Example 1: HF for Trunk Service

A. Equipment Required at Tuvalu:

2 X 1KW HF ISB Transmitters

2 X 2 Channel HF ISB Receivers

2 X 2 Channel Lincompex

2 X ARQ Systems, each handling 2 X 50 baud telegraphic inputs

1 X Log Periodic Transmit Antenna

1 X 10 KVA Diesel Alternator and Auto Start (Tx Station)

1 X 24 V Rectifier (1KVA) and Battery Set (RX Station)

1 X 8 Channel FMVFT

1 X Log Periodic Receive Antenna

The above, together with antenna baluns, multipliers and all the minor miscellany of installation material, as well as test equipment and spare parts, would cost: $ 580,000 (installed)

B. Equipment Required at Fiji: $ 550,000

The above equipment, less power supplies, will normally be required at the parent end of the link at the installed cost listed above.

C. Total Link System Cost: $1,130,000

D. Without the Duplication, Cost Would Have Been: $ 850,000

The system provides for a maximum of four voice circuits, up to three for telephony and the fourth as a record bearer equipped for four protected baud telegraph circuits (ARQ provision) and four unprotected telegraph circuits. (Note that the system is configured with all key equipment duplicated so that failure of any one major item will halve the system capacity but will not put the total link off the air.)

Example 2: Satellite Trunk Service

Now for a brief look at the satellite alternative. Assuming a satellite providing 35 dBW is available, it also assumed that around 23 dB/K earth station performance (G/T) is required.

A. Equipment Required

A station at Tuvalu would cost about $50,000-$70,000 installed for 4 channel capacity (complete with solar power supply). The link share of the cost of a larger base station at Suva would be approximately $50,000. The total capital cost of this example is $100,000-$120,000.

B. Space Segment and Other Costs:

To derive a very rough per-channel space segment cost, we will assume that a typical INTELSAT transponder is worth $1 million per year and that 200 SCPC voice grade half circuits can be put on the transponder (a relatively conservative number). The annual per-half-circuit space segment charge would be $5,000 and the total for four full-circuits would be $40,000. Now, take, for example, the life of either the HF system or the satellite system to be 10 years and that the equivalent cost of capital is twelve percent per year, the net present value of a $40,000 per year cash flow for ten years at twelve percent would be about $226,000.

For simplicity, we will ignore operations and maintenance expenses, depreciation expenses, any real estate and improvement (buildings) expenses and other factors. It has been said that for the HF System, such costs are seen by inspection to be higher than the same costs for a satellite system. Even if one is not willing to accept that these costs are higher for HF, the capital costs plus the net present value of the space segment charges leave a wide margin for raising the cost estimates for the satellite option.

Comparisons:

Assuming operating costs to be equal, the relative system costs are:

HF Radio System:	$1,130,000
Satellite System:	$ 346,000 (31% or about 1/3 of HF cost)

It is clear from these cost differences that the four channel point-to-point satellite option should be the choice. Being more rigorous in evaluation could evolve added conclusions such as the possibility of including other nodes to the satellite system while not being able to do so with an HF system. Circuit quality and availability would also be far superior in a satellite system.

Example 3: (HF) Single Channel Trunk Service

Let's now consider the cost of Tokelau/W. Samoa HF radio interconnections. Power required in the radio carriers would be less than in Example 1, and the antenna system much less complex. For Tokelau, we propose working three such terminals into the W. Samoa base for just under $500,000 as follows:

A. Equipment Required at One Tokelau Island

2 RTS 150 Remote stations RACE equipment (one standby) consisting of:

2 x CH150 HF SSB Transceiver

2 x Syncompex 80

2 x SE 150 Controller/Teletype Interface

1 x 42" Cabinet

Broadband folded dipole antenna complete with balun and feed. Solar power supply complete with batteries

$120,000

B. Equipment Required at W. Samoa End

2 x CH 150 W p e p Transmitting

2 x CH 150 W p e p Receiving

2 folded dipole antenna systems complete and duplicate master station equipment consisting of:

2 x Syncompex 80

2 x SE 150 Controller/Teletype Interface

1 x 42" Cabinet

No power supplies required at the parent end.

$120,000

C. Total Link System Cost: $240,000

Looking at the two HF examples (1 and 3), it is clear that the RACE System is much cheaper but is doing a roughly similar job. In practice, the built-in auto access and subscriber concentrating facilities make the RACE more attractive in terms of what it will do as well as in its price.

Three Tokelau stations at $120,000 each plus one W. Samoa station at $120,000 would cost about $480,000. This is, as stated, just under $500,000.

Example 4: (Satellite) Trunk Service

For Tokelau, assume single channel earth stations could be installed for a total cost of around $40,000 each plus about $30,000 apportioned cost of a bigger station at Apia. These are reasonable assumptions.

Total capital costs would therefore be three times $40,000 plus one times $30,000 for a total of $150,000. Space segment charges for full-duplex circuit (equivalent to the channel sharing scheme in Example 3) would be $10,000 per year.

The sum of the capital cost, ($150,000) plus the net present value of a $10,000 per year cash flow at twelve percent for ten years (about $56,000), is $206,500.

Comparison:

Using the same assumptions and arguments as in Example 1, but using only the costs for Examples 3 and 4 make satellite interconnection again the obvious winner:

HF Radio System:	$450,000
Satellite System:	$206,500 (45.9% or approximately half the HF cost)

Even if 35 dBW radiated satellite power were not available, necessitating larger antennas in both satellite examples, there is still sufficient cost margin to accommodate significant increases in size while keeping the rest of the earth station equipment the same.

APPENDIX B

U.S. SUPPLIERS OF SATELLITE COMMUNICATIONS EQUIPMENT AND SYSTEMS

Appendix C comprises a list of suppliers of satellite communications equipment and systems in the United States. These enterprises are categorized according to the type of product they supply. Some vendors appear in more than one section if they sell more than one kind of equipment.

SATELLITE COMMUNICATIONS EQUIPMENT SUPPLIERS -- U.S. COMPANIES

Category	Equipment Type
A	Systems -- Complete Turnkey
B	Sub-systems
C	Satellite Earth Station Antennas
D	Low Noise Amplifiers
E	Receivers
F	Antenna Positioning Equipment
G	Single Channel per Carrier Equipment
H	Time Division Multiple Access Equipment
I	Teleconferencing Equipment
J	Data Communications Equipment
K	Video Encryption Equipment
L	High Power Amplifiers
M	Test Equipment
N	Equipment Shelters

B.1 The following companies are suppliers of turnkey Satellite Communications Systems, but not necessarily limited thereto.

	Other Categories
Blonder-Tongue Laboratories, Inc. One Jake Brown Road Old Bridge, NJ 08857 (201) 679-4000	B
California Microwave, Inc. 990 Almanor Avenue Sunnyvale, CA 94086 (408) 732-4000	B
Comtech Laboratories, Division of Comtech Telecommunications Corp. 45 Oser Avenue Hauppauge, NY 11788 (516) 231-5454	B,D,L
Dalsat, Inc. P. O. Box 1960 Plano, TX 75075 (214) 424-1517	B,G
Dyma Engineering P. O. Box 1697 213 Pueblo del Sur Taos, NM 87571 (505) 758-8686	B
Fairchild Space and Electronics Company 20301 Century Boulevard Germantown, MD 29874 (301) 428-6477	B
GTE International Systems Corp. 140 First Avenue Waltham, MA 02254 (617) 466-3364	B
Hughes Microwave Communications Products P. O. Box 2999 Torrance, CA 90509 (213) 517-6233	C,E,L
ITT Space 2912 Wake Forest Road Raleigh, NC 27611 (919) 828-4441	G,K

	Other Categories
M/A-Com Video Systems, Inc. 63 Third Avenue Burlington, MA 01803 (617) 272-3000	C,D,E
Microdyne Corporation P. O. Box 7213 Ocala, FL 32672 (904) 687-4633	B,C,E
Modulation Associates, Inc. 897 Independence Avenue, B2D3F Mountain View, CA 94043 (415) 962-8000	E
Nova Engineering, Inc. P. O. Box 32943 San Antonio, TX 78216 (512) 349-8601	B
Potomac Satellite Systems 1021 S. Barton Street, Suite 128 Arlington, VA 22204 (703) 521-5844	C
RCA Astro-Electronics P. O. Box 800 Princeton, NJ 08540 (609) 426-2706	B
Rockwell International/Collins P. O. Box 1926 Richardson, TX 75080 (214) 996-5417	B,E,G
Satellite Transmission Systems, Inc. 80 Oser Avenue Hauppauge, NY 11788-3885 (516) 231-1919	B,G
Scientific-Atlanta Box 105600 Atlanta, GA 30348 (404) 441-4000	B,C,D,E,F,G,H,J,M
TRW Defense/Space Systems 1 Space Park Redondo Beach, CA 90278 (213) 535-1081, 536-3592	B

B.2 The following companies are suppliers of Satellite Communications Sub-systems, but not necessarily limited thereto.

	Other Categories
Aertech Industries 825 Stewart Drive Sunnyvale, CA 94086 (408) 732-0880	
Engelmann Microwave 662 Myrtle Avenue Boonton, NJ 07005 (201) 334-5700	
Frequency West, Inc. 3140 Alfred Street Santa Clara, CA 95050 (408) 727-8500 ext. 34	
LNR Communications, Inc. 180 Marcus Boulevard Hauppauge, NY 11788 (516) 273-7111	D,E
MITEQ, Inc. 100 Richfield Lane Hauppauge, NY 11788-2086 (516) 543-8873	E

B.3 The following companies are suppliers of Earth Station Antennas, but not necessarily limited thereto.

	Other Categories
Andrew Corporation 10500 West 153rd Street Orland Park, IL 60462 (312) 349-3300	B,F
Anixter Mark 2180 South Wolf Road Des Plaines, IL 60018 (312) 298-9420	

	Other Categories
Antennas for Communications (AFC) 486 Cypress Road Ocala, FL 32570 (904) 687-4121	B,F
Antenna Technology Corporation 895 Central Florida Parkway Orlando, FL 38809 (305) 851-1112	
Calstar Communications, Inc. 4680 Pell Drive, Unit B Sacramento, CA 98528 (916) 482-8255	
Cayson Electronics Mfg. Co. Route 3, Box 160 Fulton, MS 38843 (601) 862-2132	F
Comtech Antenna Corp. 3100 Communications Road St. Cloud, FL 32769 (305) 892-6111	B
E-Systems, Inc. Commercial Division 2910 Avenue F, East Arlington, TX 76011 (817) 461-3511	B,F
Gabriel Electronics, Inc. P. O. Box 626 Scarborough, ME 04074 (207) 883-5161	F
Harris Corp. Satellite Communications Division, Antenna Operations P. O. Box 1277, 2600 Longview Street Kilgore, TX 75662 (214) 984-0555	A,B,E,F
Microwave Speciality Corp. 7312 Convoy Court San Diego, CA 92111 (714) 278-5711	
National Microtech, Inc. P. O. Box E Grenada, MS 38901 (800) 647-6144	A

	Other Categories
Satcom Technologies, Inc. Subsidiary of Radiation Systems, Inc. 2912 Pacific Drive Norcross, GA 30071 (404) 448-2116	F

B.4 The following companies are suppliers of Earth Station LNA's, but not necessarily limited thereto.

	Other Categories
Amplica, Inc. 950 Lawrence Drive Newbury Park, CA 91320 (805) 498-9671	E
California Amplifier, Inc. 3481 Old Conejo Road, A3 Newbury Park, CA 91320 (805) 498-2108	B

B.5 The following companies are suppliers of Satellite Communications Receivers, but not necessarily limited thereto.

	Other Categories
Acrodyne Industries 516 Township Line Road Blue Bell, PA 19422 (215) 542-7000	B
Automation Techniques, Inc. 1846 North 106th E. Avenue Tulsa, OK 74116 (918) 836-2584	
Avantek, Inc. Telecommunications Division 481 Cottonwood Drive Milpitas, CA 95035 (408) 946-3080	B,D

	Other Categories
Dexcel, Inc. 2285C Martin Avenue Santa Clara, CA 95050 (408) 727-9833	D
Logus Manufacturing Corp. 22 Connor Lane Deer Park, NY 11729 (516) 242-5970	B
Merrimac Industries, Inc. 41 Fairfield Place W. Caldwell, NJ 07006 (201) 575-1300 ext. 238	B
Muntz Electronics, Inc. 7700 Densmore Avenue Van Nuys, CA 91406 (213) 988-7800	C
Pinzone Communications Products, Inc. 10142 Fairmount Road Newbury, OH 44065 (304) 296-4493	A
R.L. Drake Company 540 Richard Street Miamisburg, OH 45342 (513) 866-2421	B
Standard Communications Corp. P. O. Box 92151 Los Angeles, CA 90009 (213) 532-5300	B

B.6 The following companies are suppliers of Antenna Positioning Equipment, but not necessarily limited thereto.

	Other Categories
Basic Systems 12929 East 21st Street Tulsa, OK 74134 (918) 437-7066	

	Other Categories
Electrospace Systems, Inc. P. O. Box 1359 Richardson, TX 75080 (214) 783-2004/2005	B
Magnatech Bradley Park East Granby, CT 06026 (203) 653-2573	
Motion Systems Corp. 61 Riordan Place Shrewsbury, NJ 07701 (201) 222-1800	
Quantum Associates Box 21 Alpine, WY 83128 (307) 654-2000	

B.7 The following companies are suppliers of SCPC Satellite Equipment, but not necessarily limited thereto.

	Other Categories
Coastcom 2312 Stanwell Drive Concord, CA 94520 (415) 825-7500	B
McMartin Industries 4500 South 76th Street Omaha, NE 68127 (402) 331-2000	

B.8 The following companies are suppliers of TDMA Satellite Equipment, but not necessarily limited thereto.

	Other Categories
Commercial Telecommunications Corp. COMTEL 3130 Skyway Drive, Building 64 Santa Maria, CA 93455-1885 (805) 928-2581	

	Other Categories
COMSAT General TeleSystems, Inc. 2721 Prosperity Avenue Fairfax, VA 22031 (703) 698-4358	A,B
M/A-Comm DCC, Inc. 11717 Exploration Lane Germantown, MD 20874 (301) 428-5773	A,B,G

B.9 The following companies are suppliers of Teleconferencing Equipment, but not necessarily limited thereto.

	Other Categories
American Electronic Laboratories, Inc. P. O. Box 552 Lansdale, PA 19446 (215) 822-2929	A
Marcom P. O. Box 66507 Scotts Valley, CA 95066 (408) 438-4273	
Misar Industries 1477 East Warner Avenue Santa Ana, CA 92075 (714) 540-2477	

B.10 The following companies are suppliers of Data Communications Equipment, but not necessarily limited thereto.

	Other Categories
Codex Corporation (Motorola) 20 Cabot Boulevard Mansfield, MA 02048 (617) 364-2000	

	Other Categories
Motorola, Inc. Satellite Earth Terminal Department 8201 East McDowell Road Scottsdale, AZ 85252 (602) 949-2814	A,B
Rixon, Inc. 2120 Industrial Parkway Silver Spring, MD 20904 (301) 622-2121 ext. 361	
TIMEPLEX, Inc. One Communications Plaza Rochelle Park, NJ 07662 (201) 368-1113	

B.11 The following companies are suppliers of Video Encryption Equipment, but not necessarily limited thereto.

	Other Categories
Oak Satellite Corp. 16935 West Bernardo Drive Rancho Bernardo, CA 92127 (714) 485-9880	
Westinghouse Electric Corp. 1613 Knecht Avenue Baltimore, MD 21227 (301) 765-7845	

B.12 The following companies are suppliers of Satellite Communication Transmitters, but not necessarily limited thereto.

	Other Categories
Aydin Microwave 75 East Trimble Road San Jose, CA 95131 (408) 946-5600	B,G,H

	Other Categories
LogiMetrics, Inc. 121-08 Dupont Street Plainview, NY 11803 (516) 349-5970	M
MCL, Inc. 10 North Beach Avenue LaGrange, IL 60525 (312) 354-4350	
Teledyne MEC 3165 Porter Drive Palo Alto, CA 94303 (415) 493-1770	B
Varian MCS Division 3200 Patrick Henry Drive Santa Clara, CA 95050 (408) 496-6273	

B.13 The following companies are suppliers of Test Equipment, but not necessarily limited thereto.

	Other Categories
Dynascan Corporation 6460 West Cortland Avenue Chicago, IL 60635 (312) 889-8870	
EIP Microwave Inc. 2731 North First Street San Jose, CA 95134 (408) 946-5700	
Phillips Test and Measuring Instruments 85 McKee Drive Mahwah, NJ 07430 (201) 529-3800	
Telecommunications Techniques Corp. 7 Dalamar Street Gaithersburg, MD 20760 (301) 258-5011	
Texscan Corp. 2446 North Shadeland Avenue Indianapolis, IN 46219 (317) 357-8781	

Other Categories

Wavetek San Diego
9045 Balboa Avenue
P. O. Box 651
San Diego, CA 92112
(714) 279-2200

Wiltron Company
805 East Middlefield Raod
Mountain View, CA 94043
(415) 969-6500

B.14 The following companies are suppliers of Equipment Shelters, but not necessarily limited thereto.

	Other Categories
Fort Worth Tower Co. 1901 East Loop 820 South P. O. Box 8597 Fort Worth, TX 76117-0597	A
Grasis Corp. P. O. Box 1039 Kansas City, MO 64141 (816) 483-1100	

APPENDIX C

PACIFIC NATIONS' PLANNING OBJECTIVES

In Papua New Guinea, the emphasis is on rural development. Infrastructural expenditures (roads, communication, schools, hospitals) and other services are to be undertaken so as to expedite village development. According to the Papua New Guinea development strategy, the commercialization of subsistence agriculture so as to speed up the participation of the rural subsistence sector in the cash economy is one of the key instruments to be used to raise the level of development and living standards of the people in the rural hinterland. Resource based manufacturing is also to be encouraged; the large-scale OK Tedi copper project and small-scale manufacturing projects using indigenous resources, generating maximum possible employment, comprise an integral element of Papua New Guinea's recent development strategy. Import susbstituting industrialization which can stand the test of competition would be encouraged. Consumer welfare is to be preserved by discouraging high cost production under protection. Papua New Guinea plans explicitly attempt to direct capital expenditure to integrated rural development activity thus overcoming the "urban bias" that severely dampens modern development planning [Lipton, 1976]. The Papua New Guinea plans attempt to enlarge the cash cropping segment of the mixed subsistence cropping sector of the economy. The decentralization of decision-making and the preservation of the Melanesian way are all emphasized to stem the tide of rural-urban migration. The amelioration of the quality of life in the villages is a central objective of Papua New Guinea's development plans [Papua New Guinea, White Paper, 1976; Papua New Guinea, The NPEP, 1980].

Fiji's latest development plan [Fiji DP8, 1981-85] is a blue-print to coordinate national resource allocation according to the long-term goals of development that have been emphasized since the earlier plans, namely, DP6 and DP7. The diversification of the economic base in order to reduce the vulnerable dependence on sugar export and tourism earnings is a cardinal aim of the latest plan. The production and processing of cocoa, ginger and citrus, and the expansion of sugar milling capacity to at least 600,000 tons, are expected to diversify the narrow primary agro base of the Fijian economy. The second objective of DP8 is to promote a more equitable distribution of the fruits of development. Basic services to meet the needs of the poorest strata of the population are to be implemented via a comprehensive system of regional planning. Thirdly, DP8 aims to ensure that the benefits of productive employment will be available for those who seek it. Fourthly, while taking cognizance of the "small economy" characteristics and the prospects offered by external trade and aid, DP8 aims to inculcate attitudes and policies that will enhance national self-reliance. Fifthly, the promotion of national unity within the concept of a multi-ethnic society is envisaged. Finally, regional and international cooperation will be actively pursued [Fiji: DP8, 1980: 17-19].

The main thrust of DP8 is to direct the path of Fiji's development so that distributional skewness of growth is eliminated and fruits of growth are shared equitably between rural and urban areas. However, all past third world experience indicates the virtual impossibility of achieving this aim. Currently, urban cash incomes on the average exceed rural incomes by a factor of 4 and non-village rural cash incomes by a factor of 3. An integrated rural development strategy to regionalize development and overcome disparities is mapped out in DP8. The achievement of these objectives will require massive re-direction of infrastructure investment expenditure to the rural hinterland.

Solomon Island's National Development Plan's (NDP) [Solomon Island NDP, 1980] basic aim is to promote effective rural development which will provide the opportunity for the widespread sharing of the country's growth. NDP has many economic objectives. First, it aims to ensure the continued growth to provide the people with adequate living standards. Second, it aims to gear fiscal, land and monetary policies to the country's development needs. Third, wide geographical and social dispersion of benefits is envisaged. Fourth, the increase of opportunities from cash crop production and paid employment is expected. Fifth, the development of rural growth centers throughout the provinces by pooling transport, social and administrative services is stimulated. Sixth, the production of local foods for natural consumption is encouraged. Seventh, increased export earnings to reduce foreign aid dependency is desired. Eighth, private foreign investment to generate diversification of the range of exports is anticipated. Finally, self-reliance is sought [Solomon Islands: NDP, Vol.1, 1980:9].

Solomon Island's development strategy aims at simultaneously expanding the enclave plantation sector and the rural subsistence agriculture. The plan identifies a shortage of skilled manpower, particularly trained and experienced managerial staff, as the most binding constraint on its pace of development.

The principal objective of Western Samoa's Fourth Five Year Development Plan (1980-84) [Western Samoa, DP4, 1980] is to continue to improve the welfare of Samoans through a more effective use of the nation's natural resources. The stated aims of the recent Samoan Plan are: First, to increase production of village agriculture by working through the existing leadership hierarchy and social institutions; Second, to move towards true economic independence and self-reliance; Third, to provide greater opportunities for Samoans to actively participate in the development process; Fourth, to ensure the fair distribution of the fruits of economic development and the satisfaction of basic economic and socio-cultural needs; Finally, to protect the environment [Western Samoa, DP4, 1981:3]. Western Samoan development strategy aims at the progressive reduction of dependency on New Zealand and other metropolitan countries for aid and imported foods and jobs. The development of import-substituting agriculture and industry is to be pursued vigorously during the plan period to overcome the growing unemployment problem and adverse balance of payment trends.

Tuvalu is a predominantly subsistence economy with nearly 70 percent of its economically active population engaged in village agriculture. The main aim of Tuvalu's Second Development Plan is to achieve economic self-reliance. The long-term objectives specified in the plan are the preservation of national identity, diversification of the economy and improvement of the standard of living "within the traditional social system and customs of the island' [Tuvalu DP2: 1980]. The secondary objectives listed in the plan are: First, preservation of national sovereignty and the institutions and the process of democracy; Second, conservation of Tuvaluan culture and traditions. Third; fostering harmony with regional neighbors; Fourth, development and harnessing of land and area resources; Fifth, promotion of new commercial ventures; Sixth, creation of employment opportunities by participating with private foreign investment, where appropriate; Seventh, emphasizing rural development as a high priority objective; Eighth, improving education and social services; Ninth, the control of government expenditure at levels consistent with the goal of sustained self-reliance.

The overall objectives of the recent Kiribati Development Plan 1979-1982 are as follows: First, the preservation of Kiribati's distinctive culture during the period of rapid change. Second, the maintaining of a constitution and a political system consistent with the nation's independence; Third, the recognition of the need to respond fully to the aspirations of the rural populace for a higher standard of living; Fourth, the tackling of issues associated with population growth and expanding urbanization; Fifth, the development of international relations. The main focus of the long-term development strategy of Kiribati is directed at the maintenance of the nation's economic independence when the Banaba island's phosphate mining is exhausted. Therefore, a number of subsidiary objectives have been enunciated in the development plan to fill in the vacuum that will be created by phosphate resource depletion. They are: development of marine resources, tourism, encouragement of private foreign business investment and pruning of government expenditure.

C.1: PLANNING GOALS OF PACIFIC ISLAND NATIONS

PLANNING GOALS	COUNTRY							
	Fiji	Kiribati	Niue	PINs	Solomon Is	Tonga	Tuvalu	Western Samoa
Growth/Increase standard of living	X	X	X	X	X	X	X	X
Redistribution to meet PINs	X		X	X	X	X	X	X
Diversification (Export Base)	X			X	X	X	X	
Employment Generation	X		X	X	X	X		
Indigenization	X		X	X		X		
Industrialization or Agriculture	X			X	X	X		X
Preservation (Culture/ Environment		X		X		X	X	X
Constitutional/Territorial Integrity/Sovereignty		X		X	X		X	
Regionalism	X			X			X	
Self-reliance/economic Independence Revenue	X	X	X	X	X	X	X	X
Rural/Urban or Ethnic Balance	X	X		X	X			
Increase Private Foreign Investment	X		X	X	X	X		

Source: Various Current National Development Plans

C.2: TRADE AND CONCENTRATION RATIOS 1979

COUNTRY	Exports (1979) (A$ million)	Imports (1979) (A$ million)	Exports Concentration G_x^c	Imports Concentration G_m^c
1. American Samoa	111.804	80.613	95.5	41.81
2. Cook Islands	3.466	20.604	61.2	41.12
3. Fiji	231.225	422.388	58.8	40.29
4. French Polynesia	25.454	421.892	70.9	42.39
5. Guam	-	398.055	-	54.06
6. Kiribati	21.209	15.454	96.3	41.78
7. Nauru	67.270	-	100.0	45.70*(1977-8)
8. New Caledonia	319.557	319.438	91.6	40.18
9. Niue	0.342	1.915	71.5	42.27
10. Norfolk Islands	-	8.987	-	45.65
11. Papua New Guinea	858.605	-	53.1	44.06*(1975-6)
12. Pitcairn	-	-	-	-
13. Solomon Islands	62.692	52.681	45.6	46.25
14. Tokelau	.016	-	-	-
15. Tonga	6.854	26.210	44.6	41.96
16. TTPI	21.937	-	-	-
17. Tuvalu	0.257	1.851	92.9	44.66
18. Vanuatu	37.017	-	61.0	36.56*(1975)
19. Wallis & Futuna	-	-	-	-
20. Western Samoa	16.463	66.974	58.6	46.90
TOTAL	1784.168	-	-	-

Source: South Pacific Economies 1979: Statistical Summary. South Pacific Commission, Noumea, 1981.

C.3: TRENDS IN COMMODITY IMPORT CONCENTRATION RATIOS (G^c_m)

COUNTRY	1972	1973	1974	1975	1976	1977	1978	Decreasing (D) Trend
1. American Samoa	-	41.63	46.02	47.04	45.70	45.56	-	D
2. Cook Islands	-	42.91	42.45	41.00	41.68	40.74	-	
3. Fiji	-	40.40	39.60	39.48	39.79	39.79	-	D
4. French Polynesia	44.92	46.28	44.99	44.27	43.16	-	-	D
5. Guam	42.43	-	-	-	-	52.23	-	-
6. Kiribati	-	42.25	46.48	43.14	41.60	41.40	41.68	D
7. Nauru		44.84	41.90	48.11	40.07	45.70	38.10	D
8. New Caledonia	40.06	40.52	42.04	41.52	41.48	41.22	40.21	D
9. Niue	42.12	42.18	45.92	45.03	43.28	40.51	42.83	-
10. Norfolk Islands	42.86	41.79	41.12	40.89	39.86	43.17	-	
11. Papua New Guinea	45.70	44.26	43.22	43.81	43.90	-	-	D
12. Pitcairn	-	-	-	-	-	-	-	-
13. Solomon Islands	43.51	42.81	40.98	41.13	43.36	42.25	40.99	D
14. Tokelau	-	-	-	-	-	-	-	-
15. Tonga	42.65	43.22	44.27	41.14	40.51	40.48	41.42	D
16. TTPI	-	-	-	-	42.60	43.53	-	-
17. Tuvalu	-	-	-	-	48.06	44.69	44.44	D
18. Vanuatu	40.67	38.88	39.65	38.10	-	-	-	D
19. Wallis & Futuna	-	-	-	-	-	-	-	-
20. Western Samoa	44.80	44.03	45.49	44.51	41.92	43.93	42.36	D

Source: Overseas Trade 1978, Statistical Bulletin of the South Pacific No. 17, South Pacific Commission, Noumea, New Caledonia.

C.4: TRENDS IN COMMODITY EXPORT CONCENTRATION RATIOS (G_X^C)

COUNTRY	1971	1972	1973	1974	1975	1976	1977	1978
1. American Samoa	97.31	91.60	93.86	91.84	94.91	96.36	98.92	-
2. Cook Islands	-	72.28	74.28	63.95	75.67	71.77	68.40	68.84
3. Fiji	-	69.55	59.20	59.11	72.27	66.04	69.52	66.74
4. French Polynesia	-	80.96	76.35	82.18	81.23	78.10	64.62	83.15
5. Guam	-	-	-	-	-	-	-	-
6. Kiribati	-	-	-	-	99.85	99.79	99.78	99.90
7. Nauru	-	-	-	-	-	-	-	-
8. New Caledonia	-	82.09	76.05	77.07	78.80	75.27	75.11	-
9. Niue	-	55.23	52.29	51.73	64.76	68.88	62.92	66.27
10. Norfolk Islands	-	-	79.69	75.79	71.07	71.78	-	-
11. Papua New Guinea	53.19	67.55	75.82	69.90	67.11	62.13	60.92	-
12. Pitcairn	-	-	-	-	-	-	-	-
13. Solomon Islands	-	65.81	75.06	76.66	72.47	70.66	64.28	60.63
14. Tokelau	-	-	-	100.00	100.00	-	-	-
15. Tonga	-	66.00	72.92	74.76	-	68.16	71.49	68.25
16. TTPI	-	-	-	-	-	-	51.94	-
17. Tuvalu	-	-	-	-	-	-	-	-
18. Vanuatu	-	82.58	74.69	74.71	70.59	67.83	70.39	68.12
19. Wallis & Futuna	-	-	-	-	-	-	-	-
20. Western Samoa	-	67.14	67.33	72.99	69.76	68.14	96.56	94.12

Source: Overseas Trade 1978: Statistical Bulletin of the South Pacific Commission, No. 17, Table 8

C.5: TRENDS IN EXPORT MARKET CONCENTRATION RATIOS

COUNTRY	1972	1973	1974	1975	1976	1977	1978
1. American Samoa	96.56	98.18	97.75	99.74	95.84	99.0	98.39
2. Cook Islands	100.00	100.00	98.60	99.27	97.31	99.19	99.94
3. Fiji	41.01	42.37	41.00	59.62	49.07	50.24	48.34
4. French Polynesia	-	84.19	86.05	85.99	83.41	-	85.43
5. Guam	67.52	56.30	45.98	64.98	53.73	58.58	62.97
6. Kiribati	70.68	56.82	47.42	57.40	74.66	66.67	68.14
7. Nauru	-	-	-	-	-	-	-
8. New Caledonia	62.18	61.59	60.59	65.87	63.79	59.25	61.62
9. Niue	-	-	-	-	-	-	-
10. Norfolk Islands	-	-	-	-	-	-	-
11. Papua New Guinea	53.26	56.30	51.00	50.56	45.95	-	-
12. Solomon Islands	65.54	61.52	52.17	49.86	48.04	42.95	42.66
13. Tokelau	-	-	-	-	-	-	-
14. Tonga	56.13	53.68	56.51	66.06	61.46	67.28	60.72
15. TTPI	-	-	-	-	-	-	-
16. Tuvalu	-	-	-	-	-	-	-
17. Vanuatu	72.32	62.54	66.24	56.44	55.69	55.06	51.09
18. Western Samoa	53.10	56.37	56.59	67.00	56.59	60.44	49.32
South Pacific	40.75	42.48	41.00	39.02	37.87	38.97	39.18

Source: Table 3 Statistical Bulletin of the South Pacific, No. 17:13-15.

C.6: TRENDS IN IMPORT MARKET CONCENTRATION RATIOS

COUNTRY	1972	1973	1974	1975	1976	1977	1978	Decreasing Trend (D)
1. American Samoa	0.6541	0.7428	0.7888	0.7878	-	-	-	-
2. Cook Islands	-	0.8296	0.6524	.6379	.6798	0.7482	0.6441	D
3. Fiji	0.4040	0.4248	0.4355	0.4187	0.4298	.4246	0.4310	
4. French Polynesia	0.6082	0.6164	0.5992	0.5832	0.5667	0.5902	-	D
5. Guam	0.5162	0.5801	0.5914	.5920	0.5385	0.5096	0.6382	-
6. Kiribati	.6180	.5815	.6238	.5767	.5502	.5472	0.6200	-
7. Nauru	-	0.9995	0.9815	.9530	0.9100	0.9686	-	D
8. New Caledonia	0.5628	0.5296	0.4657	.4752	.4521	.4547	-	D
9. Niue	0.7831	0.8003	0.8067	0.6580	0.7662	0.8336	0.8212	-
10. Papua New Guinea	0.5859	0.5790	0.5633	0.5420	0.5243	-	-	D
11. Solomon Island	0.4798	0.5071	0.4958	0.4412	0.4543	0.4376	0.4399	D
12. Tonga	0.4628	0.4801	0.4540	0.4618	0.4880	0.4930	0.5111	-
13. TTPI	-	-	-	-	0.4896	-	-	-
14. Tuvalu	-	-	-	-	0.4638	0.4744	0.4803	-
15. Vanuatu	0.4429	0.4493	0.4260	0.4308	0.3747	-	-	D
16. Western Samoa	0.4216	0.4304	0.4086	0.4256	0.4074	0.4082	0.4302	-
17. South Pacific	0.3482	0.3624	0.3619	0.3210	0.3390	0.3416	0.3372	D

Source: South Pacific Commission 1980; Overseas Trade 1978; Statistical Bulletin No. 17, Table 2.

APPENDIX D

REVENUE AND TARIFF SCENARIOS

The Concept of Price Elasticity of Demand

A vital element of the discussion in Appendix D is the idea of how traffic responds to changes in the price or tariff structure. As noted previously, the 1985-1991 traffic figures neglected this vital relationship because of lack of information regarding the extent of price elasticity of demand in telecommunications, particularly in developing regions.

Suppose a quantity x of a certain commodity is sold at a unit price p. Now let the price be changed (increased or decreased) by a small amount Δp, so that the new price is $p + \Delta p$. Suppose further that the new quantity demanded after the price change is $x + \Delta x$, where Δx is the change in quantity brought about by the change in price. Normally (and this includes the case of telecommunications services) we would expect Δx and Δp to have opposite signs--that is, a price increase causes a decrease in demand and vice versa.

It is tempting to quantify the responsiveness or "elasticity" of demand x to price p by considering the ratio $\Delta x/\Delta p$. This figure, however, is not free of influence by the particular units in which price and quantity are measured. Thus, it is multiplied by the ratio p/x to remove that influence, and the result is the extremely important measure called price elasticity of demand, given by

(1) $$\varepsilon = \frac{p}{x}\,\frac{\Delta x}{\Delta p}$$

Since p and x are positive and Δp and Δx usually have opposite signs, ε is typically negative. One way of interpreting ε is that it measures the percentage change in demand caused by a one percent change in price.

If $\varepsilon = 0$, any change in price, however large, causes no change whatever in demand. This is the tacit assumption in the generation of the 1985-1991 traffic figures since no price structure was considered. If ε is between 0 and -1.0, demand is "inelastic," meaning that a one percent change in price brings about a change in demand of less than one percent--in other words, a price increase generates an increase in revenue. At $\varepsilon = -1$ demand is said to have "unit elasticity," and a one percent price change causes a one percent demand change. Revenue from sales remains the same before and after the price change. Finally, if ε is less than -1.0, demand is "elastic," and a reduction in price causes an increase in revenue from sales.

One refinement is needed for measuring elasticity when the percentage changes in price and quantity are large. In such cases it is convenient to use the so-called arc elasticity method, replacing p by $p + (1/2)\Delta p$, the midpoint of the old and new prices, and similarly replacing x by $x + (1/2)\Delta x$.

Using arc elasticity, the formula for elasticity becomes

(2)
$$\varepsilon = \frac{p + (1/2)\Delta p}{x + (1/2)\Delta x} \; \frac{\Delta x}{\Delta p}$$

Finally, it is often convenient to denote initial price and demand by p_1 and x_1, respectively, and price and demand after the price change by p_2 and x_2, where $\Delta p = p_2 - p_1$ and $\Delta x = x_2 - x_1$. Here, the price and demand midpoints are, respectively, $(1/2)(p_1 + p_2)$ and $(1/2)(x_1 + x_2)$, and the elasticity formula after cancellation of the factor (1/2) then becomes

(3)
$$\varepsilon = \frac{p_1 + p_2}{x_1 + x_2} \; \frac{x_2 - x_1}{p_2 - p_1}$$

Various Criteria of Tariff Policy

Three paradigmatic types of charging for services will be reviewed to complete the conceptual background for the INTELSAT tariff scenarios to follow.

Average Cost Pricing

Revenue equals cost times traffic. If each user of a service is charged the average cost of the units purchased, revenue will exactly equal costs. The simplicity and perceived fairness of this tariff policy make it extremely popular among regulatory authorities. It does, however, have a number of drawbacks from the standpoint of economic welfare theory. These drawbacks center on the cost of ignoring possible differences among the price elasticities of demand of different user groups with different abilities to pay, but they cannot be presented within the confines of the present report.

If, for example, the INTELSAT option summarized in Table 5.9 in Section 5 (case including FP/NC) were to be charged on an average cost basis in 1985, each user would pay $1.67 per minute, regardless of the type of user or the category of service provided. This would exactly recover the total 1985 costs of $50,464,000 assuming a traffic level of 30.18 million paid minutes at that price.

Marginal Cost Pricing

Marginal or incremental cost is the cost of providing the last or most recent unit of service. Economic welfare theory indicates many advantages for charging only the "out-of-pocket" expense for each additional item and ignoring fixed costs which are not sensitive to the level of service provided. In telecommunications and many other public utility services, however, economies of scale dictate that marginal cost is less than average cost, and in such cases charging only marginal cost does not recover all operating costs, thereby resulting in an operating deficit.

Table 5.9 in Section 5 indicates that marginal cost in the context of the INTELSAT option is $5,000, i.e., $5,000 per circuit provided. This is the amount ascribed to miscellaneous OMM expenses and it is assumed to be directly sensitive to the traffic level provided. Actually, this is short-term marginal cost. In the long run, the number of transponders and earth stations is also dependent on the traffic level, and suitable levels of these expenses would have to be included in long-term marginal cost. For purposes of the present study, however, only short-term marginal cost is considered. Charging $5,000 per circuit, i.e., on a marginal basis, would clearly result in a substantial operating deficit for the INTELSAT option.

Inverse Elasticity or Ramsey Pricing

A seminal contribution to the problem of marginal cost pricing in the presence of economies of scale was made by Frank Ramsey (1927) and expanded and refined by Baumol and Bradford (1970). These authors essentially prove the optimality of segregating users into groups according to their differing elasticities of demand and then levying a price for each such that the markup from marginal cost is inversely proportional to that group's price elasticity of demand. The absolute amount of markup is such that operating expenses are just covered. Thus, lower-elasticity (less price responsive) users are charged higher prices, and higher-elasticity (more price responsive) users are charged lower prices.

Any public utility pricing based on elasticity of demand is philosophically and administratively difficult despite its proven advantages from the standpoint of economic welfare theory. There are, however, many instances of such pricing. One is charging lower air fares for passengers willing to plan their trips far in advance (excursion fares) or to wait until the last minute for confirmation (standby fares). These presumably higher-elasticity customers profit from the desire of lower-elasticity passengers (presumably business travelers) for planning flexibility and their ability to pay for it. Snow offers a similar interpretation of INTELSAT's transponder tariff (1977) and of its tariff structure in general (1976).

The inverse elasticity rule for user groups one and two, with price p, marginal cost MC, and price elasticity of demand ε appropriately subscripted, is given by

(4) $$\left(\frac{P_1 - MC_1}{P_1}\right)\varepsilon_1 = \left(\frac{P_2 - MC_2}{P_2}\right)\varepsilon_2 .$$

For more than two user groups, one such equation would apply to every pair of groups.

Three Inverse Price Elasticity Tariff Scenarios for the INTELSAT Option

An illustration of tariffing INTELSAT-provided services in the South Pacific interim system will now be undertaken. First, a criterion for determining two (or more) user groups must be selected. One such criterion already available is that of type of service, i.e. international/urban and domestic/rural.

A system of four equations will be developed to determine the Ramsey or inverse elasticity prices, and the corresponding quantities of each type of service that will just cover costs.

First, consider the situation in 1985 to which this exercise is to be applied. As Tables 5.2 and 5.9 in Section 5 indicate, 1,904 circuits are to be provided at a total cost of $50,464,000 under the case including FP/NC traffic. Of these 1,904 circuits, 1,204 are international/urban and 700 are domestic/rural. The marginal cost of each type of service is \$5,000 per circuit, i.e., the amount by which total costs increase for each additional circuit provided.

Initially, average cost pricing is applied, and both urban and rural users are charged \$26,504 per circuit which covers operating costs. In fact, now that the link between price and traffic level is no longer assumed away, it must be explicitly posited that the price of \$26,504 will give rise in 1985 to a demand for precisely 1,204 urban and 700 rural circuits.

Now segregate users into the two categories and require that new prices be charged which satisfy the inverse elasticity requirement of demand for urban last important assumption involves the price elasticity of demand for urban and rural users which will be designated by ε_u and ε_r, respectively. As already noted, no data or studies are extant which would permit a reliable estimate of these measures. Common sense and telecommunications demand literature from the industrialized countries [Taylor (1980)], however, dictate that the absolute value of rural price elasticity exceed that of urban elasticity--in other words, urban users (including higher-income individuals, news services, multinational corporations, government ministries and so on) have a greater "ability to pay" (are less sensitive to price) than do rural users. To be specific, assume $\varepsilon_u = -0.8$ and $\varepsilon_r = -1.2$.

p_1, in terms of Equation (4), is simply the "new" price for urban service, to be redesignated p_u. Likewise, subscript 2 refers to rural service, and p_2 is the price of rural service now called p_r. $MC_1 = MC_2 = 5000$ is marginal cost, and the elasticities ε_1 and ε_2 become -0.8 and -1.2, respectively. Thus, the inverse elasticity equation becomes

(5) $$\left(\frac{p_u - 5000}{p_u}\right)(-0.8) = \left(\frac{p_r - 5000}{p_r}\right)(-1.2),$$

which when solved for p_r becomes

(5a)

$$p_r = \frac{6,000\ p_u}{0.4\ p_u + 4,000}$$

The second of the four equations requires that revenues equal costs, i.e., that the system operate on a break-even basis rather than provide an operating profit or loss. Revenue after the tariff rearrangement will be

$$p_u x_u = p_r x_r,$$

where x_u and x_r are, respectively, the new levels of urban and rural demand in circuits, where the old levels were 1,204 and 700, respectively.

Costs are \$50,464,000 at the level of 1,904 circuits, and will increase (decrease) by \$5,000 for every circuit above (below) that level. Costs are then given by the expression

$$50,464,000 + 5,000[(x_u + x_r) - 1,904],$$

and the equation aligning revenue with costs becomes

(6)
$$p_u x_u + p_r x_r = 50,464,000 + 5,000\,[(x_u + x_r) - 1,904].$$

The last two equations of the required four are simply variants of (3) above, which are used to determine the new levels of price and demand given the assumed elasticities:

(7)
$$\left[\frac{(p_u + 26,504)}{(x_u + 1,204)}\right]\left[\frac{(x_u - 1,204)}{(p_u - 26,504)}\right] = -0.8$$

(8)
$$\left[\frac{(p_r + 26,504)}{(x_r + 700)}\right]\left[\frac{(x_r - 700)}{(p_r - 26,504)}\right] = -1.2$$

Unfortunately, the solution to the system of Equations (5) through (8) in the four unknowns p_u, p_r, x_u and x_r involves the solution of a sixth-order polynomial and more resources than those available for the present report. Nevertheless, determining conditions for existence of a solution, as well as obtaining particular solutions, would be perfectly straightforward.

For purposes of the present study, a roundabout course can be taken. Let us assume, for example, that it is decided to charge p_u = \$30,000 to the low-elasticity urban users, which is somewhat above the average cost of \$26,504. Substitution into equation (5a) then yields p_r = \$11,250, the below-cost price to be charge to the high-elasticity rural users. Equation (7) yields x_u = 1,090 as the new urban circuit demand level (down from 1,204), and Equation (8) gives x_r = 2,017 as the new rural circuit demand level (up substantially from 700).

The question now is whether revenues are less than, equal to or greater than cost. Substitution into (6) shows that revenues are \$55,391,250, of which \$22,691,250 is from rural users and \$32,700,000 from urban users. Costs are as follows: \$50,464,000 for the first 1,904 circuits, and 5,000 x (2,017 + 1,090 - 1,904) for the marginal cost of the new 1,203 circuits over and above 1,904, i.e., 5,000 x 1,203 = \$6,015,000. Thus, total costs are \$56,479,000, less than two percent above revenues. The "true" solution of the four-equation system could not be far from this outcome, since costs are relatively quite close to revenues and the other three equations are satisfied exactly.

How can we interpret this scenario? The most dramatic result is that rural users benefit greatly, being offered a price equivalent to only about 42 percent of average cost. The elastic (price-sensitive) response of the rural users increases their usage dramatically, from 700 circuits to 2,017, up by a factor of 2.88. Overall circuit usage is up by a factor of 1.63, from 1,904 to 3,107. Responding to a modest price increase of 13 percent from \$26,504 to \$30,000, urban users, being relatively inelastic (price-insensitive), reduce their usage only slightly, down by only 11 percent from 1,204 circuits to 1,090 circuits. One important additional consideration here is whether the system can handle the additional traffic generated by the tariff re-alignment. A glance at Table 5.2 in Section 5 shows that the new usage level of 3,107 in 1985 corresponds to that originally anticipated for 1990. Since earth stations are available to meet demand up to the level of 1991, however, the new traffic can be handled. Even if the earth station capacity is seemingly exceeded, it seems plausible to meet short-run excess demand by putting more than 20,000 paid minutes per year on urban (thick) circuits and more than 10,000 paid minutes per year on rural (thin) circuits. As noted above, these adjustments, as well as the earlier acquisition of new earth stations and transponders occasioned by the increase in traffic, must ultimately be accounted for in the long-run marginal cost, which is the correct measure of marginal cost in Equation (5). Such accounting precision, however, exceeds the scope of the current report.

This scenario gives an overall positive picture. By realigning the tariff to reflect "what the traffic will bear," system usage has been increased, but operating costs are still recovered. Users less able to pay high prices are charged a lower tariff, and users less sensitive to price pay more.

A second paradigm will now show how a different tariff structure, one which departs from the letter but not the spirit of the inverse-elasticity rule, might be used to deliver a net operating surplus to the telecommunications administrations involved, which could then be used as they desire.

Let p_u = \$40,000. The inverse-elasticity rule, Equation (5), would require p_r = \$12,000. Decide, however, to charge p_r = \$20,000, which is still below average cost and only half the price charged the urban users. Via Equations (7) and (8), these prices generate the traffic levels $x_u = 868$ and $x_r = 983$. Equation (6) shows that system revenue will then be \$54,380,000 against system costs of only \$50,199,000, which is an operating surplus of over 8 percent. The good aspect of this scenario is obviously the operating surplus, but it must be weighed against the fact that overall traffic has diminished slightly, from 1,904 to 1,851 circuits. Furthermore, certain economic welfare benefits beyond the scope of this report are forfeited by the conscious departure from the inverse-elasticity pricing rule. Finally, the earth station equipment already in place, as well as other fixed costs, is used less intensively, causing greater costs for all categories of users.

A third and final tariff scenario examines the opposite case, in which there is a conscious policy decision to encourage the growth of telecommunications services for developmental reasons, under the assumption that heightened levels of telecommunications infrastructure and service are prerequisites for economic development in the Pacific Basin countries. Therefore, the price of urban usage is cut to p_u = \$15,000, well below cost, and only two-thirds of that, p_r = \$10,000, is charged for rural usage. This generates urban traffic at the increased level of x_u = 1,890 circuits, and rural traffic at the increased level of x_r = 2,460. The revenue generated is now \$52,950,000, while total cost is \$62,694,000. In this case, the dramatically lowered prices have increased urban traffic by a factor of 1.57 and rural traffic by a factor of 3.51. Revenue is increased modestly by five percent, but the additional traffic at $5,000 per circuit drives costs up by a factor of 1.24, causing an operating deficit of 18 percent. In this setting it would be an important policy decision to determine whether making good the operating deficit of almost $10,000,000 from outside sources--such as direct development assistance from the industrialized world, or internally via bonds or general government revenue--would be worth the presumed contributions to economic development brought about by increased levels of telecommunications usage and hastened improvements to the associated infrastructure.

Table D.1 summarizes the three tariff scenarios outlined above. For purposes of exposition there, "Scenario 0" is taken as the case of average cost pricing.

Concluding Remarks

Appendix D has depended even more crucially than the cost development in Section 5 on assumptions for which firm empirical backing is not yet available, particularly for developing countries. This is true above all for elasticity estimates. All the results in Table D.1, for example, would have been different had a different pair of elasticities been chosen. In addition, the four-equation system presented is highly non-linear, and no effort was made to determine what the nature of its solutions might be under varying assumptions regarding elasticities and costs. Appendix D should be taken above all as the presentation of a methodology for determining the effects of differing tariff structures on revenues and traffic, given elasticity estimates. As such, it can be a planning framework for tariff policy analysis of an interim Pacific Basin satellite system and its successor.

TABLE D.1 -- Summary of INTELSAT Tariff Scenarios

Financial Data

Scenario #	($) p_u	($) p_r	x_u= Urban Circuits	x_r= Rural Circuits	Total Circuits	($000) Urban Revenue	($000) Rural Revenue	($000) Total Revenue	($000) Total Cost	(%) Operating Surplus(+) or Deficit(-)
0	26504	26504	1204	700	1904	31911	18553	50464	50464	0.0
1	30000	11250	1090	2017	3107	32700	22691	55391	56479	+2.0
2	40000	20000	868	983	1851	34720	19660	54380	50199	+8.3
3	15000	10000	1890	2460	4350	28350	24600	52950	62694	-18.4

Effect of Tariff Scenarios

Scenario #	Stimulate Traffic	Cover Costs	Cause Deficit	Cause Surplus	Spirit of Inverse-Elasticity Pricing	Letter and Spirit of Inverse-Elasticity Pricing	Average Cost Pricing
0	No	Yes	No	No	No	No	Yes
1	Yes	Yes	No	No	Yes	Yes	No
2	No	Yes	No	Yes	Yes	No	No
3	Yes	No	Yes	No	Yes	No	No

Finally, mention should be made of another obvious method of classifying system users into subgroups based on differing price elasticities of demand, in addition to the urban/rural distinction already used. Karunaratne (1982) developed an "ability to pay" index for the 18 Pacific Basin entities using variations in income, trade and aid among them. Certainly this index has a close relationship to the concept of price elasticity of demand for telecommunications. Based on the index rankings, one could consider the following tripartite classification of those countries with respect to potential tariffs (scores in parentheses are rank scores):

High Ability To Pay	Medium Ability To Pay	Low Ability To Pay
Nauru (1)	Papua New Guinea (7)	Trust Territory (13)
American Samoa (2)	Solomon Islands (8)	Tuvalu (14)
New Caledonia (3)	Kiribati (9)	Wallis and Fortuna (15)
French Polynesia (4)	Vanuatu (10)	Niue (16)
Fiji (5)	Western Samoa (11)	Tokelau (17)
Guam (6)	Tonga (12)	Cook Islands (18)

Beyond the ordinal rankings, one might even use cardinal scores of the ability to pay index reported in Table 2 of Karunaratne (1982) as crude relative estimates of price elasticity of demand for satellite circuits. Once calculated, such elasticities could be used to determine the optimal inverse-elasticity pricing regime.

If developmental needs of the nations for cheap telecommunications are deemed to be more important than the welfare benefits of inverse-elasticity pricing, the "basic needs" index of Karunaratne (1982, Table 26) could be used instead. Here, the tripartite division with rank order scores is as follows.

High Basic Needs	Medium Basic Needs	Low Basic Needs
Solomon Islands (1)	Western Samoa (7)	American Samoa (13)
Vanuatu (2)	Wallis and Fortuna (8)	New Caledonia (14)
Niue (3)	Trust Territory (9)	Guam (15)
Tonga (4)	Fiji (10)	Papua New Guinea (16)
Kiribati (5)	Tuvalu (11)	Cook Islands (17)
Tokelau (6)	French Polynesia (12)	Nauru (18)

Prices under this approach would presumably be set in inverse proportion to the level of basic needs, perhaps with an overall operating loss ascribed to promotion of economic development. In any event, there is certainly a strong negative correlation observable between the rank of ability to pay and the rank of basic needs.

APPENDIX E

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